

वार्षिक प्रतिवेदन Annual Report

2000-2001

National Standards
&
Measurements

Superconductivity
&
Cryogenics

NPL

Materials Development
&
Characterization

Radio
&
Atmospheric Sciences



राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली
National Physical Laboratory, New Delhi

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FOREWORD



It gives me great pleasure to present the Annual Report of the National Physical Laboratory for the year 2000-2001.

NPL is custodian of the national standards of measurements as the National Metrology Institute of India. It provides apex level calibration to users in all sectors of economy and security related organizations. This service ensures traceability to measurements made in the country to the international standards as per well established mechanism of linkages with the International Committee for Weights and Measures (CIPM) / International Bureau of Weights and Measures (BIPM) as well as the Asia Pacific Metrology Programme (APMP). NPL conducts advance research and development in standards, engineering materials, electronic materials, polymeric and soft materials, materials characterization, radio and atmospheric sciences, superconductivity and cryogenics. In addition to the in-house R&D, the laboratory undertakes sponsored projects, consultancy assignments and contract research. It provides calibration and testing services against payment. During 2000-2001 the R&D activities were organized in the following Divisions :

(i) Physico-Mechanical Standards; (ii) Electrical and Electronic Standards; (iii) Engineering Materials; (iv) Electronic Materials; (v) Polymeric and Soft Materials; (vi) Materials Characterization; (vii) Radio and Atmospheric Sciences and (viii) Superconductivity and Cryogenics. One of the current important R&D activities in the field of standards is concerned with establishing equivalence of Indian national standards and measurement capabilities with the international standards. For this purpose, NPL is a signatory to a Mutual Recognition Arrangement (MRA) established through mutual agreement by most of the countries, which are members of the Meter Convention. In this context NPL's scientists have participated in several key comparisons of the consultative committees of CIPM, as well as the key comparisons organized through APMP. Inter-comparisons on the following parameters have been completed: (i) Pressure - 0.1 mPa to 1000 mPa, 10 kPa to 140 kPa, (ii) Photometry and Radiometry - luminous responsivity; and (iii) AC/DC Voltage Transfer Standards - frequency ranges, 1 kHz to 1 MHz and 1 MHz to 50 MHz. Three new Certified Reference Materials named as Bharatiya Niradeshak Dravyas or BNDs in short were released during this year. In addition, fresh lots of six BNDs were also released. Three of these were prepared a third time whereas the remaining three were being released for the second time.

Some of the important products and processes developed during the year are : (a) titanium fasteners for aerospace industry; (b) piezoelectric accelerometers for vibration measurements and similar applications; (c) gadolinium oxysulfide phosphor coated screen for imaging X-rays in real time; (d) niobium-tin insert coils for superconducting magnets; and (e) first south Asian medium-size free air carbon dioxide enrichment facility.

The following new facilities had been established:

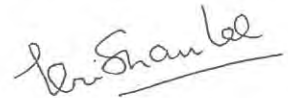
- (a) gonio-reflectometer for characterizing surfaces regarding their roughness by measuring reflectance at various angles;
- (b) a new measurement and calibration facility for DC high voltage upto 100 kV useful for TV and X-ray industries;
- (c) a fully automatic facility for DC measurement of soft magnetic materials using standard permeameters; and
- (d) a state-of-the-art advanced digital ionosonde IPS-71 providing conventional and Doppler ionograms

for studying radio environment.

During the year 2000-2001 NPL scientists published 174 papers (SCI papers 92), presented 219 papers in national and international conferences/symposia/workshops etc. out of which 88 have been published in the proceedings. In all 13 patents were filed out of which six patents were filed outside India. Two patents, which were filed earlier, had been granted in USA. Technology of a miniature teleclock was transferred to industry. Twenty-three new R&D projects worth Rs. 157 lakhs were initiated. Consultancy services worth Rs. 30 lakhs were provided. The revenue generated through calibration and testing service was Rs. 227 lakhs. The total NPL budget covering plan and non-plan expenditure was Rs. 2609.122 lakhs.

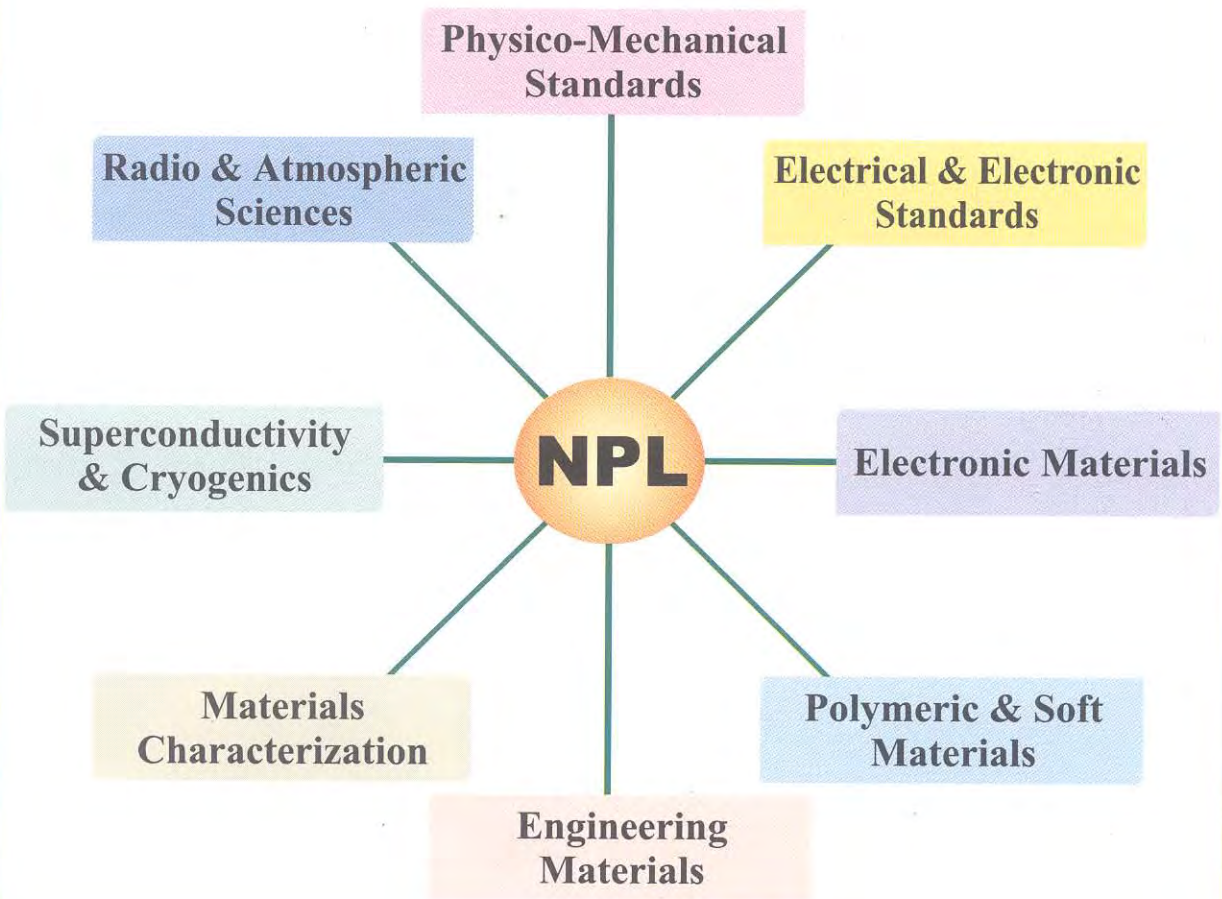
It is a pleasure to acknowledge the contributions of NPL scientists and engineers, administration, finance and accounts, stores and purchase, supporting staff and infrastructure services for making several notable achievements. I am very confident that in future the rate of growth will go up significantly in terms of quality and quantity. Colleagues at NPL are quite capable of achieving higher targets.

It is, indeed a pleasure to acknowledge the efforts of the Annual Report team in bringing out this document. In particular, efforts made by Drs. S.M. Dhawan, S.K. Gupta, Ravi Mehrotra, M.K. Goel, V.N. Ojha, (Ms.) P.S. Upadhyaya, T.D. Senguttuvan, (Mrs.) Reena Sharma, (Mrs.) S. Sharma, M.K. Tiwari, V.S. Tomar, Shri N.K. Wadhwa and Shri N.S. Verma are highly appreciated.



Krishan Lal
(Director)

R & D Divisions of NPL



भौतिक - यांत्रिक मानक

PHYSICO - MECHANICAL STANDARDS

भौतिक - यांत्रिक मानक

भौतिक-यांत्रिक मानक प्रभाग की मुख्य गतिविधियाँ द्रव्यमान, आयतन, घनत्व, श्यानता, लम्बाई, विमा, कोण, पृष्ठीय रूक्षता, तापमान, अनआयनकारी विकिरण [पराबैंगनी (अल्ट्रावायलेट), प्रकाशीय (ऑप्टिकल) तथा अवरक्त (इन्फ्रारेड)], बल, कठोरता, बलआघूर्ण, दाब, निर्वात, तरल-बहाव, ध्वानिकी, पराश्रव्यिकी, तथा कंपन के प्राथमिक/राष्ट्रीय मानकों को स्थापित करना व उनका अनुरक्षण करना, अन्तर्तुलन द्वारा इन्हें अन्तर्राष्ट्रीय मानकों के समकक्ष बनाना और उपयोगता स्तर के उद्योगों के उपकरणों के अंशशोधन के द्वारा इनका प्रसार करना तथा पृष्ठीय (Surface) भौतिकी का अध्ययन करना है। इसके अतिरिक्त उद्योगों के लिए विश्वस्तर पर आने वाली चुनौतियों का सामना करने हेतु गुणवत्ता में आवश्यक सुधार के लिए तकनीकी परामर्श प्रदान करना और विद्यमान मानकों में संशोधन तथा नए मानकों को स्थापित करने के लिए अनुसंधान एवं विकास परियोजनाओं का उत्तरदायित्व लेना, उद्योग और परीक्षण प्रयोगशालाओं के मध्य मापन अनिश्चितता के विषय में जागरूकता लाना तथा इसके मूल्यांकन के लिए प्रशिक्षण प्रदान करना इस प्रभाग के कार्यकलापों में सम्मिलित हैं।

यह प्रभाग देश की प्रयोगशाला प्रत्यायन संस्था 'राष्ट्रीय परीक्षण और अंशशोधन प्रयोगशाला प्रत्यायन बोर्ड' को अत्यधिक सहयोग प्रदान करता है। बोर्ड के कार्य के लिए प्रशिक्षित और अनुभवी एसेसर तथा बोर्ड द्वारा, प्रयोगशालाओं को मापन अनिश्चितता के मूल्यांकन विषय पर दिये जाने वाले प्रशिक्षण के लिए अनुभवी प्रशिक्षक एवं 'प्रत्यायित प्रयोगशालाओं के परीक्षण प्रवीणता कार्यक्रम के लिए उपकरण, सुविधाएँ तथा विशेषज्ञ प्रदान करना इस सहयोग में सम्मिलित हैं।

पिछले कुछ वर्षों के दौरान प्रयोगशाला द्वारा ए.पी.एम.पी. और सी.आई.पी.एम. की विभिन्न भौतिक यांत्रिक पैरामीटरों से सम्बन्धित मुख्य अन्तर्तुलनाओं में प्रतिभागिता के फलस्वरूप प्रयोगशाला को दाब-0.1 से 1000 मिलिपास्कल; 10 से 140 किलोपास्कल; 20 से 100 मेगापास्कल और प्रकाशीय व विकिरण मापिकी - ल्युमिनस रेस्पॉन्सिविटी के लिए अन्तर्राष्ट्रीय माप-तोल ब्यूरो (बी.आई.पी.एम.) की परस्पर पहचान व्यवस्था (एम.आर.ए.) के ड्राफ्ट 'ख' में सम्मिलित कर लिया गया है। अन्य पैरामीटरों के लिए प्रयोगशाला को एम.आर.ए. में सम्मिलित करने के लिए, उन पैरामीटरों के लिए की गई अन्तर्तुलनाओं के निष्कर्ष विचाराधीन हैं।

इन सभी गतिविधियों ने भारतीय उद्योगों को अंतर्राष्ट्रीय स्तर पर स्वीकार्य यथार्थ मापन करने हेतु सक्षम बनाया है। इससे अन्तर्राष्ट्रीय बाजार में भारतीय उद्योगों की प्रतिस्पर्धा को बढ़ावा मिलता है।

PHYSICO - MECHANICAL STANDARDS

The Physico-Mechanical Standards Division is engaged in development and maintenance of primary/ national standards of Mass, volume, density, viscosity; Length, dimension, angle, surface roughness; Temperature; Non-ionizing radiation- ultraviolet region, visible region, infrared region; Force, hardness, torque; Pressure, vacuum; Fluid flow; and Acoustics, ultrasonic and vibrations. The major activities are: i) to establish and maintain primary/ national standards, making these traceable to the international standards by intercomparison methods, and disseminate the same to the user level industries by way of calibrating their instruments and reference standards, ii) to provide technical consultancy to industries for enhancing their quality to meet the challenges in the global scenario, and iii) to undertake research and developmental projects, in particular establishing new standards and improving upon the existing standards, iv) to bring awareness about measurement uncertainty amongst industry and testing laboratories and provide training for its estimation.

The Division extends very close cooperation to the accreditation body of the country i.e. National Accreditation Board for Testing & Calibration Laboratories (NABL) by providing: (a) trained and experienced assessors, (b) faculty to train testing laboratories for estimation of uncertainty in their measurements, (c) instruments, facility and expertise to their programme on proficiency testing of their accredited laboratories.

The APMP and CIPM key comparisons made during past few years in various Physico-Mechanical parameters have lead the laboratory for its entry to Draft 'B' of Mutual Recognition Arrangement (MRA) of International Bureau of Weights & Measures (BIPM) for the parameters Pressure-0.1 mPa to 1000mPa, 10 kPa to 140 kPa, 20MPa to 100 MPa; and Photometry & Radiometry - Luminous Responsivity. The results of intercomparison on other parameters are being considered for their entry.

The significance of all these activities paves way for the industries to make precision measurements that are traceable to international standards. This in turn leads to enhancement of competitiveness of Indian industries in the international market.

Acoustics Standards

Sound transmission characteristics of several complicated structures consisting of rooms, separating panels and cavities were studied analytically by using the statistical energy analysis (SEA) and by formulating a set of simultaneous power balance equation using certain algorithm. A simple matrix has been developed for the general solution for one acoustic power input. The results have been experimentally verified.

Noise labelling of household electrical appliances was undertaken at the initiative of the sub-committee of Noise Pollution Control Board constituted by Central Pollution Control Board, New Delhi to prepare the modalities for bringing in regulations for machinery noise labelling of products which emit noise harmful to human health and welfare. This exercise has helped to identify the various noise sources and their categorisation.

Sodar studies of ABL (Atmospheric Boundary Layer) in relation to (i) foggy weather conditions in Delhi, and (ii). Bio-mass burning in shifting cultivation areas in A.P. was undertaken. Sodar observations of fog layer depth in conjunction with

other meteorological parameters have been used as input for developing a model to predict onset and clearance of fog. Preliminary model validation studies have also been carried out. Similarly sodar observations were made to monitor mixing heights variation during bio-mass burning in shifting cultivation areas. The effect of trace gases and aerosol emission in the atmospheric stability has also been studied.

Design and development in respect of the different subsystems of the **Acoustic Wind Profiler** were completed. The complete system was integrated with the phased array antenna and lab tested.

Piezoelectric Accelerometers

The piezoelectric accelerometer (10 Hz to 10000 Hz frequency range, all stainless steel construction) type PL810, indigenously developed in NPL, has been designed for use in general purpose vibration measurement applications in industrial plants, test laboratories, aviation, automobiles, mines, engines and structures, etc. The accelerometer has a mass of 40 gm and reference sensitivity of 20 mV/g. The device is suitable for reliable measurements in the frequency



Fig: 1.1 : Piezoelectric Accelerometer PL-810

range 10 Hz to 10000 Hz for measuring vibrations and shocks up to 3000 g. Indigenously developed accelerometer and its typical frequency response curve is shown in Figures 1.1 & 1.2 respectively.

Ultrasonic Standards

For the accurate assessment of concrete strength, improvement has been done in the accuracy of measurement of time of flight of the ultrasonic waves across the material. Mono-shot has been introduced in the electronic circuit which results in an improvement by 2 ns. Several experiments were conducted to verify the accuracy of the circuit using low to very highly attenuating materials. An empirical relationship was also derived between strength and ultrasonic parameters. It was based on a large number of concrete blocks, which were prepared with specifications M15 and M35. The blocks were subjected to destructive testing to evaluate the strength and to nondestructive testing to evaluate the ultrasonic velocity and attenuation. The predicted values were found to be in excellent agreement with experimental values.

The IEC 1157(1992) requires the declaration of a large number of parameters of ultrasonic medical diagnostic equipment. Three new parameters were added this year in the list of parameters being measured at NPL using multielement PVDF hydrophone.

Based on the theoretical study and experimental observations, most appropriate lining

material has been identified for designing the anechoic water tank. It has been experimentally shown that the new design results in zero reverberation, an ideal condition for the measurement of ultrasonic power.

Length Standards

Dissemination of unit of length 'Metre' was continued by providing testing and calibration services to the industries and other organization. These services were provided for calibration of laser interferometers, Metre bars, and other length measuring machines and testing of holograms and optical flats. A new type of calibration work performed this year was calibration of scale bars used in theodolites.

Precision optical components were fabricated and optical polishing services were provided to users from NPL as well as outside.

A frequency stabilized extended cavity diode laser has been developed in Littrow configuration. The diode laser wavelength has been tuned to 6S1/2 -6P1/2 transition of Cs at 852 nm and hyperfine transitions were observed in Cs saturated absorption setup. Cs hyperfine transitions from both the ground states F=3 and F=4 of Cs were obtained in a flat background by employing a reference probe beam and subtracting the Doppler profile by fabricating a difference amplifier.

A Cs saturated absorption spectrometer with DBR diode laser has been set up. Second ECDL in Littman configuration has been designed and fabricated.

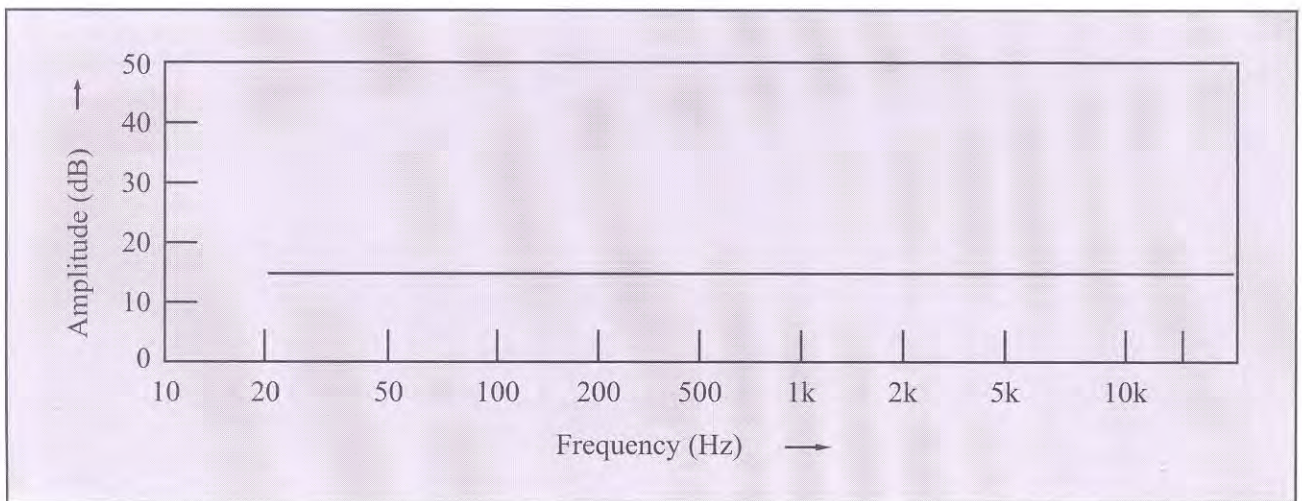


Fig: 1.2 : Frequency Response Curve of Piezoelectric Accelerometer PL-810

Dimensional Metrology

Calibration services to the industries were provided for all length related parameters including angle, form deviation, surface roughness and roundness etc. The equipments / instruments which can not be transported to NPL are calibrated at the site of the customer. About 12 outstation customers were provided calibration service on site. Training to the industrial personnel in calibration of length measuring instruments was provided as per NPL calendar and under consultancy projects. Consultancy was provided to M/s Research and Development Centre for Bicycles and Sewing machine, Ludhiana and M/s SITARC, Coimbatore for developing calibration facilities and methodology in dimensional metrology along with other parameters.

Vacuum and Pressure Standards

Vacuum & Leak rate standards and compatibility through comparisons were established by participating in the BIPM/CCM Key comparisons, organized by NIST USA CCM PK-3 in the range 10^{-3} to 10^{-6} Pa. The participating laboratories are, NIST, USA; PTB, Germany; IMGIC, Italy; KRIS, Korea; NPL, UK; CSIRO, Australia and NPL, India. The transfer standards used were three nos. of Ionization Gauges and two nos. of Spinning Rotor Gauges.

A Computer Software was developed in WINDOWS environment for "**Calibration Database Management and Calibration Report Generation with the Statement of Measurement Uncertainty**", using Visual BASIC and MS Access 97 Systems. The "Measurement Uncertainty Model" used in this software includes, measurement uncertainty components of the reference standard used, the resolution and hysteresis of the Gauge under Calibration apart from other factors like Calibration Factor, Reproducibility etc.

Characterization of APMP artifact, Ruska Air Piston Gauge and the NPL Ruska Air Piston Gauge Sr. No. TL-508 in the range 20 to 105 kPa absolute mode was carried out using Ultrasonic Interferometer Manometer (UIM) as the primary pressure standard. The APMP artifact was used as the Transfer Standard in inter comparison exercise under APMP, a RMO Key Comparison.

A differential pressure transducer, which can

operate upto line pressure of 70 bar giving differential pressure range of 0-35 bar, was characterized against the secondary pressure standard NPL-8 through automated as well as manual data acquisition. ADDR 6000, a digital pneumatic pressure standard was characterized in pneumatic pressure range 0-125 bar against NPL-8, a secondary pressure standard. Software was developed in Visual Basic for automated data acquisition from the differential pressure transducer to a PC through a 16-bit A/D interface card.

Raman studies were carried out on GaAs samples which were double implanted with Si and subjected to rapid thermal annealing (RTA) at temperatures of 900°C for 25s (Sample -A), 925°C for 15s (B) and 950°C for 6s (C). In order to study the diffusion profiles of these implanted dopants, the dopant concentration Vs. depth of all these three samples were obtained by secondary ion mass spectrometry (SIMS) studies. From the Raman studies, it is observed that the LO phonon mode interacts with the plasmons resulting in L_+ and L_- phonon-plasmon modes in all the three samples. Further, from the peak value of these L_+ and L_- phonon-plasmon modes, the active carrier concentration in the samples using the plasmon frequency versus carrier concentration curve were found to be $4.49 \times 10^{17} \text{ cm}^{-3}$, $7.06 \times 10^{17} \text{ cm}^{-3}$ and $4.70 \times 10^{17} \text{ cm}^{-3}$, respectively. These values are compared with the dopant concentration as obtained from the SIMS depth analysis. It is observed that dopant concentration obtained through SIMS is higher than the carrier concentration obtained from Raman studies in samples A and B, but in sample C these concentrations are nearly the same. SIMS data further shows that the diffusion of Si is highest in sample C. Raman studies show that the carrier concentration is highest in sample B which agrees well with the concentration obtained from Hall Effect and electrical conductivity measurements.

High pressure Raman studies of the heavily n-doped GaAs semiconductors with an emphasis to investigate the variation of the phonon frequency with pressure has been continuing. The concentration of the n-dopant (silicon) is determined by the Secondary Ion Mass Spectrometer (SIMS). It is observed that the

LO phonon interacts with the macroscopic electric field of the plasmon giving rise to the formation of coupled L_+ and L_- modes. The frequency of these coupled modes changes with pressure.

High Pressure Band Structures and Structural Stability of European Monochalcogenides

Band structure calculations were carried out to study the pressure induced structural transitions and structural stability of the magnetic compound EuS. The first principal tight-binding linear muffin-tin orbital method (TB-LMTO) within local density approximation (LDA) was used to study the band structure. The magnetic phase stability was determined from the total energy calculations within the atomic-sphere approximation (ASA) for both the nonmagnetic (NM) and magnetic (M) phases. These theoretical calculations clearly indicate that both at ambient as well as at high pressures, the M phase is more stable than the NM phase. The phase transition from NaCl (B1) type to CsCl (B2) type structure was found to occur. The bulk modulus and magnetic moments are found to be in agreement with earlier experimental results.

Establishment of Measurement Uncertainty and Characterization of Hydraulic Pressure Standards

The new hydraulic pressure standards (100 MPa, 200 MPa and 500 MPa), procured from D & H France have successfully been installed, characterized, intercompared with other national standards and dedicated to national calibration and consultancy services to the users. An extensive in-house laboratory intercomparison exercise involving all the eight national hydraulic pressure standards has been carried out. The compatibility, uniformity and reaffirmation of results is re-established by comparing the values of zero pressure effective area (A_0) and distortion coefficient (b) with the values obtained during bilateral and international key comparisons sponsored by BIPM, CCM, APLAC, LNE (France) and NIST (USA).

Development of a Software Package for the Calibration of Pressure Measuring Instruments

A computer software package has been developed for

the calibration of pressure measuring instruments. This software, available in executable mode for commercial use, is a complete package written in MSDOS QBASIC environment for the calibration of both hydraulic and pneumatic pressure measuring instruments using simple / reentrant type dead weight testers as pressure standards. This software can be used for the computation of generated / measured pressure, determination of effective area and distortion coefficient, data regression through curve fitting, computation of measurement uncertainty associated with pressure and effective area measurements and finally preparation of calibration reports for various pressure measuring instruments.

Development of a Method for the Establishment of Measurement Uncertainty of Pressure Dial Gauges and Transducers

A method of characterizing the data obtained from different types of pressure measuring instruments by curve fitting has been devised. By processing large amounts of data, a systematic trend for any particular type of gauge can be estimated. This method has allowed us to improve the specification of the measurement uncertainty of our pressure measuring instruments with respect to that specified by the manufacturers.

Maintenance of Surface Analytical Facilities and Services to Indian Industries

Epitaxial Growth of Sb on 7x7 Reconstructed Single Crystal Si(111) Surface:

The adsorption of Sb from a Knudsen cell on to a single crystal Si (111) surface is carried out in an UHV chamber of 5×10^{-10} torr in the sub-monolayer regime. In-situ, the evolution of the interface is monitored by surface sensitive probe of XPS. The 7x7 reconstruction of the single crystal Si(111) substrate described by the DAS model yields a quasi-continuous distribution of states resulting in a metallic character of the surface. The extra valence of Sb the Gp V adatoms on Si allows various ways to minimize the number of surface dangling bonds resulting in a passivated stable surface.

The uptake curve manifesting the attenuation of the photoelectron signals due to the over layer indicates an epitaxial Frank Van Der Merwe growth

mode for Sb deposited at a rate of 0.1 ML/min onto a (7x7) reconstructed Si(111) surface. At lower coverages small Sb non-metallic 2D clusters grow on the (7x7) surface which has a metallic character, resulting in a flat-band at the interface. At 1 ML either the Sb clusters attain sizes to acquire metallicity or the surface (7x7) reconstruction undergoes a phase transition destroying its metallic character, thus resulting in the band-bending at the interface. As seen in Figure 1.3, formation of the Schottky Barrier is manifested in the core-level shift of Sb 3d peak, which at 1.0 ML coverage abruptly shifts by about 0.85 eV. The FWHM of the core-level peak also significantly widens at this coverage. Observation in change of anisotropy in spin-orbit splitting of the 3d core levels also indicates a gradual structural change up to 1.0 ML. After 1 ML the excess Sb atoms quench some of the gap states and relax the band bending partially tending towards the Schottky Mott values. The work demonstrates the role of the kinetics of growth in forming metallic epitaxial over layers. It is suggested that the Sb adatoms first occupy the faulted and unfaulted (1x1) regions of the (7x7) unit cell. At higher coverages, this energetically relaxes the dimers at the

unit cell boundaries and eventually releases the Si adatoms which fill in the corner holes to cause the (7x7) to (1x1) phase transition of the substrate at 1.0 ML. This is clearly observed by the LEED pattern presented in Figure 1.3. The slow changes in the spin-orbit splitting anisotropy and the sharp change in the FWHM of the core-level peak also suggests a cluster size effect, which seems to coalesce at 1.0 ML thus completing the metallic band at this critical coverage.

Force and Hardness Standards

In order to keep pace with the latest developments in the field and growing need of the industries to automate the processes, design and developmental work on strain gauge force transducers has been taken up. These transducers will have an edge over the conventionally used analogue force transducers due to their digital output, user friendly operation and its use over a wide range without any degradation in its accuracy. This work is among the first ones, where the group has successfully designed and developed these force transducers of 2 to 100 kN capacity with an accuracy of $\pm 0.03\%$ has been designed and

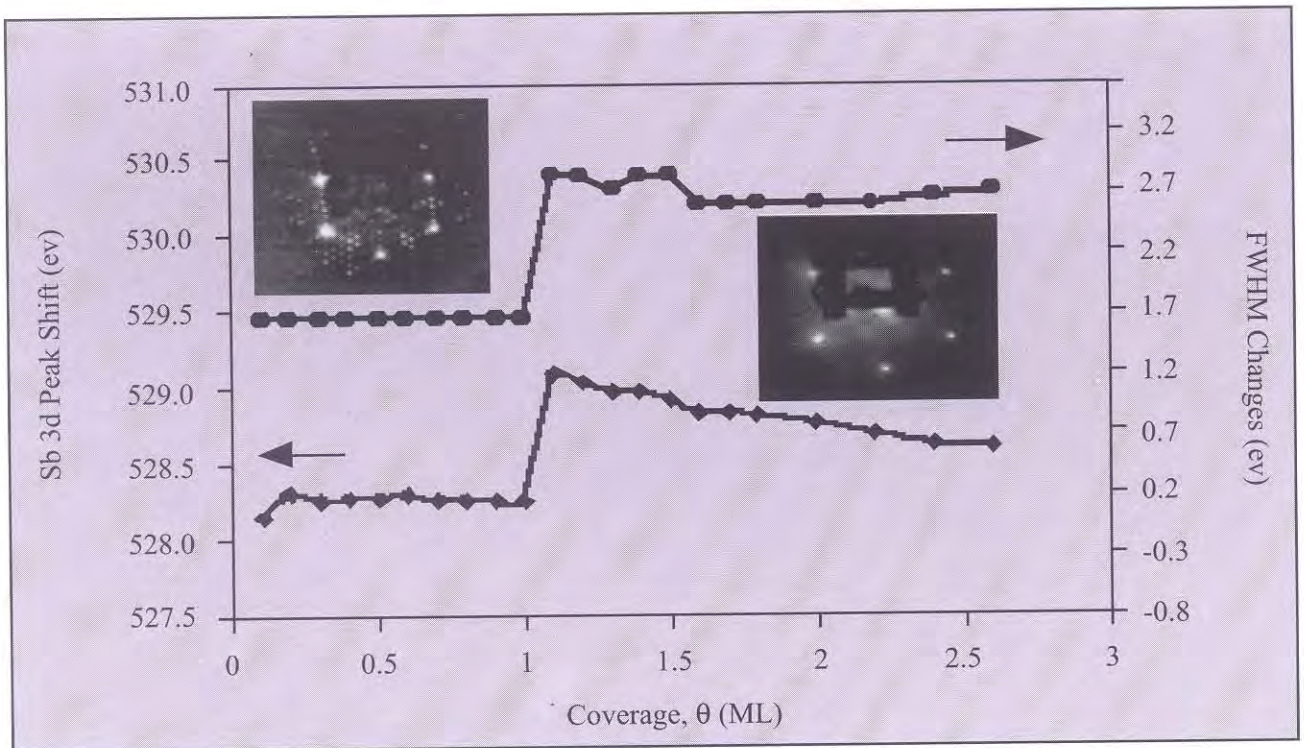


Fig. 1.3 : Figure shows abrupt changes in Sb 3d peak positions (a) and width (b) at a Sb coverage of 1.0 ML. The respective LEED pattern manifesting 7x7 as to 1x1 structural phase changes are given as insets.

developed (Fig. 1.4). This is an import substitute product and has already been given to the user industry for their feedback. Further work is in progress to extend its range up to 1MN without degradation in the measurement accuracy.

Due to the advancement in the science & technology and the growing demand to develop newer materials having good weight to strength ratio, need was felt to have precision characterization of these materials using the conventional universal testing machines. The UTMs usually have an accuracy less than 0.1%, which is maintained using transfer standards. In order to improve upon the capability to transfer the accuracy to these UTMs to the level 0.05% or better, a dead weight force standard machine of 10 kN capacity has been designed and developed (Fig. 1.5). It has some novelties such as hydraulic loading and unloading of the dead weights, a central pin to hold a weight with another weight to minimize the error due to non-axiality have been incorporated in designing the machine. This is to enable

measurement as per the different calibration standards such as ISO-376, ASTM E74-00, IS: 4169-1988 and OIML- RJ60. The preliminary metrological characterization of the machine shows an expanded uncertainty of 40ppm over whole of its range at $k=2$.

A series of forces have been measured from 0.1 kN to 500 kN during this bilateral international intercomparison exercise between NPL (India) and PTB (Germany). The agreement in the intercomparison data is remarkably excellent.



Fig.1.4 : 200 kN Strain Gauge Force Transducer

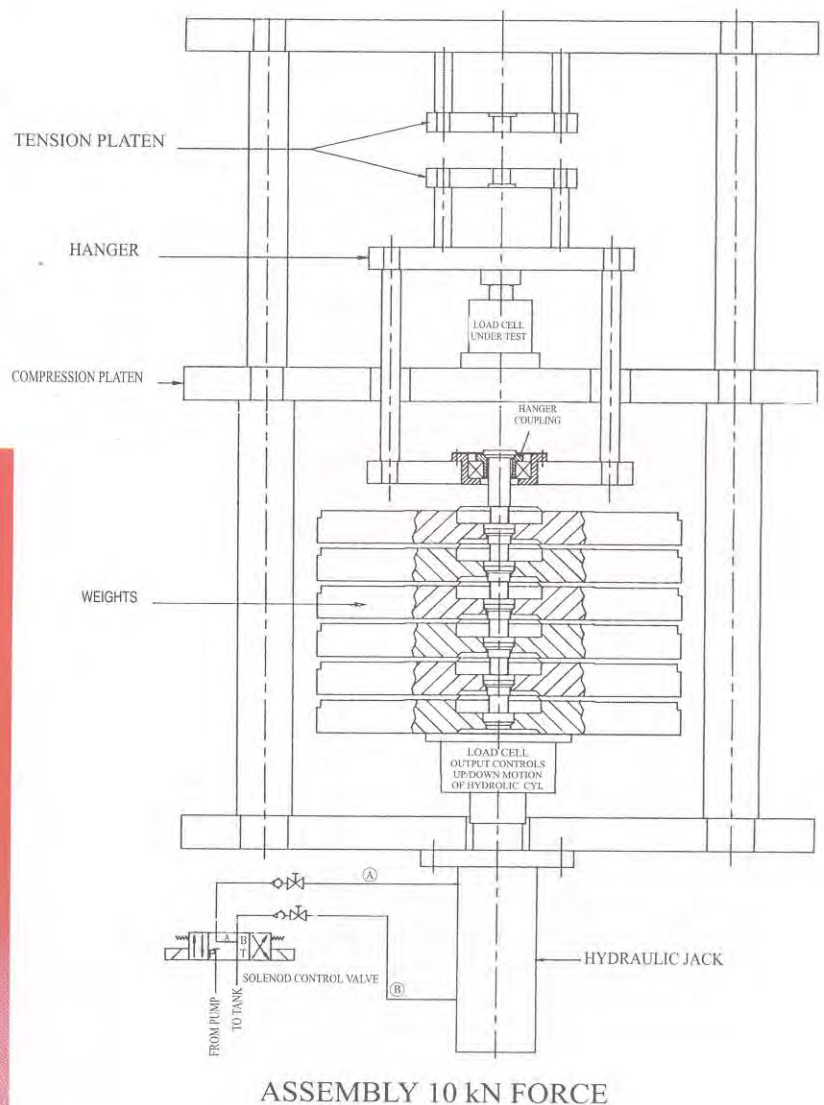


Fig.1.5 : Schematic of the 10 kN Dead Weight Force Standard Machine

The work on the establishment of the first-ever national hardness primary standard (Rockwell scale), based on the first principle has been initiated. In this standard, the application of the load is through the dead weights, operatable by stepper motors and traceable to NPL kilogram (BIPM copy no.57), having an overall measurement uncertainty better than 10 ppm. The depth of indentation is measured through the spiral microscope, of resolution 0.2 micron and traceable to NPL Length Standard. The primary standard is designed, developed and fabricated as shown in Fig.1.6.

The repeatability of 0.5 HRC were obtained over whole of the Rockwell C scale using the standard hardness blocks traceable to MPA, Dortmund (Germany). Further, work is in progress to improve upon its accuracy and automation of the operation of the machine.

Temperature Standards

Mercury Temperature Standard has been established at NPL using indigenously developed mercury cell in S S envelope. Participated in the Asia Pacific Metrology

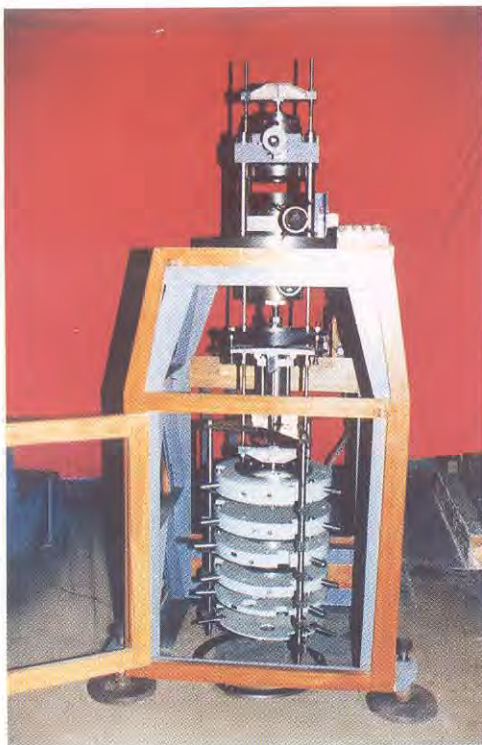


Fig.1.6 : Hardness Primary Standard for Rockwell Scale

Program (APMP) regional comparison 'KC - 3' between 12 countries in the range 38.8344°C (T.P. of Mercury) to 419.527°C (F.P. of Zinc) using travelling standard platinum resistance thermometer. The results have been submitted to co-ordinator NML (CSIRO) Australia. One SPRT (range 0°C to 660°C) Sr. No. NPL-S1-00 was fabricated and calibrated.

NPL participated in the SADC- MET (CSIR-NML, South Africa) Pilot Comparison of liquid-in-glass thermometer calibrations against ITS-90 in the range 0°C to 50°C. The results of comparison communicated to the co-ordinating Laboratory NML, South Africa. Silver Temperature Standard has been established for the calibration of standard thermocouples. The facility for calibration of standard thermocouples by fixed point method has been established up to gold point.

Ultraviolet Radiation Standards

Calibration and measurement facilities in air UV spectral region was maintained and extended to user industries and institutions. UV-A, UV-B and UV-C intensity meters received from industries were calibrated. Irradiance value of a UV-C source being used in water purifier at 253.7 nm was measured at a specified distance. UV transmission measurement of computer monitor screen was performed. Low-pressure Hg lamps commercially available in 5-10 Watt range are very efficient emitter of line spectrum. Nearly 95% radiation is emitted at 253.7 nm that has germicidal effect and are used for disinfecting water, air and food etc. Measurement on six commercially available lamps has been made and a comparative study of irradiance value has been made. Studies of Polycyclic aromatic hydrocarbon using photoacoustic spectroscopy have been continued.

A simple reflectometer for measurement of total reflectance of plane specularly reflecting surfaces at normal incidence has been designed, setup, and used for testing of samples. The remarkable feature of this reflectometer is that it does not require any reference sample for comparison. A simple method to measure refractive index of convex lenses with an accuracy of ± 0.01 has been devised. The method has no limitation of measurement of refractive index value for existing materials.

Optical Radiation Standards

Establishment of Gonio-reflectometer Facility

A new facility for measurement of reflectance called gonio-reflectometer has been set up and is being used for characterizing the surfaces for their roughness colour by measuring the reflectance at various angles. Studies have been made regarding measurement of the roughness of some metallic surfaces. Back scattered light from random rough surfaces was studied with the purpose of characterizing surface statistical properties. The ratio of the height of the rough surface to the correlation length of the light was obtained by developing a theoretical model and the experimental results were compared. The advantage of this method is that one can determine the localized roughness of the surfaces and might find application in characterizing the patrimonial items kept in museums, and used for characterizing coloured surfaces such as textiles, paints etc.

Studies on the Effect of Spatial Coherence in Optical Measurements

An experimental procedure has been developed for the measurement of the phase of the correlated light which is very important for many optical applications. The spectral degree of coherence and the cross-spectral density of the field fluctuations at symmetrically located pair of points in the region of superposition were determined. The advantage of this study is that not only can one study the correlation properties of the field over the plane of superposition, but one can determine the amplitude and the phase of the partially correlated light over the Young's plane which has many applications, particularly in astronomy.

Determination of Average Roughness of Surface by Spectral Interferometry

Determination of average roughness of surface is one of the important aspects for characterizing the optical surfaces. A simple method based on spectral interference has been developed. The advantage of this method is that the restriction, that the path difference between the arms of an interferometer, e.g., a Michelson's interferometer should be less than the correlation length of the light, vanishes. The advantage of the present method that the path difference could be much larger than the correlation length helps in

determining the average roughness of surface in the subscales of the optical wavelengths.

Infrared Radiation Standards

Fourier Transform Infra - Red (FTIR) Spectrophotometer was maintained and testing of materials was provided to R&D groups of the laboratory and out side institutions. The spatial efficiency of the integrating sphere installed with the FTIR for spectral diffuse reflectance and spectral diffuse transmittance measurements was evaluated. Various samples in the form of powders, crystals and thin layers were studied for their spectral diffuse reflectance in the 2.5 μm to 15 μm spectral region. In an effort to correlate the experimentally obtained values of diffuse spectral reflectance with the computed values, a model was worked out and software to compute easily and simultaneously specular reflectance and diffuse reflectance of a material from its optical constants and grain size/ surface roughness was developed.

ELICO make Near Infra Red (NIR) spectrophotometer was successfully used for on site calibration on molasses, filter cake, bagasse and prepared cane in sugar factory. Error analysis on solid samples (prepared cane and bagasse) was completed. Preliminary studies on identification of synthetic milk from milk by infrared techniques lead to valuable information on commonly used adulterants. A strip for detection of urea in milk above a permissible limit was developed and standardized. Near Infrared technique was also used for determination of moisture content in raw tobacco.

Mass Standards

Calibration of (a) Mass of level I and level II of 1 kg and sub-multiples of 1 kg and (b) sets of balances of various capacities were provided. Training was imparted to personnel from Department of Legal Metrology. Weights and Dead Weights from the Force, Pressure & Fluid Flow Activities were calibrated. Density and volume measurements of the Optical Glass Sphere (Transfer Density Standard) were carried out against the two Primary Solid Density Standards by using the newly established computer controlled facility with relative standard uncertainty of 1 ppm. Density of the organic liquid n-Nonane and distilled

water were carried out against transfer solid density standard. Reference Grade Hydrometers, of the following ranges, were calibrated by hydrostatic weighing, using liquid of density measured from transfer solid density standard.

Ranges:

- (700 to 750 ; 750 to 800) kg/m³
- (800 to 850 ; 850 to 900) kg/m³
- (900 to 950 ; 950 to 1000) kg/m³

Standard Relative Uncertainty : (2-3) ppm,
Directly traceable to Primary Solid Density Standards.

Measurement of viscosity in the temperature range from 5°C to 850°C of 70 samples of various Polymer Gel Electrolytes of Polymeric and Soft Material Division of NPL is being done since October 2000. The work is related to the Project "Development of Electrochromic Devices" of this Division. Gravimetric measurement has been done for comparative study of Primary Vacuum Standard Section of NPL. Mass measurement of some of the components of the Project "Development of Hardness Metrology" of the Force and Hardness Standard Group of NPL has also been done. This unit also provided technical support by the way of mass measurement in APMP Sponsored Regional Pneumatic Pressure Comparison of Pressure and Vacuum Standard Division of NPL.

Measurement of Avogadro Constant

In order to determine Avogadro Constant approximately, optical grade, monocrystalline n-type silicon, purchased from M/s. Eagle Picher, USA. in 1999, was converted into a sphere of diameter 38.1955 mm. A sample of diameter of 10 mm and thickness 3 mm was fabricated and characterized for lattice

spacing and surface roughness through STM and AFM studies as follows:

- Lattice spacing : 0.397 nm
- Roughness : 0.07 nm with S.D.= 0.01nm
- Porosity : 2 pores in 5 nm²
- Measured mass of the sphere in air :
= (67.98433 ± 0.000104)g
- Density of the Silicon Sphere
= (2.329001 ± 0.000032) cm³
- (Preliminary measurement by Hydrostatic Weighing)

Fluid Flow Measurement Standards

Study on Pipe Prover calibration (survey on related standards and development of calibration procedure etc.) for carrying out in-situ calibration of the pipe prover system of a fluid flow calibration laboratory in the country has been made. Study on the ultrasonic flow meter for in-situ calibration (size 2000 mm diameter) was carried out.

Major work in the Fluid Flow section is to provide the calibration services to the users. The group has given primary calibration services to six users, consisting of three flow meter manufacturers, one flow calibration laboratory, and two research organizations.

Various fittings accessories for the mounting of the flowmeters in the test section, the jigs and fixtures for making the various rotameters compatible to be fitted in the test rig were designed and got fabricated. The various end -connections, pipe fittings and the flexible joints etc., were also designed and got fabricated. Also a pipe line was laid down connecting the on-line density meter to the under ground water reservoir. Procedures for calibration of Rotameters and mechanical water meters were further modified.

विद्युत तथा इलेक्ट्रॉनिक मानक

**ELECTRICAL AND ELECTRONIC
STANDARDS**

विद्युत तथा इलेक्ट्रॉनिक मानक

विद्युत तथा इलेक्ट्रॉनिक मानक प्रभाग डी सी वोल्टता, धारा तथा प्रतिरोध, ए सी वोल्टता, धारा तथा प्रतिबाधा, ए सी पॉवर तथा ऊर्जा, ए सी उच्च धारा तथा उच्च वोल्टता, एल एफ तथा एच एफ वोल्टता, धारा, पॉवर तथा प्रतिबाधा (लम्ब्ड पैरामीटर्स), एच एफ क्षीणन (अटैनुएशन), सूक्ष्मतरंग शक्ति, क्षीणन प्रतिबाधा तथा शोर, समय तथा आवृत्ति, चुम्बकीय प्रेरण के प्राथमिक और राष्ट्रीय मानकों की प्रतिष्ठा, अनुरक्षण और उन्नयन (अपग्रेड) करने में जुटा हुआ है। अनुसंधान और विकास सम्बन्धी गतिविधियां (आर एण्ड डी एक्टिविटीस) जैसे मानकों, यथार्थ मापन, स्क्वडस, जीव चिकित्सा यंत्रों आदि के विकास के लिए भी कार्य किया जाता है। यह प्रभाग अंशांकन और परामर्श सेवाएं भी विभिन्न अंशांकन प्रयोगशालाओं और उद्योगों को प्रदान करता है।

इस वर्ष के दौरान इस मानक प्रभाग ने दो बी आई पी एम/ सी सी ई एम मुख्य अन्तर्तुलनाओं तथा एक ए पी एम पी अन्तर्तुलना में अपनी सहभागिता दर्ज की। पिछले तीन सी सी ई एम मुख्य अन्तर्तुलनाओं के आंकड़े अन्तर्राष्ट्रीय परस्पर पहचान व्यवस्था (एम आर ए) के परिशिष्ट 'ख' में शामिल किए गए हैं।

ELECTRICAL AND ELECTRONIC STANDARDS

The Electrical & Electronic Standards Division is engaged in establishment, maintenance and upgradation of primary/national standards of DC voltage, current and resistance; AC voltage, current and impedance; AC power and energy; AC high current and high voltage; LF & HF voltage, current, power and impedance (lumped parameters); HF attenuation; microwave power, attenuation, impedance and noise; time and frequency; and magnetic induction. R&D activities on development of standards, precision measurements, SQUIDS, bio-medical instrumentation are also carried out. Calibration and consultancy services are provided to various calibration laboratories and industries.

During the year the division participated in two BIPM/CCEM key comparisons and one APMP key comparison. The data of earlier three CCEM key comparisons have been approved for provisional equivalence for inclusion in the Appendix B of the global Mutual Recognition Arrangement (MRA).

Josephson Voltage Standard and Superconducting Devices

Josephson Voltage Standard

Josephson series array voltage standard has been maintained at 1 volt level. The "National Standard" of volt which is based on Zener diode has been calibrated against the Josephson voltage. R&D work has been initiated to develop 10 volt Josephson voltage standard.

High- T_c SQUID Based NDT Set Up

A high- T_c SQUID based computer controlled non-destructive testing (NDT) set up is developed. BSCCO high- T_c rf-SQUID is used in this setup. Figure 2.1 shows photograph of the SQUID-NDT setup. The SQUID remains at liquid nitrogen temperature whereas the specimen under inspection is kept on a computer controlled X-Y stage. Movement of X-Y stage is achieved through two stepper motors. An area of 10cm x 10cm can be scanned in this setup with the positional accuracy of 100 μm . A computer program for X-Y stage control and graphical display of NDT results is developed. A low frequency ac field (~ 10 -20 Hz) is applied on the specimen and the observation is recorded for each position during scanning. Presence of defect/slot in the specimen distorts the magnetic field distribution which is detected by the SQUID.

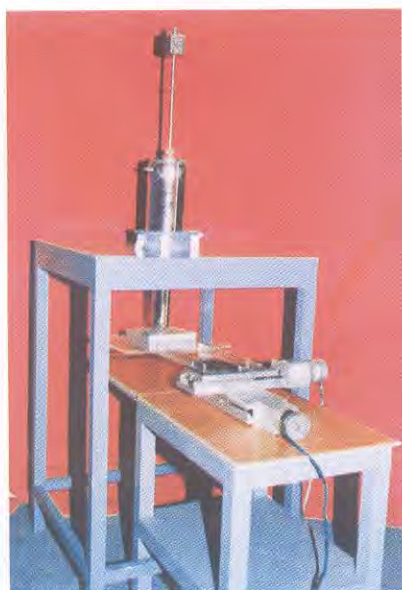


Fig. 2.1 : High- T_c SQUID based NDT set up

Rf-SQUID Effect in Quaternary Borocarbide Superconductors

We had earlier reported rf-SQUID effect in $\text{YNi}_2\text{B}_2\text{C}$ and in two magnetic borocarbide superconductors ($\text{DyNi}_2\text{B}_2\text{C}$, $\text{ErNi}_2\text{B}_2\text{C}$) which indicated that natural grain boundary in these three borocarbide superconductors behave as Josephson junctions. In order to check the universality of the nature of the grain boundaries in quaternary borocarbide superconductors, rf-SQUID effect is also studied in $\text{LuNi}_2\text{B}_2\text{C}$ ($T_c \approx 16.5\text{K}$) and $\text{YPd}_5\text{B}_3\text{C}_{0.35}$ ($T_c \approx 23\text{K}$). RF-SQUID voltage-flux modulations in both the superconductors are observed from 4.2 K to near superconducting transition temperature confirming that natural grain boundaries in these two superconductors also behave as Josephson Junctions. Thus it establishes that natural grain boundaries in all the borocarbide superconductors behave as Josephson weaklinks.

Study of Destabilization of Charge Ordering in Pr-Ca-Mn-O Single Crystal Using High- T_c SQUID

$\text{Pr}_{0.63}\text{Ca}_{0.37}\text{MnO}_3$ single crystal shows charge ordered (CO) insulating state at lower temperature. This charge ordered state can be destabilized by the application of an electric field beyond a threshold value. I-V characteristic of the crystal shows non linearity after a threshold value of voltage which is due to destabilization of charge ordered state. A High- T_c BSCCO rf-SQUID is used for checking the appearance of magnetic signature due to destabilization of charge ordered state. The $\text{Pr}_{0.63}\text{Ca}_{0.37}\text{MnO}_3$ single crystal is placed just above the SQUID and the experiment is performed at 77K. I-V characteristics of the charge ordered single crystal is measured and simultaneously magnetization of the crystal is also measured using High- T_c SQUID. Figure 2.2 shows plot of the SQUID output and voltage across the crystal at 77K as a function of biasing current. It clearly shows that the current induced destabilization of charge ordered state leads to a small enhancement of the magnetization of the sample, indicating ferromagnetically aligned moment. This suggests that destabilization of CO state suppresses AFM spin correlation and promotes FM spin correlation.

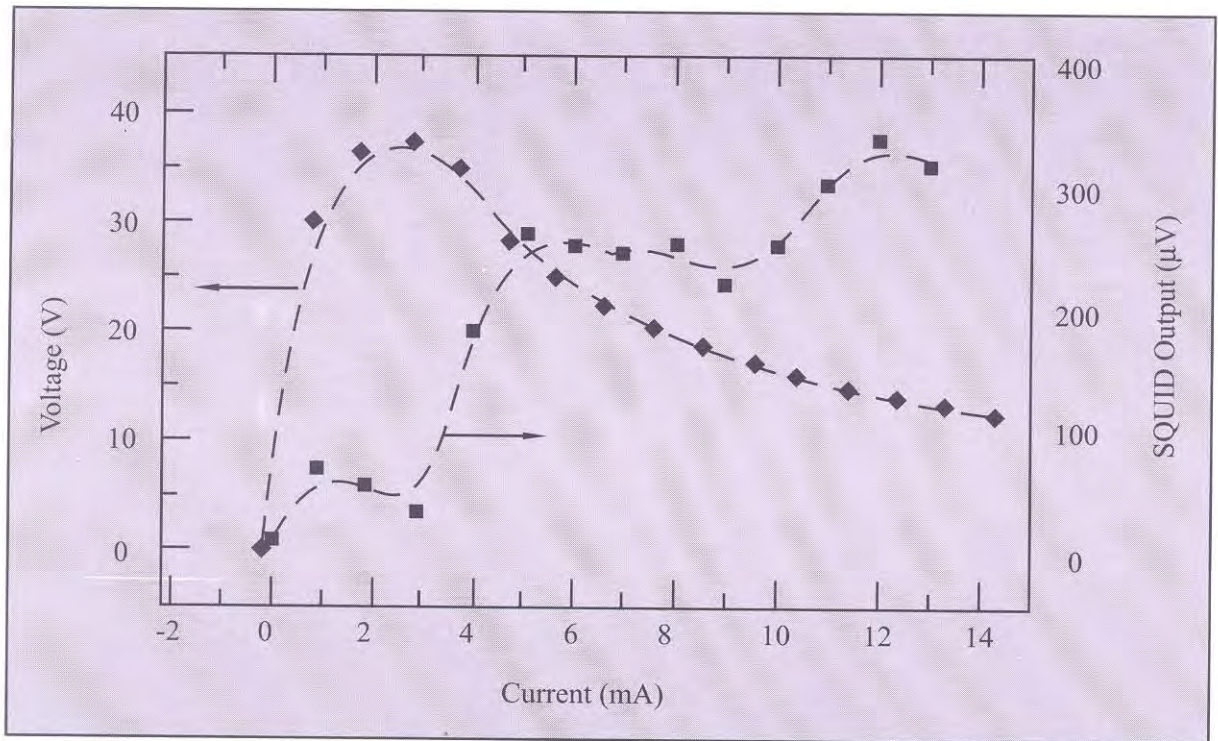


Fig. 2.2 : Variation of SQUID Signal and Voltage across the $\text{Pr}_{0.65}\text{Ca}_{0.37}\text{MnO}_3$ single crystal at 77K as a function of biasing current

Study of Conduction Noise in Polycrystalline CMR Films

Temperature and frequency dependence of conduction noise in screen printed $\text{La}_{0.67}\text{Ca}_{0.33}\text{MnO}_3$ polycrystalline film is studied. The film has a metal-insulator transition temperature (T_p) and ferromagnetic transition temperature (T_c) at 140 K and 230 K, respectively. The magnetoresistance ratio (MR) of the film at 1kOe is found to be mainly due to grain boundaries. The observed voltage noise spectral density (S_v) shows $1/f$ type behaviour for all the temperatures ranging from 77 K to 300 K. S_v shows an increase as the temperature is decreased below T_c and reaches a peak value at T_p . The increase in S_v below T_c is attributed to extra noise arising due to fluctuations in spin alignment in the ferromagnetic state. Application of a 1kOe magnetic field reduces noise and the reduction in the noise is observed upto T_c . A comparison of the temperature dependence of MR and noise reduction ratio due to magnetic field indicates that the magnetoresistance in the polycrystalline film of $\text{La}_{0.67}\text{Ca}_{0.33}\text{MnO}_3$ is strongly

influenced by the grain boundaries but the noise due to fluctuations in spin alignment is intrinsic and comes mainly from the grains.

The properties of Ag added $\text{La}_{0.67}\text{Ca}_{0.33}\text{MnO}_3$ (Ag-LCMO) polycrystalline film are compared with those of the $\text{La}_{0.67}\text{Ca}_{0.33}\text{MnO}_3$ (LCMO) film prepared under similar conditions. The addition of silver in LCMO films improves surface morphology and reduces the lattice constant. During the synthesis process, the silver in the Ag-LCMO film melts and segregates at the grain boundaries. The semiconductor-metal transition temperature (T_p) increases by 10K. Normalized voltage noise reduces by more than one order of magnitude. Improvement in surface morphology and better oxygenation of the film due to the presence of silver leads to improvement in the properties of polycrystalline LCMO film.

Study of Magnetoresistance and Non - Linear Conductance of Bicrystal Grain Boundary in CMR Film

Epitaxial film of $\text{La}_{0.67}\text{Ba}_{0.33}\text{MnO}_3$ (LBMO) is prepared

on 36.7° SrTiO₃ bi-crystal substrate using laser ablation technique. For studying the effect of the grain boundary on transport characteristics, two microbridges have been fabricated. One microbridge was created across the bicrystal grain boundary and the other one away from the bicrystal grain boundary. The grain boundary exhibits substantial magnetoresistance at low temperatures (Figure 2.3) and also shows non-linear I-V characteristics. Analysis of temperature dependence of the dynamic conductance allows us to identify three carrier transport mechanisms across the grain boundary. These mechanisms exist in parallel and at a given temperature one mechanism may dominate. Particularly at higher temperatures (T>170K) the transport across the grain boundary involves spin flip scattering, which we establish leads to decrease of grain boundary contribution in magneto resistance. At lower temperature (4.2K-45K) tunneling through a disordered oxide at the grain boundary is dominating

whereas in the temperature range from 100K to 170K carrier transport is dominated by inelastic tunneling via pairs of manganese atoms.

DC Standards

DC Standard maintains national standard of DC voltage, current and resistance and provides apex level calibration to various laboratories and industries. The group has participated in BIPM key comparison, CCEM-K8 programme for voltage ratios. IEN, Italy acted as coordinating laboratory for the programme. The participating laboratories were : Australia, New Zealand, Canada, China, France, India, Japan, Korea, Russia, Spain, South Africa, Sweden, UK, and USA. During the year an automated precision multifunction calibrator facility has been established for providing high precision calibration facilities to various governmental, industrial and other users.

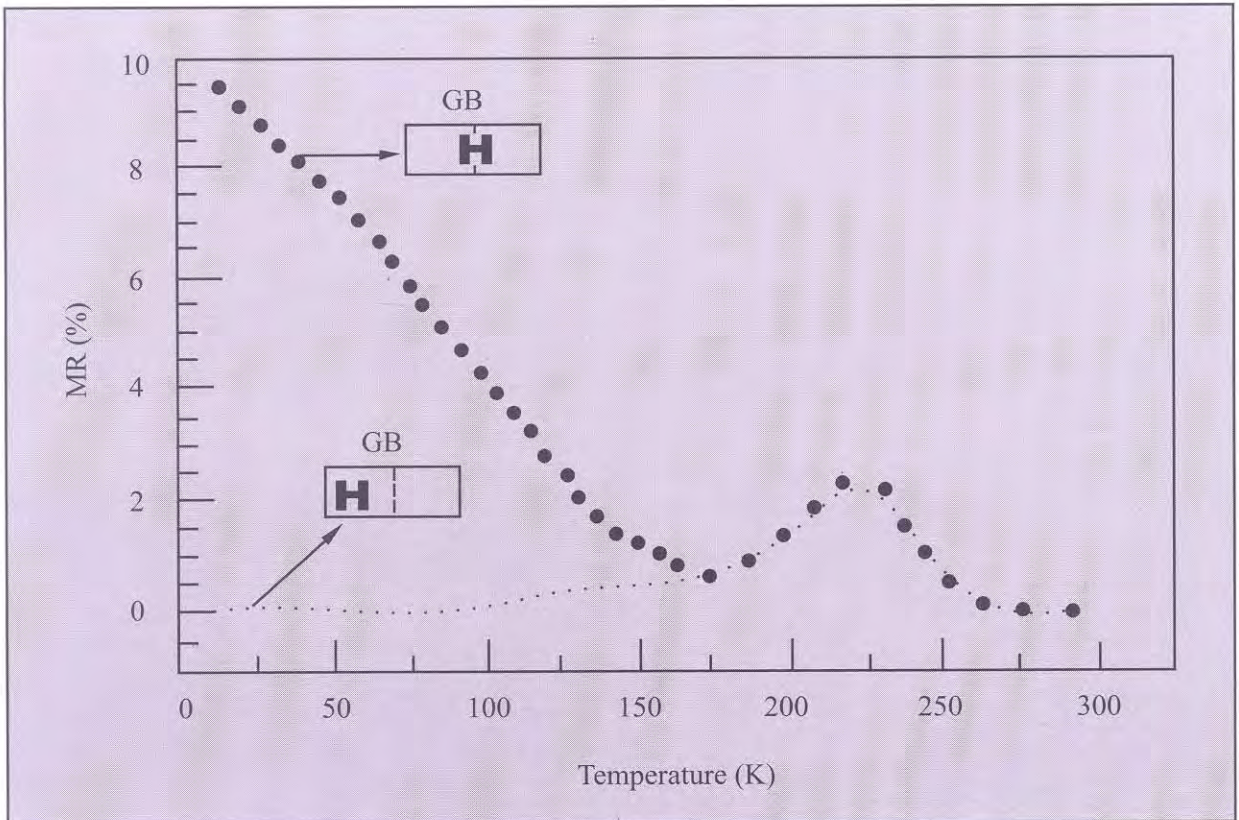


Fig 2.3 : Temperature dependence of magnetoresistance (MR) of LBMO thin film microbridges across bicrystal grain boundary and away from the grain boundary. Magnetoresistance has been calculated using the relation; $MR = \frac{R(0) - R(H)}{R(0)} \times 100\%$; where R(H) and R(0) are resistance of the microbridge in presence and in the absence of magnetic field, respectively

DC High Voltage Standard

A new measurement and calibration facility for DC high voltage up to 100kV has been established. This will help our TV & X-ray industries and also various calibration laboratories in the field of HV calibration. Initially, it is planned to calibrate the equipments

upto 100kV including HV probes, Electrostatic voltmeters, dividers and Power supplies, with an accuracy of 0.02%.

AC Power & Energy Standards

The AC Power & Energy Standard section is



Fig. 2.4 : The experimental set-up of DC high voltage measurement facility



Fig.2.5 : Close-up of 100kV divider

providing testing and calibration facility for single phase and three phase AC power meters, power analyzers, power factor meters and single phase and three phase AC electromechanical energy meters, static energy meters for active, reactive and apparent energies at power frequencies. The test and calibration facility is widely used by all power utilities, electricity boards, meter manufacturers and other test and calibration laboratories.

Several coils were developed to create AC axial magnetic induction of varying strength at the center of a circular 320 mm internal diameter coil and its influence on the performance of a number of static energy meters were studied. The test was conducted by keeping the coil in various orientations. The test was included in CBIP report as amendment " Test of influence of alternating (a.c.) abnormal magnetic induction of 10 milli tesla produced at the center of a circular coil of 320mm internal diameter."

By installation of a 3 phase reference standard COM 303, the uncertainty of measurement has been improved from $\pm 0.02\%$ to $\pm 0.01\%$ with respect to apparent power.

AC High Current & High Voltage Standards

This section is maintaining National Standards of AC

high current and high voltage at power frequencies (50 Hz). Calibration services was provided for Current Transformers, CTTS, Clamp Meters, AC Current Shunts, Weld Testers, CTTS Jigs, CT Burdens and for Potential Transformers, PTTS, H.V. Probe, Electrostatic Volt Meters (ESVM), HV Breakdown Test Sets, and PT Burdens etc. As many as 75 calibration certificates were issued to the electrical manufacturers and utilities.

Work has been initiated on the development of a laboratory grade current transformer which will ultimately lead to the establishment of absolute method for the calibration of current transformers. It is planned to push up the calibration facilities for the calibration of current transformers to a better accuracy from $\pm 0.005\%$ to $\pm 0.001\%$.

LF and HF Impedance Standards

This section is maintaining primary standards of capacitance which is Calculable Cross Capacitance based on Lampard-Thompson theorem. The unit of inductance, Henry, is realized from capacitance using Maxwell-Wien Bridge. The unit of resistance, Ohm, is also realized from capacitance using Quadrature Bridge (Fig. 2.6) and other precision ac bridges. This section also provides apex level calibration for the

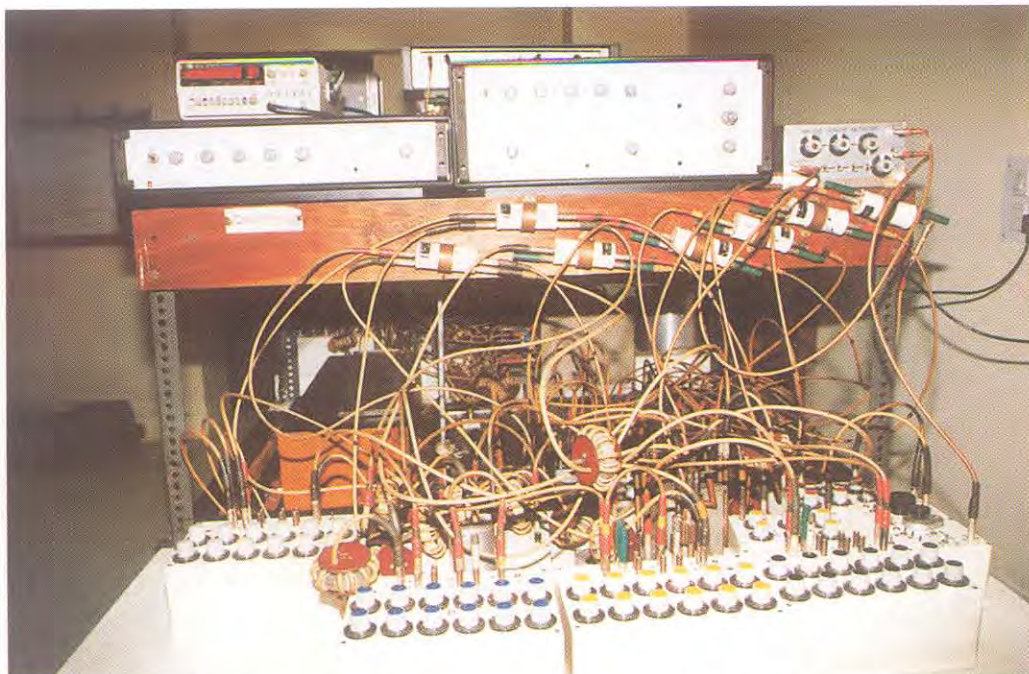


Fig. 2.6 : Quadrature Bridge for Realisation of 'Ohm' through 'Farad'

above parameters at low and high frequencies, to various calibration laboratories and R & D organizations.

The setup for absolute calibration of Inductive Voltage Divider (IVD) was modified, re-established and evaluated to assign the value to standard IVDs. At present, an uncertainty of few parts in 10^9 is achieved in comparison to previously achieved uncertainty of 5 parts in 10^8 .

International inter-comparison of AC voltage ratio under CCEM key comparison has been completed. In this inter-comparison, 15 laboratories like NIST USA, PTB Germany, NPL UK, NML Australia etc. are participating.

One scientist from CSIR-NML, South Africa visited for 5 weeks to get training on Quadrature Bridge. He also brought one 10 pF capacitor for calibration against our national standard of capacitance.

Proficiency Testing Programme for NABL accredited laboratories in measurement of ac resistance and capacitance has been initiated in collaboration with NABL. In this programme 6 and 13 calibration laboratories of India are participating for ac resistance and capacitance, respectively.

LF, HF and MW Standards

This section carried out BIPM comparison CCE 92-03 on AC/DC voltage transfer standards at the lowest level of uncertainty in the frequency range 1 kHz to 1 MHz (declared as a key comparison CCEM-6.a) and CCE 92-05 on AC/DC voltage transfer standards at higher frequency range 1MHz to 50 MHz - declared as key comparison CCEM-K6.c by the BIPM Consultative Committee on Electricity and Magnetism (CCEM). In CCEM-K6.a twenty two standards laboratories belonging to countries including Germany, USA, India, UK, France Australia and the Netherlands have taken part, whereas in CCEM-K6.c the number of participating laboratories was only fifteen. These included those of USA, UK, Germany, the Netherlands, India, Australia and Canada etc. Fig.2.7 shows the set up used in CCEM-K6.a.

Our results have been included for the determination of comparison reference value at all the frequencies (both comparisons) in order to derive equivalence among different countries. The criteria for inclusion of results for determination of comparison reference value was that the laboratory must have independent realization of AC/DC transfer error for their standards associated with small uncertainty and having a sound uncertainty budget. In both these



Fig.2.7 : Set up for Low Frequency Voltage Comparison (CCEM K6.a)

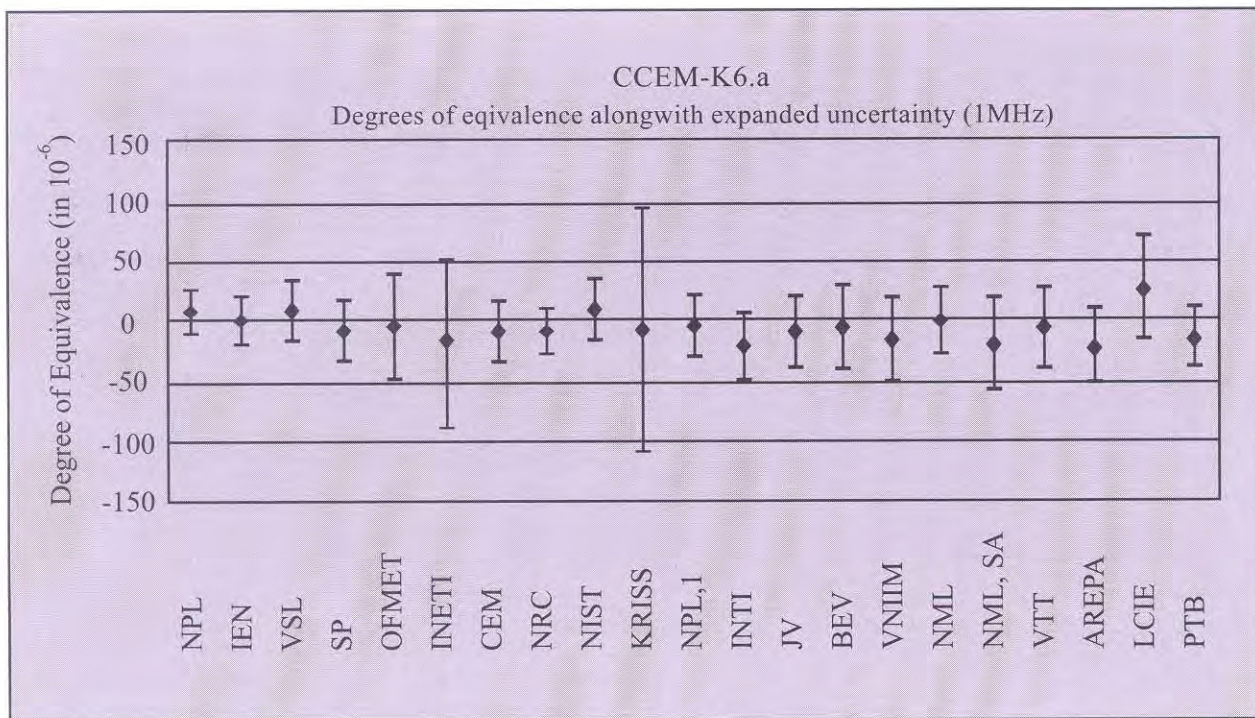


Fig. 2.8 : Degree of equivalence for different NMIs with respect to comparison reference value at 1 MHz (CCEM-K6.a)

comparisons the values of AC/DC transfer error assigned to the respective travelling standards by our laboratory have very close agreement with the comparison reference values at all the frequencies. Fig. 2.8 shows degree of equivalence of standards of different countries with respect to reference value at 1 MHz (CCEM-K6.a). It clearly shows that our value is very close to the comparison reference value. CCEM has recommended the results to be included in appendix B of BIPM data base.

A number of standards and precision instruments of various user organizations have been calibrated. 51 calibration certificates have been issued during this year

HF & Microwave Attenuation and Impedance Standards

The spot frequency calibration facilities in attenuation and impedance parameters established at 30 MHz & 1 to 18 GHz in 50 Ω coaxial system and 3.95 to 18 GHz in waveguide system are being used by various user organisations. The calibration facilities have also

been extended upto K- band (18 - 26.5 GHz) in the waveguide system. A set of coaxial transfer standards of VSWR 1.10, 1.30 & 1.50 has been designed and developed in the frequency range 2-18 GHz by modifying the existing HP-905A sliding load. The facilities for measurement of attenuation and impedance in terms of scattering parameters have been established using vector network analyser (VNA) based system in the frequency range 40 MHz to 20 GHz. The experimental set-up for the measurement of s-parameters using Wiltron-37247B VNA is shown in Fig. 2.9

Magnetic Standards

DC Measurements on Soft Magnetic Materials

Facility has been established for the DC measurement on soft magnetic materials using standard permeameter as per IEC standard. The DC measuring system consists of permeameter, precision DC power supply, data acquisition and parameter control unit. The system is fully automated. The samples used are in the shape of rods and bars. The parameters measured



Fig. 2.9 : Wiltron Vector Network Analyser (40 MHz-20 GHz)

are field strength, coercivity, remanent induction etc.
The measurement range is :

- Coercivity: ~ 100 A/m to 1 kA/m
- Remanent induction: 0.5T to 1.5T
- Field strength : 10^{-2} A/m to 10^5 A/m

The setup is shown in the Figure 2.10.

Bilateral International Inter-comparison in the Area of DC Magnetic Measurements

Bilateral international intercomparison on soft magnetic materials with PTB, Germany as per IEC Standard 60404-4 has been done. Measurements were conducted on two steel samples in the shape of rods both at NPL and PTB, Germany. The results obtained

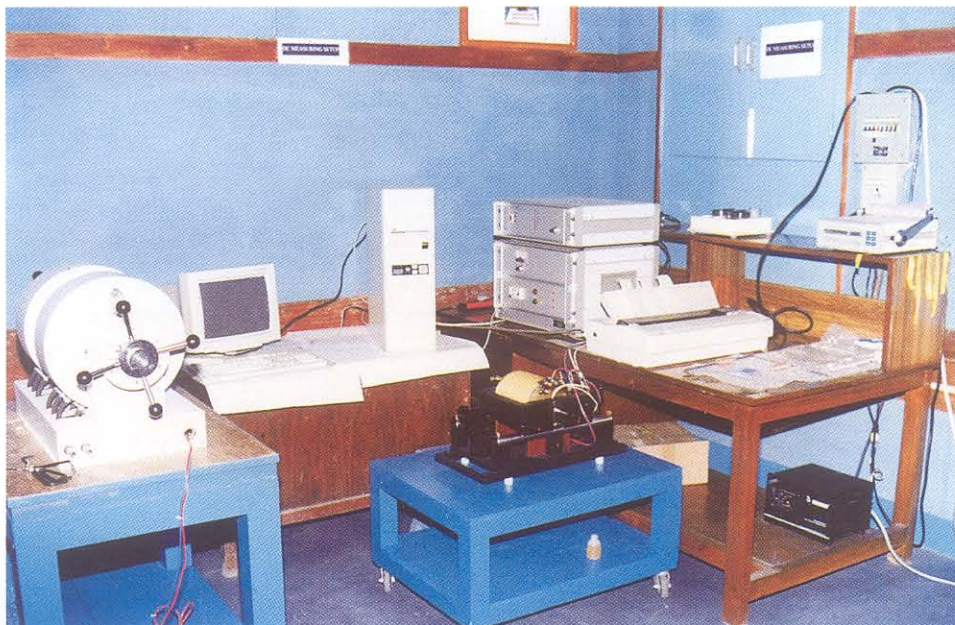


Fig. 2.10 : The set up of the DC Magnetic Measurement using Standard Permeameter

are given in Table-1.

TELECLOCK Service. NPL time service via telephone can not only be accessed by a computer but

Table-1

Sample No. 1

Para-meter	PTB	NPL(I)
H _{cb}	0.726 kA/m	0.762 kA/m
H _{cj}	0.7278 kA/m	0.763 kA/m
B _r	1.480 T	1.480 T

Sample No. 2

Para-meter	PTB	NPL(I)
H _{cb}	0.972 kA/m	0.919 kA/m
H _{cj}	0.972 kA/m	0.919 kA/m
B _r	1.574 T	1.571 T

Calibration of Reference Gaussmeter and Reference Magnets Against National Standards

Calibration of reference Gaussmeter and reference magnets have been done against NMR Gaussmeter (National Standard). Detailed calculations for determining the measurement uncertainties have been carried out.

Time and Frequency Standards

A Project on the "Studies on the Potentiality of GLONASS (Global Navigation Satellite System) for the Positioning and Timing vis-à-vis applications of GPS (Global Positioning System)" was completed. The Report of this project has been published in the form of a book. The report elaborates the observations for effective utilisation of GPS and GLONASS constellation and serves as a reference document for users of GPS and GLONASS. The work on a New PLL (Phased Locked Loop) which increases locking range as well as improves the noise immunity to discipline the Frequency Standard has been completed in collaboration with PTB Germany.

A new technique to improve the accuracy of GPS timing has been developed. BIPM has taken keen interest to consider this technique to improve the accuracy of on-line GPS time through the geodetic GPS receiver.

Digital time service via telephone line has already been started by most of the developed countries but these services can only be accessed by computers only. But NPL has started similar service recently with some unique feature in the name of

also by an innovative receiving system. Clocks of Lok Sabha are now synchronised to IST through Teleclock service. This system to access digital time service from NPL has been granted US Patent.

Three major projects were carried out to design and develop INSAT STFS receiving systems for the NTPC, Dadri, Gujarat Electricity Board (GEB), Vadodara and MP State Electricity Board (MPSEB), Jabalpur. These systems have specific interfaces that are used to accurately synchronise the timing of the event logging process at these sites to IST. With STFS based synchronisation at GEB and MPSEB, the entire western grid is synchronised to IST. This greatly helps identification of grid disturbances. All these systems were installed and commissioned and are fully operational.

As a part of the Project sponsored by BRNS, Dept of Atomic Energy, long term differential STFS data were collected at NPL; ERTL(E), Calcutta; BARC, Trombay and BARC, Mt Abu in Sept - Dec 1999 and analyzed. Numerical simulations were carried out on the multi-station data resulting in high degree of improvement in the satellite orbital parameters and hence the time transfer accuracy.

Under the Indo-US project on precision Frequency Metrology, work was continued on design and development of a microwave synthesiser for laser cooled Cs fountain standard. A newer version of the Cs synthesiser was designed in collaboration with NIST, Boulder, USA for use with the proposed PARCS (Primary Reference Clock in Space) to be flown on board the Space shuttle in Dec 2004. This work was

carried out at NIST. The Cs synthesiser has the best reported performance in terms of its internal stability. Ten units of the synthesiser have been developed - to be used by several major time standards laboratories in their Cs fountain standards work. One of the units is for NPL, India for our proposed Cs fountain.

Several electronic circuits such as temperature controller, laser diode current controller, photodiode monitor and the servo controller were designed and developed to achieve the stabilisation and subsequent frequency locking to a Cs hyperfine line using a Cs vapour cell. An 852 nm diode laser has been successfully locked to hyperfine lines of Cs.

Bio-Medical Measurements and Standards

Basic research has been carried out on the characterisation of biological tissues for ultrasonic and electrical properties, to enable develop 'safety standards' for avoiding side effects on the surrounding tissues. The human teeth and tumours have been studied in detail. It has been further investigated that cavitation bubble formation is enhanced by external stimulation to increase the efficiency of the stone disintegration in lithotripters.

Leiomyoma Uteri: Ultrasonic characteristics of these uterine tumours, in vitro, have been studied, by using a double-probe through-transmission technique. The average acoustic velocity and attenuation are found to be 1550 m/s and 433 dB/sq m, respectively, at 3.5 MHz frequency and room temperature 28°C. The present investigation is useful in tissue differentiation to enable the doctors to give proper treatment.

Bone Cystic Lesion: Ultrasonic and physical properties of bone cyst, a non-neoplastic tumour, have been studied, in vitro. Average ultrasonic propagation velocity and attenuation are found to be in the range 1602 to 1669 m/s and 1846 to 2181 dB/m, respectively. The main causes of the variation of these parameters are porosity and complex nature of the samples used. The data is used as an index of identification of

diseases, after proper standardisation.

Human Teeth: The human teeth, collected from different hospitals, have been studied for dielectric, physical and ultrasonic properties. Porosity and XRD studies are made for comparative study for the chemical constituents. The investigation is useful to the doctors to develop dentures and other dental materials. The effect of ultrasound intensity on the tissue structure, particularly thermal behaviour, has been studied in detail.

Electro-medical Standards: Current status and the need of biomedical standards among the users/hospitals and manufacturers of biomedical equipment in India and abroad were explored. A brainstorming meeting of one day on biomedical standards was organised at NPL in collaboration with industries, hospitals and other agencies. Biometry calibration set up was developed and established for monitoring the resolution and sensitivity of biometry probes/transducers, by using trajectory control system in X, Y, Z and directions. A special sensor has been designed to study and monitor the intensity output of high power transducers. The studies in biological tissues (human teeth, tumours and biomaterials), ancient preservative materials, were continued. A special thermal profile monitoring system was developed to study the temperature elevation in the deep seated tumours in the brain or other parts of the body.

Lithotripsy Research: Shock Wave Lithotripter was studied for its working parameters like excitation voltage, resonance frequency, bandwidth, and output energy. It was found that an acoustic transducer with 40 to 60 kHz, with several watts of power can be used, for external stimulation. A special VFVAT (variable-frequency-variable-amplitude transducer) was used for acoustic stimulation. It was found that with the increase of the frequency and power of the stimulating transducer, the size and the number of cavitation bubbles are found to be enhanced.

इंजीनियरी पदार्थ

इंजीनियरी पदार्थ प्रभाग में तीन ग्रुप समाविष्ट हैं अर्थात् धातुएं तथा मिश्र धातुएं, उन्नत कार्बन उत्पाद तथा उच्च दाब प्रौद्योगिकी ग्रुप। यह प्रभाग मुख्यतया पदार्थों के प्रौद्योगिकी विकास, सामरिक महत्व के घटक और प्रक्रियाएं, उच्च निष्पादन तथा सामान्य इंजीनियरी अनुप्रयोगों से संबंध है। वर्ष के दौरान अधिकांश विकासात्मक परियोजनाओं को प्रयोक्ता संगठनों/ एजेन्सियों जैसे – हिन्दुस्तान एयरोनॉटिक्स लिमिटेड, बंगलौर, विक्रम साराभाई स्पेस सेन्टर, मुम्बई, इंस्टीट्यूट फॉर प्लाज्मा रिसर्च, गांधी नगर, इंडियन ऑयल कारपोरेशन, फरीदाबाद के लिए हाथ में लिया गया है। आजकल कुछ अन्तर्राष्ट्रीय एजेन्सियों के साथ मिलकर उनके संयुक्त प्रयास से की जाने वाली परियोजनाएं भी कार्य अधीन हैं।

ENGINEERING MATERIALS

The Division of Engineering Materials comprises of three groups, namely, Metals & Alloys, Advanced Carbon Products and High Pressure Technology. The Division is primarily engaged in technology development of materials, components and processes, for strategic, high-performance and general engineering applications. Several developmental projects were undertaken for user organizations/agencies, like, Hindustan Aeronautics Limited, Bangalore; Vikaram Sarabhai Space Centre, Thiruvananthapuram; Bhabha Atomic Research Centre, Mumbai; Institute for Plasma Research, Gandhinagar; Indian Oil Corporation, Faridabad; etc., during this year. A few joint collaborative projects with international agencies are also currently underway.

Metals & Alloys

The Metals & Alloys group is mainly engaged in the primary, secondary processing and characterization of monolithic and composite materials. During this year, developmental efforts were concentrated mainly on the projects pertaining to development of process technology for critical components for aerospace agencies. Considerable progress was also made in an on-going in-house project on Spray Forming and process parameters were optimized for the synthesis of Aluminium using the Spray Atomization & Deposition technique. An international joint collaborative project, on Precision Forging, with Mechanical Engineering Laboratory, Japan, was also successfully completed this year.

Precision Forging for Near-Net Parts

This project, which was in joint collaboration with Mechanical Engineering Laboratory, AIST, MITI, Japan, was successfully completed this year. In this project, some prototype Ti-alloy fasteners on reduced scale were developed. The sequence of operation for forging, estimation of forging pressure, design of tooling and actual forging experiments were undertaken for the development of these prototype Ti-fasteners. Several exchange visits from both countries were also made under this project. In the this year, cold/warm forging tooling worth Rs. 10.5 lakh was gifted by Mechanical Engineering Laboratory, AIST, MITI, Japan, to NPL under this project.

Development of Oval Shaped Tube, as Skid Landing Gear for Advanced Light Helicopter (ALH) Phase-I

This is an on-going project which was sponsored by Hindustan Aeronautics Limited, (HAL) Bangalore. This project is under the indigenization and weight reduction programme for Advanced Light Helicopter and envisages a substantial weight reduction. This project is to be undertaken in two phases. The first phase comprises development of actual sized oval shaped tubes from circular mother tubes of Al-alloy, within the dimensional tolerances, as specified by HAL.

In the current year, six numbers of oval shaped Al-alloy tubes were developed after optimizing the process parameters. These tubes had the dimensions:

150 mm X 100 mm (oval cross-section), 3 mm thickness and about 4.5 m in length. These six tubes developed were inspected by the representatives of HAL and CEMILAC, Bangalore and have met all the dimensional tolerances, as specified by HAL.

The first phase of this project has been successfully completed in this year and HAL has issued the test report for these six oval shaped tubes developed at NPL.

Development of Oval Shaped Tube, as Skid Landing Gear For Advanced Light Helicopter (ALH) Phase-II

This is the second phase of the HAL sponsored project to develop oval shaped tube as skid landing gear for ALH, which has commenced in this year. This project involves solutionizing the 4.5 m long oval shaped tubes (developed in the first phase of the project) followed by quenching and finally giving a 2-3% reduction draw on a draw bench to achieve T3 condition. These solutionized and cold-drawn oval shaped tubes are then to be bent from the front end, to achieve a radius of 800R.

The oval tubes were solutionized in a horizontal furnace, (at $495 \pm 5^\circ\text{C}$) which had to be suitably modified to accommodate this 4.5 m long oval shaped tube. The tubes, on water quenching (subsequent to solutionizing at high temperature), were getting distorted in shape due to their large length/diameter ratio and thickness, leading to a banana-type shape. In order to avoid this distortion, 4.5 m long special clamping fixtures had to be developed and installed on the oval shaped tubes, so as to encapsulate its entire length, while solutionizing and quenching. It was found that the shape distortion of these oval shaped tubes could be avoided using these clamping fixtures. These tubes were subsequently cold drawn to 2-3 % reduction on a draw bench to achieve final T3 condition. Experimental trials are in progress to bend one end of these tubes to achieve a radius of 800R, on a specially developed tube-bending machine, which has been conceptualized, designed and fabricated in-house. Presently, these tubes are experiencing wrinkles in the inner curvature due to bending. Efforts are presently underway to improve the design of the bending machine and to make it more automated so as to avoid these wrinkles on the inner curvature of these tubes, on bending.

Selection of Sequence of Operation and Design of Tooling for the Development of Prototype Titanium Fasteners (Reduced Scale) using Cold/Warm Forging Technique

This project, sponsored by Hindustan Aeronautics Limited, Bangalore, was also concluded in this year. This project, under the technology indigenization programme of HAL, was undertaken as there is tremendous demand of Ti-fasteners in the aerospace

industry, the needs of which are met solely through imports.

In this project, exploratory work for the prototype development of Hexagonal and Allen-headed fasteners in two grades of Ti-alloys, viz, (a) Ti-6Al-4V and (b) Ti-16V-4Sn-3Al-3Nb, on a reduced scale, was taken up. The design of the sequence of operation for cold/warm forging and design and fabrication of cold/warm forging tooling, for development of Hexagonal and Allen-headed

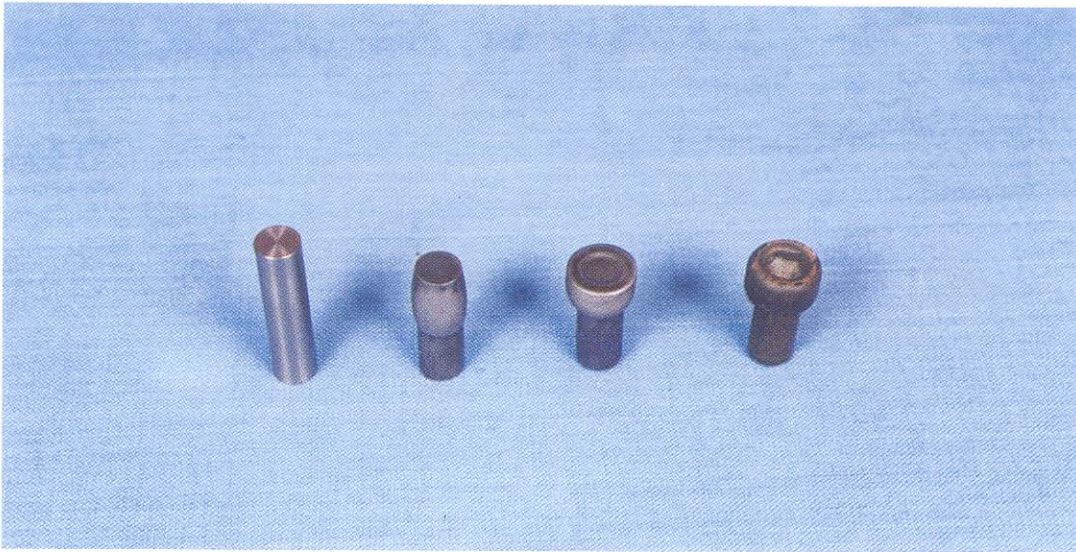


Fig. 3.1 (a) : Pictorial view of the Ti-6Al-4V fasteners (allen headed)

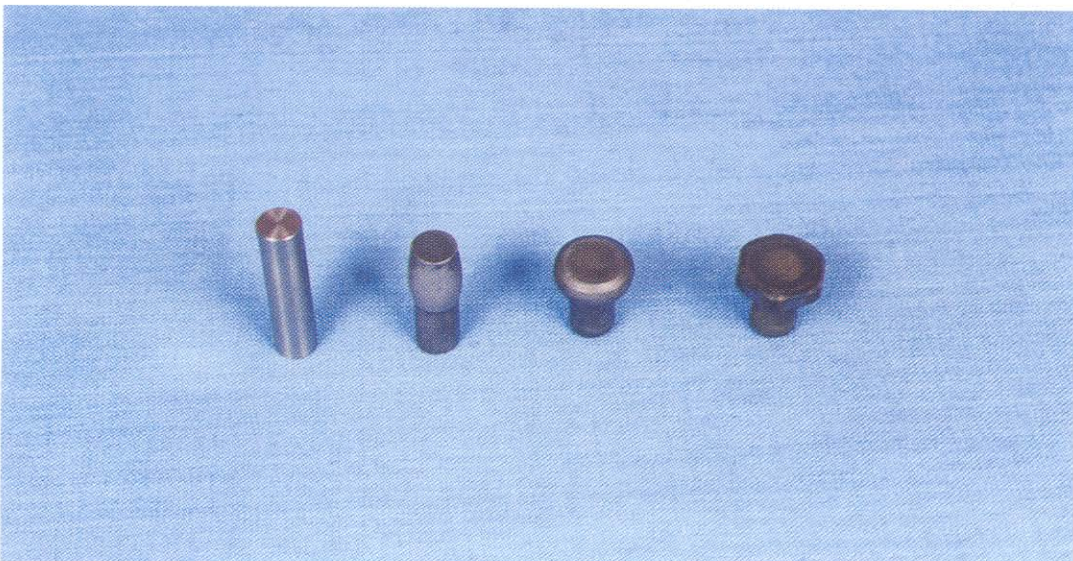


Fig. 3.1 (b) : Pictorial view of the Ti-6Al-4V fasteners (hexagonal headed)

Ti-fasteners, was completed. Several experiments were conducted in order to understand the deformation characteristics of these two types of Ti-alloys at different temperatures. After optimizing all the process parameters it was concluded that, it was not feasible to cold forge Ti-6Al-4V alloy and this alloy could only be warm or hot forged. However, it was found that Ti-16V-4Sn-3Al-3Nb alloy was cold forgeable. It has thus been suggested to the user agency that these Ti-fasteners would be made using Ti-6Al-4V alloy by hot forging followed by cold working on the shank. Figure 3.1 shows a pictorial view of the Ti-6Al-4V fasteners, made in three sequence of operation of forging.

Rapid Solidification of Aluminium Alloys

This is an on-going in-house project to develop aluminium/aluminium-alloys using Spray Atomization and Deposition (SAAD) unit, which was developed in-house in an earlier AR&DB funded project.

In this project, commercial grade aluminium has been successfully spray deposited by disintegrating the liquid melt by a stream of nitrogen gas jets and depositing the atomized droplets on a rotating water-cooled substrate, which also has a provision of fine vertical/rotary movement. Several experiments were carried out on the Spray Atomization & Deposition Unit and the process parameters (such as, melt temperature, flight distance, gas pressure, melt flow rate, substrate rotation/vertical movement speed, atomizer design, etc.) were optimized to spray deposit pure aluminium in flat and conical shapes. A gas atomizer, used in the SAAD experiments, was also fabricated in-house in this project. Typical yields of the as-sprayed conical deposits are in the range 60-70% of the weight of the melt with a density of about 90% of the theoretical density in the core region. The microstructure of the as-sprayed deposits indicated uniform microstructure with equiaxed grains and no indication of dendritic features, normally observed with conventional cast alloys. A few cylindrical billets, machined out of conical as-sprayed aluminium deposits (typical dimensions of 73 mm ϕ and 190 mm length), were secondary processed on a vertical hydraulic press, using the extrusion technique. Different extrusion process parameters were optimized to obtain a cylindrical rod with 36:1 extrusion ratio at 400°C

extrusion temperature. The as-extruded rod exhibited a density of more than 99.9 % of the theoretical density with UTS of about 350 MPa.

Advanced Carbon Products

The advanced carbon products group is engaged in both basic and applied research, covering various aspects of carbon. The emphasis is on developing new carbon products as import substitutes or for strategic applications. In the current year, work was continued on several projects sponsored from national and international agencies. A few new projects were also initiated in this year.

Development of Carbon-Ceramic Composites

Carbon-Ceramic composites were developed by incorporating SiC (particulates or through sol-gel) and B₄C (particulates) in the NPL-developed green coke based carbon matrix. The composites were heat-treated to 1400°C and characterized for their physical, mechanical and oxidation resistance properties. It was observed from X-ray diffraction studies that silicon alkoxide alone could not yield SiC in the composites and B₄C helped in the formation of SiC in the sol-gel technique. By changing the carbon to ceramic and ceramic to ceramic ratio, the carbon-ceramic composites with improved oxidation resistance were obtained using both the techniques. However, composites developed through the particulate route were found to exhibit better oxidation resistance as revealed by a lower weight loss of 6.6% at 1000°C as compared to 14.3% in the case of sol-gel route. Further work is in progress to obtain carbon-ceramic composites exhibiting a weight loss of $\leq 1\%$ at 800-1000°C.

Development of Pitch-based Carbon Monofilament

Work was continued under the on-going project (sponsored by AR&DB) on the "Development of carbon monofilament suitable for CVD-based SiC fibres". Having developed a 'Pitch Spinning Assembly' and a suitable precursor pitch for the carbon monofilament, vigorous efforts were made to improve the strength of the green pitch filament by way of modifying the precursor pitch by adding different types of polymers, namely, high density polyethylene (HDPE), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS), high impact polystyrene (HIPS) and polymethyl methacrylate (PMMA). The

resultant pitches were subjected to spinning to obtain the green pitch filaments, which were tested for tensile strength, tensile modulus and strain-to-failure ratio and also subjected to scanning electron microscopy. The additions of PMMA and PS have been found to lead to significant improvement in the handleability and flexibility of the resulting green pitch filaments with respective green tensile strength of 220 and 70 MPa and tensile modulus of 10 and 12 GPa, respectively. However, the PMMA modified pitch led to a highly porous carbon filament with poor mechanical properties. The PS, on the other hand resulted in a carbon filament of tensile strength of 880 MPa and tensile modulus of 68 GPa. Further work is continuing to optimize the process parameters and to study the microstructure.

Development of High Thermal Conductivity Graphite

Extensive work was carried out under the on-going project (sponsored by IPR, Gandhinagar) entitled, "Development of high thermal conductivity special graphite for first wall component of SST-1 tokamak". The special graphite to be developed under this project is required to possess a thermal conductivity of 90 W/mK, bulk density of 1.7 g cm^{-3} , bending strength of 40 MPa, electrical resistivity of $2 \text{ m}\Omega\text{cm}$ and an ash content of $\leq 0.2\%$. To accomplish the development of such a graphite, the 'green coke' method of producing the high density graphite was made the basis wherein the green coke was modified by way of addition of small amounts of synthetic graphite or natural graphite into the precursor pitch. The resultant graphite, made by both conventional pressing as well as isostatic pressing, was found to meet all the required characteristics of the special graphite except the thermal conductivity where a value of 77 W/mK was obtained with synthetic graphite addition as against the threshold value of 90 W/mK. Efforts are continuing to obtain this special graphite with a thermal conductivity value of 90 W/mK by the above said modification of green coke.

Feasibility Studies of Petroleum Streams as Precursor for High Performance Carbon Fibres

Under the on-going project (sponsored by IOC) entitled, "Feasibility studies on various petroleum refinery streams as precursor for high performance carbon fibres", work was carried out on the development of standard pitches (by techniques of condensation, polymerisation and distillation) with

softening points of $125 \pm 10 \text{ }^\circ\text{C}$ from all the five streams, namely, Short Residue (SR), Residual Fuel Oil (RFO), Blue Oil Extract (BOE), Clarified Oil (CLO) and Coker Fuel Oil (CFO), supplied by IOC R&D Centre, Faridabad. The resultant pitches were studied for pyrolysis behaviour and mesophase formation at different temperatures and periods of time. With respect to the yield of pitch obtained from the different streams, the streams are found to be in order of SR (35.5%), RFO (25.0%), BOE (11.5%), CLO (5.8%) and CFO (3.5%), whereas w.r.t. the coking yield obtained from the different standard pitches, the streams are found to be in order of CLO (55.9%), CFO (53.5%), RFO (47.0%), BOE (41.3%) and SR (33.1%). Thus, w.r.t. the overall coking yields, the streams were found to be in order of RFO (11.8%), SR (11.7%), BOE (4.7%), CLO (3.2%) and CFO (1.9%). Besides this, pitches from all the streams were found to form liquid crystalline phase (mesophase) on heat treatment, which is a pre-requisite for any material to be a precursor for high performance carbon fibres. Thus, from techno-economical considerations, the RFO could be regarded as the best stream for the development of precursor for high performance carbon fibres. Fig.3.2 shows the optical micrograph of bulk mesophase formed in RFO-based pitch on heat-treatment at 490°C for 1h. Further work to develop general-purpose carbon fibres from this stream is in progress.

Synthesis of Carbon Nanotubes

Using the dc arc discharge technique, it has been possible to obtain carbon nanotubes, both, as cathode deposit, as well as in the carbon deposits, inside the chamber. This has been possible by optimizing various processing parameters as well as using special graphite electrodes. The study has given useful insight into the formation of carbon nanotubes and will be quite helpful in increasing the yield of carbon nanotubes in future and their applications in composites.

Development of Carbon Composite Fermural Arch for Polio Patients

Under this project, carbon fibre reinforced composite 'Fermural Arches', also known as 'Italian Arch', were developed as an extension of the earlier project, which was on the development of these rings for Illizarov Fixator. These have been successfully tried on the polio patients at Agrawal Orthopaedic Hospital, Gorakhpur.

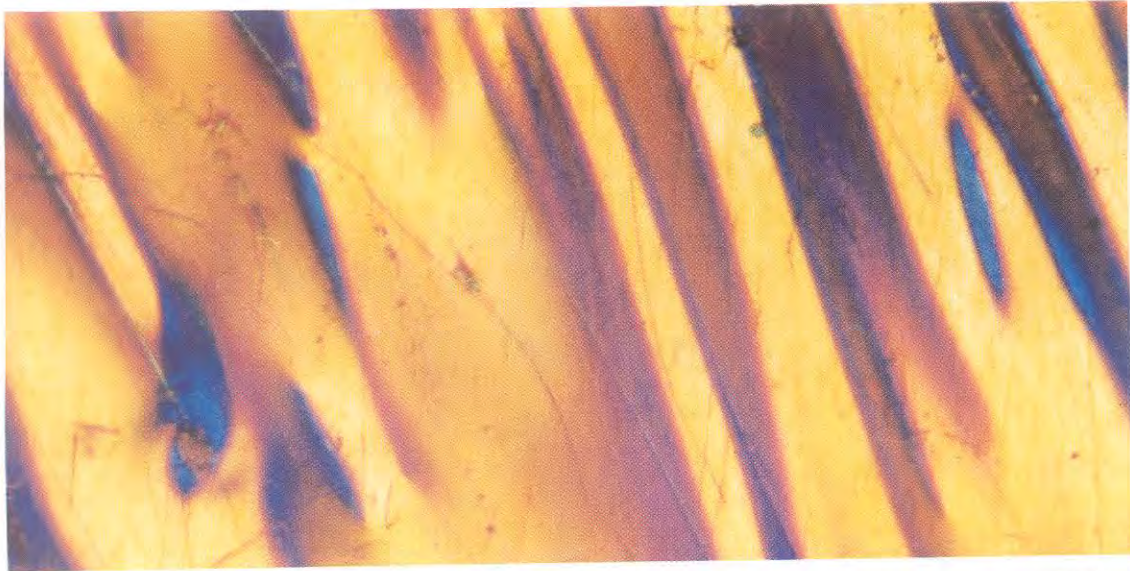


Fig. 3.2 : Optical micrograph of bulk mesophase formed in RFO-based pitch on heat-treatment at 490°C for 1h.

High Thermal Conductivity Carbon/Carbon Composites

Under this sponsored project "Development of High Thermal Conductivity Carbon-Carbon Composites" funded by (UISTRF, INDO-UK), carbon-carbon composites were developed using different reinforcements (chopped PAN and pitch based fibres) and matrices (Coal Tar Pitch, modified Coal Tar Pitch and mesophase Pitch) with the main objective of developing composites having high thermal conductivity (150-200W/mK). Composites were characterized for physical, electrical and thermal properties. X-ray diffractometry showed the crystallite dimensions in ab plane to be 31 nm and d_{002} to be 0.3392 nm. Electrical resistivity of the graphitised sample was found to be 0.5- 0.8 m Ω cm. A new technique, micro Thermal Analyzer AFM, was

used for measurement of Thermal Conductivity which combines the visualization power of Atomic Force Microscopy (AFM) with the characterization capabilities of thermal analysis. Fig. 3.3 shows the topographic and thermal images of F3M1 sample which clearly shows that carbon fibres possess more thermal conductivity compared to the matrix.

Development of Porous Conducting Carbon Paper

The objective of this project is to develop porous conducting carbon paper, which will be used in Fuel cells as a gas diffusion type electrode and also as a catalyst. The specifications of the carbon paper, (sponsored by Naval Materials Research Laboratory) which were targeted and achieved so far, are reproduced in the table :

Table : Specifications of Carbon Paper

Property	Specification Targeted	Specifications Achieved
Porosity	70 %	>70 %
Gas Permeability	3.59 cm ³ /sec	3.5 cm ³ /sec
Electrical Resistivity in plane	0.005 Ω cm	0.003-0.008 Ω cm
Flexural Strength	40 MPa	40-45 MPa

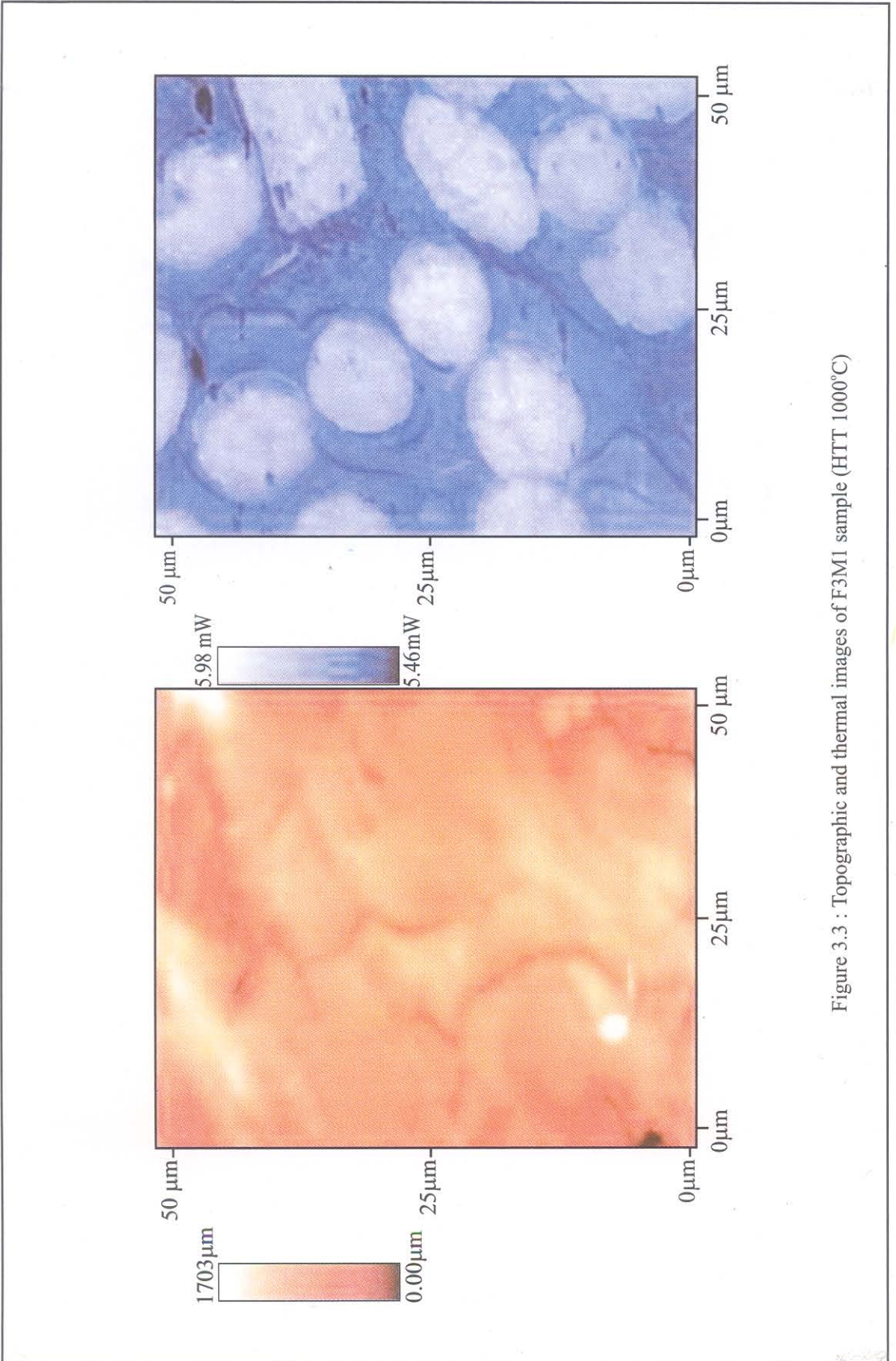


Figure 3.3 : Topographic and thermal images of F3M1 sample (HTT 1000°C)

Asbestos - Free Brake Materials for Automobiles - Tailoring, Characterization and Evaluation

This activity was continued and the samples of size 6 cm x 6 cm x 0.5 cm were prepared and characterized for density, hardness, flexural strength & flexural modulus. The studies were mainly confined to control the scleroscopic hardness of the samples which was brought down from a value of 60 reported last year to a desired value of 40-45. Few samples were also given to ITTMEC, IIT Delhi for their characterization of friction and wear properties.

Development of Radiationally Stable Carbons

The studies were continued in the project (sponsored by BARC) to develop carbon composite samples which are isotropic as well as amorphous in nature. Carbon composite samples were prepared by changing fibre and matrix volume fractions. These composites were characterized through XRD for their amorphous nature. The isotropic nature was established by measuring their coefficient of thermal expansion and by optical microscopy. Few samples of size 18 mm dia and 20 mm thickness were supplied to BARC for keeping them inside the nuclear reactor for the evaluation of their thermal stability.

High Pressure Technology

The group has been engaged in the synthesis of cubic boron nitride at pressures lower than those used by other researchers employing the conventional techniques which uses pressure (50kb) and temperatures (>1500°C). We had earlier synthesized cubic boron nitride under a DST funded project at pressures as low as 25 kb. As an extension of this activity, a project entitled "Low pressure synthesis of cubic boron nitride by means of supercritical fluid" in collaboration with Mineralogical Institute, University of Bonn, Bonn, Germany, under DST - DAAD Project Based Personnel Exchange Programme has been approved. In this programme, experiments on cBN synthesis using liquid ammonia, as a supercritical fluid, were carried out. However, the initial experimentation did not show encouraging results with respect to cBN conversion using hBN-Li₃N- NH₃ system. This work is under progress.

Trial runs were also made to synthesize cBN compacts on 1000 ton press using imported cBN powder (6-9 micron) and TiC/TiN as the binding material. cBN compacts with a microhardness of about 3000 kg/mm² were obtained.

इलेक्ट्रॉनिक पदार्थ
ELECTRONIC MATERIALS

इलेक्ट्रॉनिक पदार्थ

इलेक्ट्रॉनिक पदार्थ प्रभाग विभिन्न प्रकार के पदार्थों का अभिलक्षणन करने और उन्हें तैयार करने में जुटा हुआ है। इस प्रभाग द्वारा विशिष्ट पदार्थ (प्रलेखित) की पूर्ण प्रक्रिया तकनीक तथा सम्बन्धित उपकरणों व साधनों के विकास के लिए प्रयास किये जा रहे हैं। यह प्रभाग छः विभिन्न ग्रुपों के अन्तर्गत कार्य करता है। ये इस प्रकार हैं : सूक्ष्म संरचना पदार्थ और साधन ग्रुप, सिलिकॉन और सिलिकॉन साधन ग्रुप, संदीप्तिशील पदार्थ और साधन ग्रुप, वैद्युत क्रोमिक तथा बहुलक साधन ग्रुप, तनु परत प्रौद्योगिकी ग्रुप तथा विशेष सेरामिक ग्रुप।

उद्योगों तथा अन्य अनुसंधान तथा विकास संस्थाओं की रुचि के विविध अनुप्रयोगों के लिए ये ग्रुप अनेक अर्धचालकों और विद्युतरोधों, तात्विक और यौगिक दोनों के स्थूल और तनु परत रूपों में और इसी प्रकार बहुलक तथा सेरामिक पर कार्य कर रहे हैं। प्रतिनिधि के रूप में अनुसंधान तथा विकास विषय इस प्रकार हैं :-

- इलेक्ट्रोडिपॉजिटिड द्विअंगी तथ त्रिअंगी अर्धचालक फिल्मों का अध्ययन
- एथानॉल तनु परत संवेदक तथा तनु परत चुम्बकी संवेदकों का विकास
- गामा किरण पहचान के लिए प्रकाश संवेदनशील डायोड का विकास
- दीर्घ क्षय एवं रीयल टाइम एक्स रे इमेजिंग इत्यादि साधनों के लिए विशेष संदीपको का विकास
- एनर्जी एफिशिएन्ट इलेक्ट्रोक्रोमिक विंडोज का विकास
- पॉलीमरिक शॉटकी जंक्शन साधनों और जल के शुद्धिकरण के लिए पॉलीमरिक मेम्ब्रेन्स का विकास
- ऑटोमोबाइल उद्योग के लिए तनु परत प्रकाशीय कोटिंग्स का विकास
- सूक्ष्मतरंग पी ई सी वी डी द्वारा कार्बन नैनोट्यूब्स, नैनोडायमण्ड फिल्मों तथा टेट्राहेडरल कार्बन फिल्म डिपोजिशन के लिए फिल्टर्ड कैथोडिक आर्क सिस्टम का विकास, पारदर्शक डी एल सी फिल्मों का विकास
- उच्च तापमान अतिचालकीय मल्टीफिलामेन्टरी टेपों का विकास
- कणिका फिल्टर कैण्डलों के लिए ग्रेडिड पोरोसिटी सेरामिकों का विकास

ELECTRONIC MATERIALS

The Division of Electronic Materials is engaged in the preparation and characterization of electronic materials of various kinds. A conscious attempt is being made to develop a complete process technology for a particular material (documented) and in many cases related devices and processing equipment as well. The Division carries out these tasks under six different groups. These are the Microstructure Materials and Devices Group, Silicon and Silicon Devices Group, Luminescent Materials and Devices Group, Electrochromic & Polymeric Devices Group, Thin Film Technology Group and Special Ceramics Group.

These groups are working on a large number of semiconductors and insulators, both elemental and compound, in bulk and thin film form, as well as polymers and ceramics, for a variety of diverse applications of interest to industry and other R & D institutions. Representative R & D themes are :

- *Study of electrodeposited binary and ternary semiconductor films*
- *Development of ethanol thin film sensor and thin film magnetic sensors*
- *Development of photodiodes for gamma ray detection*
- *Development of long decay phosphor devices, phosphors for real time X-ray imaging, etc.*
- *Development of energy efficient electrochromic windows*
- *Development of polymeric Schottky junction devices and polymeric membranes for water purification*
- *Development of thin film optical coatings for automobile industry*
- *Development of clear DLC films, carbon nanotubes and nanodiamond films by microwave PECVD, as also development of filtered cathodic arc system for tetrahedral carbon film deposition*
- *Development of high temperature superconducting multifilamentary tapes*
- *Development of graded porosity ceramics for particulate filter candles*

Microstructure Materials and Devices

Semiconductor II-VI compounds form solid solutions over a considerable range of compositions, better control over various properties and structural changes could be achieved in ternary semiconductors. The band gap and lattice parameters of the compounds can be varied continuously by changing the composition. Investigations were carried out to prepare ternary alloy films using CdTe as main binary compound by electrodeposition. Such study can provide a large degree of freedom in designing material properties i.e. band gap and lattice constant etc. Alloys of CdTe with other compounds, particularly low band gap compounds such as PbTe have not been attempted so far using the electrodeposition technique. Investigations were therefore carried out on preparation of ternary alloys of PbTe with CdTe by electrodeposition technique. Thin films of $Cd_{1-x}Pb_xTe$ ($x=0$ to 0.2) have been electrodeposited under constant deposition potential onto transparent conducting glass substrates by varying the Pb content in the deposition solution. The electrodeposition bath consists of $CdCl_2$, TeO_2 and $PbSO_4$. To improve the deposit quality and stabilize the bath EDTA was added in the bath. To study the development of phase, composition and structure, films were characterized by XRD, SEM and EDX technique. Electrodeposited $Cd_{1-x}Pb_xTe$ films show cubic structure. The crystallinity of the films was found to undergo a drastic change on addition of Pb in the electrodeposition bath. The crystallinity changed from (111) preferred orientation to no preferred orientation for $x=0.1$, and to (200) orientation for $x=0.2$. The grain size of the films shows a decrease on increasing Pb content in the solution. A decrease in lattice parameter and optical band gap confirmed the formation of the ternary compound.

The ethanol sensing characteristics of bismuth molybdate semiconductor material were studied. Metallorganic compounds containing Bi- and Mo- were prepared and films from the precursor solution were prepared by spin coating and spray drying technique. Different phases of bismuth molybdate were successfully prepared on quartz, silicon and glass substrate. The phase formed is studied by X-ray diffraction studies and the composition in the final product by EDAX studies. The ethanol gas sensitivity was measured at various

temperatures and concentrations. The response time was found to decrease in the film form as compared to the pellets prepared by solid state route having the same composition as that of films.

Nanocrystal semiconductor quantum dots due to its unique non-linear optical and quantum confinement effects are emerging as a new class of future photonic materials. NPL has been carrying out the synthesis of CdTe nanocrystalline quantum dots. These quantum size effects are observed when the nanocrystals are isolated in an insulating matrix TiO_2/SiO_2 forming nanocomposite film. A systematic dependence of the optical band edge on the CdTe nanocrystal size shows a strong quantum confinement effect. The current transport in these films is due to the Space Charge Limited (SCL) mechanism rather than by thermally assisted tunnelling of carriers between the adjacent CdTe nanocrystals. The injection of carriers from a CdTe nanocrystal follows the spherical radial flow into TiO_2 . This modifies the more dominant planar SCL current transport through the TiO_2 insulating matrix under certain conditions of field and temperature to yield a $3/2$ power law dependence instead of the usual quadratic law.

Molecular Beam Epitaxy (MBE) offers a unique ability to prepare epitaxial layers of compound and elemental semiconductors and composition profiles with atomic dimensional precision down to a few Angstroms. NPL group has taken initiative for the implementation of GaN work with a view to conceive new device structures and exploring new physics. Presently, work is being done to identify the conditions for the epitaxial growth of GaN and to form heterostructures for application in blue light emitting diodes and high power electronic devices.

The magnetic nanomaterial and thin film activity in the microstructure devices group during the year 2000-2001 had its major emphasis on the DST sponsored project on magnetic thin film sensors. Two multilayers of 20 and 35 bilayers of the Co/Ag type were deposited in UHV environment, annealed under vacuum to obtain the so called Discontinuous Multilayer (DML) Structure. Structural, magnetic and magnetoresistance properties the films were studied in order to investigate the effect of number of bilayers. Improved magnetoresistance properties were obtained for films with larger number of bilayers. Apart from this nanocomposite magnets of the NdFeB type with

low rare earth content, which are potential low cost high energy permanent magnets, were investigated which on 600°C annealing produced good permanent magnet properties. Li ferrite nanoparticles in the 10-12 nm size range prepared by a citrate precursor method has shown a very interesting β to α transformation in the 200 to 350 °C annealing temperature range and encouraging properties for ferrofluid application.

Silicon and Silicon Devices

Studies Relating to Silicon Photodiodes

Under the on going BRNS project entitled "Development of silicon photodiodes for use with scintillating crystals for detection of γ rays" work to develop silicon PIN photodiodes suitable for use with BGO/CWO scintillation crystals for detection of the light emitted by the crystal with intensity peaking at wavelength of 470-480 nm under excitation by γ -rays was started. Methodology for photodiodes to be fabricated on high resistivity (~1000 ohm cm) wafers has been completed and a set of device processing steps including the patterns for photo masks were worked out. Photo masks to be use with the positive photoresist have been made for processing of four photodiodes of 1cm x 1cm size on a single 50 mm diameter wafer. Shallow junction p^+n-n^+ and n^+p-p^+ structures were made on 10 ohm cm resistivity n and p-type Cz-Si wafers of 50mm diameter by B and P diffusion using SiO_2 as the diffusion mask. This was

done to ascertain the desired processing parameters.

A few shallow n^+p junctions were also made with solid source diffusion of P in p-Si wafers at (900°C/30 min.). A sheet resistivity of 95 Ω/\square was achieved with radial uniformity of $\pm 2 \Omega/\square$. Efforts are on to develop Ti/Ag contacts on the front and back sides of p^+n-n^+ and n^+p-p^+ structures.

Phosphosilicate glass (PSG) formed at the temperature range of 800-900°C during phosphorous diffusion into silicon from liquid $POCl_3$ source in an ambient of N_2 and O_2 was investigated for its suitability as antireflection coating on silicon solar cells or photodiodes. The thickness of oxides and their refractive indices were measured by the ellipsometer. The refractive index increased with the temperature of forming up to 875 °C and then become constant at which point PSG is saturated with P. From the growth rate data at different temperatures the linear and parabolic activation energies were determined as 0.79 and 1.43 eV for linear and parabolic rate constants respectively. Therefore growth rate of PSG is higher than of thermal oxide. The PSG films were found to have refractive indices 1.85, 1.78, 1.74 and 1.71 for forming temperatures 800, 825, 850 and 875 °C respectively (Fig. 4.1). Reflectivity varied from 2.5 to 7.5% in the wavelength range 450-700 nm as shown in Fig. 4.2. SIMS depth profiling suggests that there has been pile-up of P at the Si/SiO₂ (PSG) interface. From above it is clear that PSG may be a good anti-reflecting coating for PIN silicon diodes.

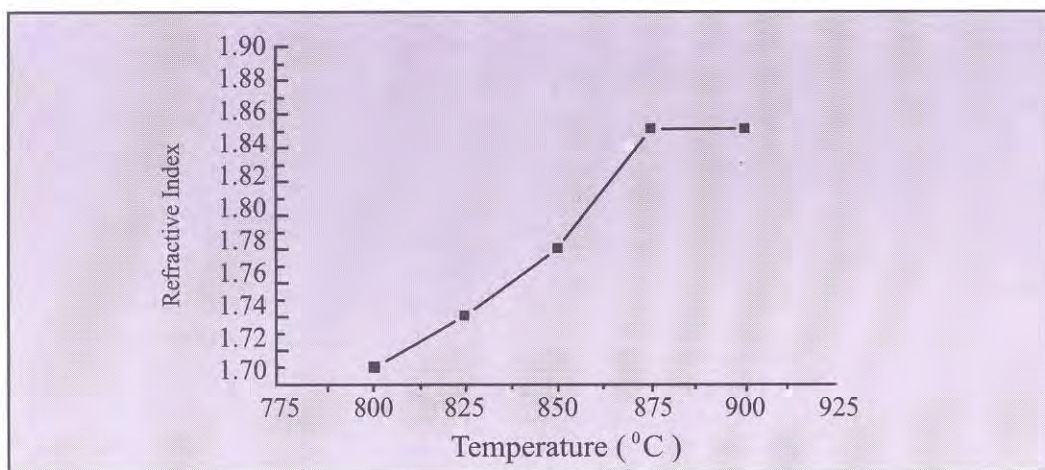


Fig 4.1: Variation of refractive index of PSG surface as a function of temperature of growth. The measurements were carried out at 633 nm wavelength using Ne-He laser source.

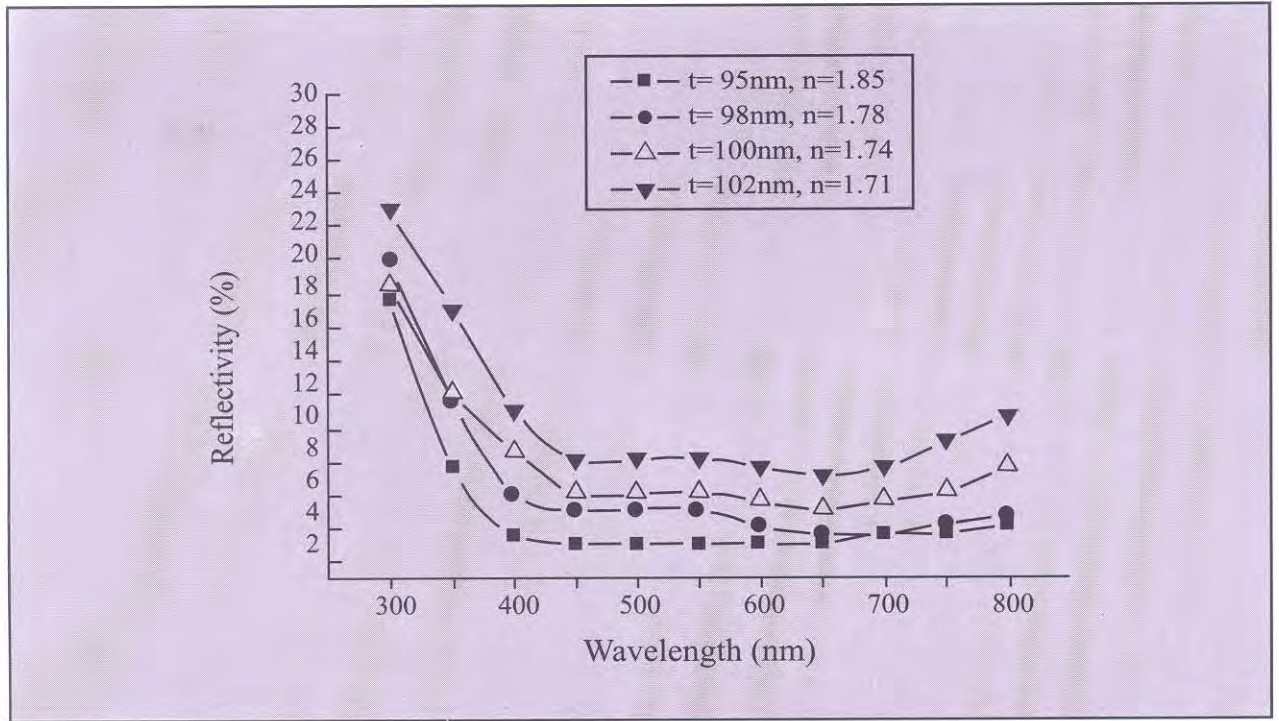


Fig. 4.2: Front surface reflectivity of PSG layers of different thickness and refractive index

Studies Relating to Silicon Solar Cells

In photovoltaic industry, orientation dependent etching of single crystal silicon is used to control reflection losses by altering the highly reflecting silicon surface. The anisotropy in etching gives rise to surfaces covered with upright random pyramids defined by intersecting $\{111\}$ and $\{100\}$ planes due to difference in etch rates in different crystallographic orientations. No systematic study of variation on cell performance parameters with the alteration in surface topography was available in the literature. To fill this gap, silicon solar cells on (100) boron doped Cz silicon wafers of $\sim 1 \Omega\text{-cm}$ resistivity textured for different durations (t_{txt}) by standard anisotropic etching solution were fabricated. Scanning electron microscope was used to study surface topography. Surfaces resulting from the different duration of texturisation varied from no texture to a near ideal texture with uniform coverage of intermingled pyramids. It was observed that for $25 < t_{\text{txt}} < 35$ minutes the surface topography does not change significantly and that the average pyramid base size is 4-6 μm . In the case of prolonged texturisation, some pyramids grow

at the expense of others leading to their non-uniform distribution.

Solar cell performance parameters namely open circuit voltage, short circuit current density, curve factor and efficiency have been studied as a function of anisotropic etching time. A parameter $f_{\text{eff},\lambda}$, called optical effectiveness factor was defined and its value was estimated from reflectivity using following equation;

$$R_{\text{expt},\lambda} = R_{\text{min},\lambda} f_{\text{eff},\lambda} + R_{\text{max},\lambda} (1 - f_{\text{eff},\lambda})$$

where $f_{\text{eff},\lambda}$ represents the combined effect of pyramid size and their spatial density and is a function of t_{txt} . $R_{\text{max},\lambda}$ (=35%) is the maximum reflectivity of silicon and $R_{\text{min},\lambda}$ (=11%) is the minimum value achieved on a textured silicon surface at wavelength λ and $R_{\text{expt},\lambda}$ is the measured reflectivity of the test sample. The deduced values of $f_{\text{eff},\lambda}$ using above equation from the reflectivity data at $\lambda = 950\text{nm}$ have also depicted in Fig. 4.3 along with short circuit current density (J_{sc}).

The observed increase in short circuit current density with t_{txt} is the direct manifestation of the

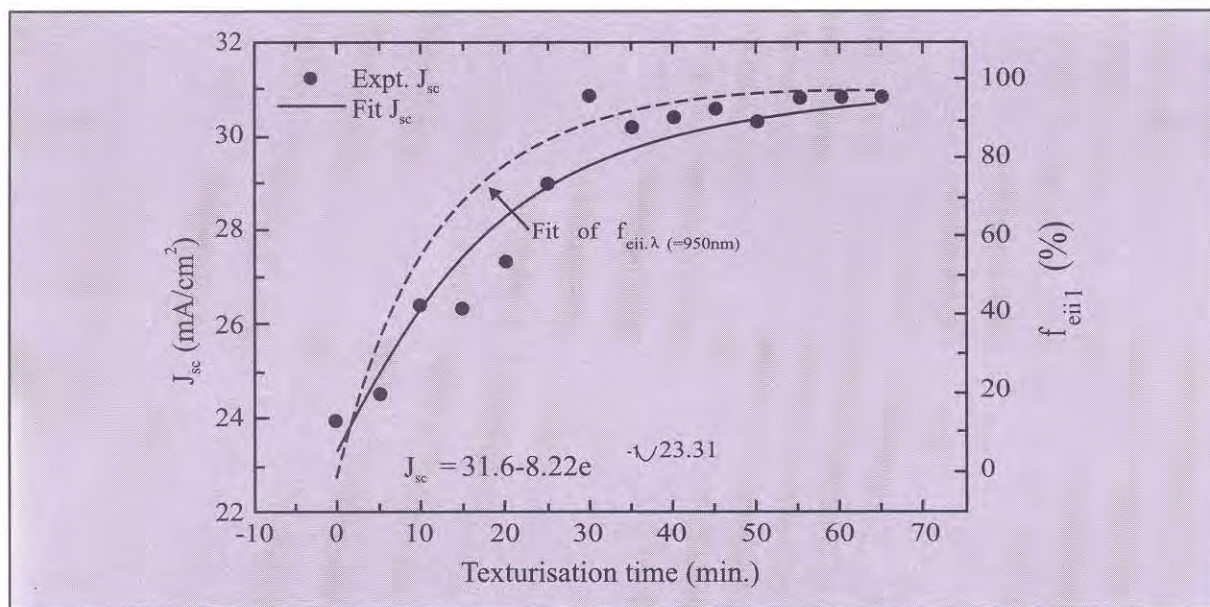


Fig. 4.3: Short circuit current density as a function of texturisation time along with the deduced $f_{eff,\lambda}$ values.

decrease in the $R_{cxt,\lambda}$ with texturisation time as the contribution of back surface field (BSF) is the same in all cases. The stabilization of J_{sc} for $t_{xt} > 30$ minutes indicates the fully-grown pyramid (with base size 4-6 μm) structure leading to uniform reflectivity. This observation was also confirmed by SEM studies. J_{sc} for the control cell made on polished wafer was 23.8 mA/cm². This is close to the value obtained for damage etched surface and is much smaller compared with those of textured cells. Empirical relations were deduced for all the measured parameters, which may help in process development and computer modeling.

Luminescent Materials and Devices

The Group successfully completed a project entitled "Development of Long Decay Phosphors and Phosphor Coated Tapes for Army" sponsored by Defence Laboratory, Jodhpur (DRDO). The results were so encouraging that DRDO sponsored following two projects namely, (1) Development of Luminescent Screens (i) Gadolinium oxysulfide based x-ray/gamma/neutron sensitive phosphor screens and (ii) Electroluminescent screens and (2) Preparation of Long Decay Phosphor and Phosphor based paint and adhesive Tape.

The Long Decay Phosphor developed earlier was based on Zinc Sulfide. However, another host

material Strontium Aluminate has been reported to have longer decay time compared to the Zinc Sulfide. Now DRDO wanted us to develop Strontium Aluminate based long decay phosphor for them. Development work on the Phosphor had already been started anticipating DRDO's future requirements. Good measure of success had already been achieved in making smaller amount of samples. In strontium aluminate system, the structure being quite complicated with the possibility of many phases, up-scaling required a very careful approach. Synthesis parameters were zeroed for higher production after a lot of experimentation with respect to amount of flux, material and geometry of firing capsules, temperature, duration and atmosphere of firing. The capacity of 100 g of finished phosphor has been established. Work on development of paint and fabrication of tapes using Long Decay Phosphor for end use as per DRDO requirement is in progress.

Phosphor-Gadolinium Oxysulfide doped with terbium is regarded as an efficient scintillator/solid state detector for X-ray real time imaging with very high conversion efficiency and X-rays stopping power. This phosphor also offers a good spectral match to the photographic film sensitivity as compared to the conventional calcium tungstate and other phosphors. These features of the phosphor prompted DRDO to

sponsor the project of developing Gadolinium Oxysulfide (GOS) Phosphor coated screens. Work on synthesis of GOS Phosphor was initiated using indigenous rare-earth oxides from Indian Rare Earths Ltd. Requisite amounts of rare-earth oxides were mixed with optimized proportions of flux chemicals viz. Sodium Carbonate, Sulfur, and Potassium Phosphate. Various other dopants were tried to improve emission efficiency. 40-50 per cent enhancement in brightness was achieved by optimizing the synthesis parameters.

Experimental screens (10x10 cm) of different GOS Phosphor samples on a variety of substrates were made and tested successfully at Defence Laboratory, Jodhpur under 140 kV X-rays. Work on material preparation and higher size (20x20 cm) screens, which are to be supplied as part of the project, is continuing.

DRDO had been using Beta Lights as track marker/indicator for movement of tanks and artillery in battlefield. Beta Lights are radioactive tritium gas filled glass bulbs with phosphor coating. Because of radioactivity involved they were looking for an alternate stand alone light source. Battery operated large area uniformly illuminated electroluminescence panels were found to be suitable. NPL was also entrusted to develop EL panels of size 20x10 cm.

An EL panel requires a deterioration resistant phosphor for longer life. Synthesis of such zinc sulfide EL phosphor was based largely on H_2S gas. H_2S is highly toxic. A need to replace H_2S gas was strongly

felt. A number of processes were thought of and tried. A new synthesis route to prepare zinc sulfide EL phosphor with bromine incorporation has been established. One step process uses a composition with activators, co-activators, bromine salts, sulphur source and heating in inert atmosphere. Emission spectrum obtained with typical processes has been shown in the Fig.4.5. The optimized one step process yields an emission spectrum with well defined peak at 530nm.

Electrochromic Devices

Under this activity sustained efforts were made to develop all the three components of an Energy Efficient Electrochromic Window or the so called "Smart Window". In these transmissive electrochromic devices the primary electrochromic electrode is based on sol-gel deposited WO_3 films with superior electrochromic properties. The counter electrodes based on doped SnO_2 that have been prepared by adopting peroxo sol-gel route have shown properties best suited for achieving good reversibility and, as a result, good performance characteristics of the completed electrochromic devices. Some new materials were taken up for investigation and are under preparation for the counter electrodes as well. The two electrodes of the devices are separated by Li^+ gel polymeric electrolytes with excellent liquid like ionic conductivity, which is almost invariant in the operational temperature range for these devices. Additionally these gel polymeric electrolytes are characterized with excellent adhesive properties.

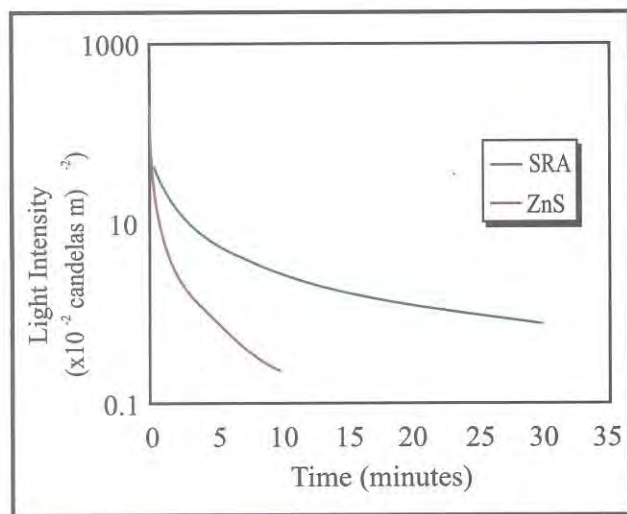


Fig. 4.4 : Comparison of decaytime of ZnS and $SrAl_2O_4$ Long Decay Phosphors

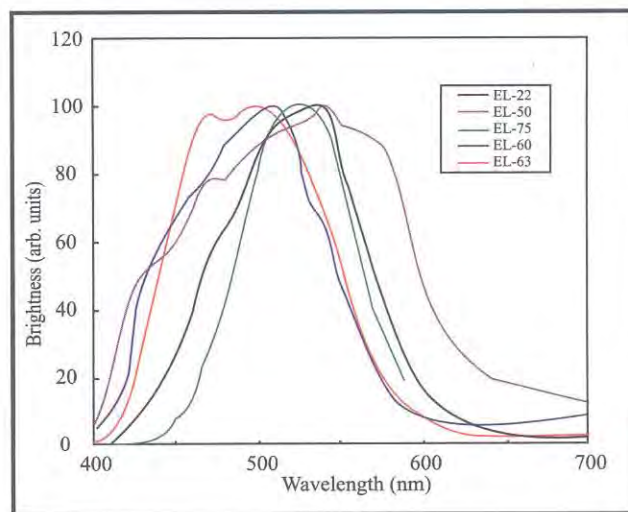


Fig. 4.5 : EL emission spectra of various samples

Attempts are under way to laminate these devices making use of this important property.

Many prototype electrochromic windows of dimensions up to 4 x 4 square inch have been fabricated and their testing for performance and life is being carried out. Packaging of the devices for longer operational life with acceptable performance is an important consideration, which is currently being addressed. The ultimate goal is to fabricate prototype electrochromic windows of large enough area suitable for office, residential and automotive purposes.

Polymeric Devices

The frequency and temperature dependence of ac conductivity of poly(N-methyl pyrrole) thin films in the temperature range 77-350 K and in the frequency range 10^2 - 10^6 Hz have been qualitatively explained by considering contribution from two mechanisms; one giving a linear dependence of conductivity on frequency and other having distribution of relaxation times giving rise to broad dielectric loss peaks.

A comparative study of effect of protonic acid (hydrochloric, sulphuric and phosphoric) doping on dielectric constant, ac conductivity and dc conductivity measurement of polyaniline in the temperature range 77-410 K was carried out. The ratio of measured ac to dc conductivity shows dispersion at 77 K which decreases with the increase of the doping level for all the protonic acids. A close look at the correlation of dielectric relaxation and dc conductivity data suggests that both the phenomenon may, perhaps, be controlled by the same hopping mechanism.

Polymeric Schottky junction devices based on aluminum/poly(N-methyl pyrrole-pyrrole) have been fabricated and the detailed analysis of their behavior is under investigation. These devices may have many interesting sensor applications. The present investigations reveal that the contribution to the conduction process in these junctions is not only coming from the surface states but localized states in the bulk also determine the carrier transport near the junction.

The polypyrrole/sodium nitrate (PPY/NaNO₃) composites have been synthesized and characterized for possible use as a substrate to support endothelial cell proliferation. Furthermore, the mechanism of charge transport in this system was also

examined in the temperature range 15-295 K. Such studies assume great importance before this material could be used as a substrate for human endothelial cell growth. This composite film being biocompatible in nature has potential application in the growth and development of bio-artificial organs.

A prototype of Water Purifier has been designed and fabricated. Raw water taken from Yamuna river has been filtered through this Water Purifier and is being tested for its efficacy by an outside agency, an ISO 9001 Organization, Sriram Institute for Industrial Research, Delhi as also by AIIMS, New Delhi.

Thin Film Optical Coatings

The externally funded (Min. of Info. Tech., Govt. of India) project entitled 'Silica-on-silicon integrated optical devices for wavelength division multiplexing applications - Part I' made slow but steady progress during this period. The Flame Hydrolysis Deposition (FHD) system comprising the FHD deposition chamber and its accessories and sub-systems -- the Constant Temperature Environment Chamber to house the reactant vapours and liquids, the Gas Handling system and the Scrubber for safe disposal of the toxic waste products was fabricated by a local manufacturer after extensive consultations with NPL, and installed in a newly set up laboratory in NPL. Initial trial runs were carried out in the new facility to deposit thick silica films on silicon substrates. As an alternative to the FHD approach, the PECVD based techniques developed in the group were also used to deposit silica layers on silicon substrates. In order to analyze the thick silica films deposited by FHD, PECVD and e-beam evaporation, a method (with the associated software) for determining the refractive index profiles of thick inhomogeneous optical films from their spectrophotometer traces was developed.

The Group has also developed three thin film multilayer optical coatings which should be of commercial interest, especially for the automobile industry and is prepared to transfer the technology to manufacturers of optical coatings for commercial applications. These are:

- (a) Anti - Glare Coatings On Glass Spectacle Lenses For UV Protection And Night Driving Applications with the following specifications :
 - (i) Transmission 50-85 % in the 500-800 nm range

(visible range) (ii) Cuts off harmful UV radiation down to less than 5 % at and below 340 nm (iii) Coating meets DIN specs 58216 Part A formulated for night driving applications (iv) Passes thermal stability test (heating in air at 65 deg C for 8 hrs) and other tests (MILS, UK-BSG) for adhesion, abrasion, humidity and solubility of coating.

(b) Front Surface Coated Rear View Mirrors For Automobiles with the following specifications : (i) Average reflectance 40-70 % (point 3.4, p. 12 of document no. O.J.L8 of European Economic Community, pertaining to rear view mirrors of motor vehicles, issued in Oct. 1992) (ii) The coating passed moisture resistance, temperature resistance and weather resistance tests prescribed in IS document no. IS 14210:1994, pertaining to automotive vehicle rear view mirror specifications.

(c) Fog Coatings on Covers of Fog Lamps of Automobiles: The coating has wavelength-selective transmission, reflection and absorption in the visible region. In reflection it appears bluish-green and in transmission it appears golden yellow, which is comfortable to the eyes of the driver and enables him to distinguish objects while driving in foggy weather.

Using a process developed earlier, narrow band interference filters for the UV region were fabricated for use in Radio Science Division, NPL.

Amorphous Thin Films, Devices and Systems

Under a DST sponsored project completed in Jan. 2001 it has been demonstrated how by decoupling the plasma generation process upstream (at 2.45 GHz) and biasing the substrates kept downstream of a remote plasma CVD reactor (13.56 MHz), ion flux and ion energy can be independently controlled. This together with the use of Argon as a diluent for the hydrocarbon used (C_2H_2) has allowed us to prepare a range of DLC compositions with varying optical properties which can be used as clear DLC coating on watch glass plates. When tailored for solar cell applications, such clear DLC films have been found to enhance short circuit current by almost 30%. By predictably changing the set of process parameters (as also Argon dilution) one can induce crystallinity in the films being grown and nano-diamond films with characteristic Raman signature at (1314 cm^{-1}) could be reproducibly grown (Fig. 4.6 and 4.7). What is most interesting, however, is that, by further careful manipulation of the process parameters, multiwalled CNT could also be produced in the same system (Fig. 4.8 and 4.9). Our basic understanding of the plasma processes taking place in such a PECVD reactor has allowed us to produce the required carbon films in a reproducible manner.

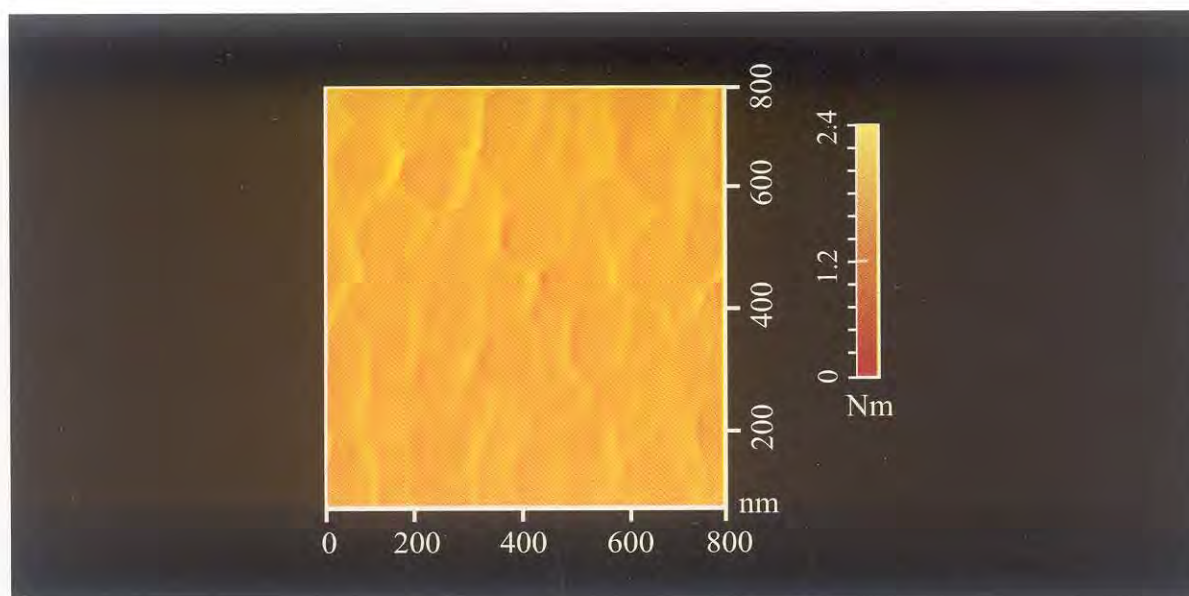


Fig. 4.6 AFM micrograph of nano diamond films deposited at -250V RF bias + 25 W microwave power (x,y and .. Axes in nm.)

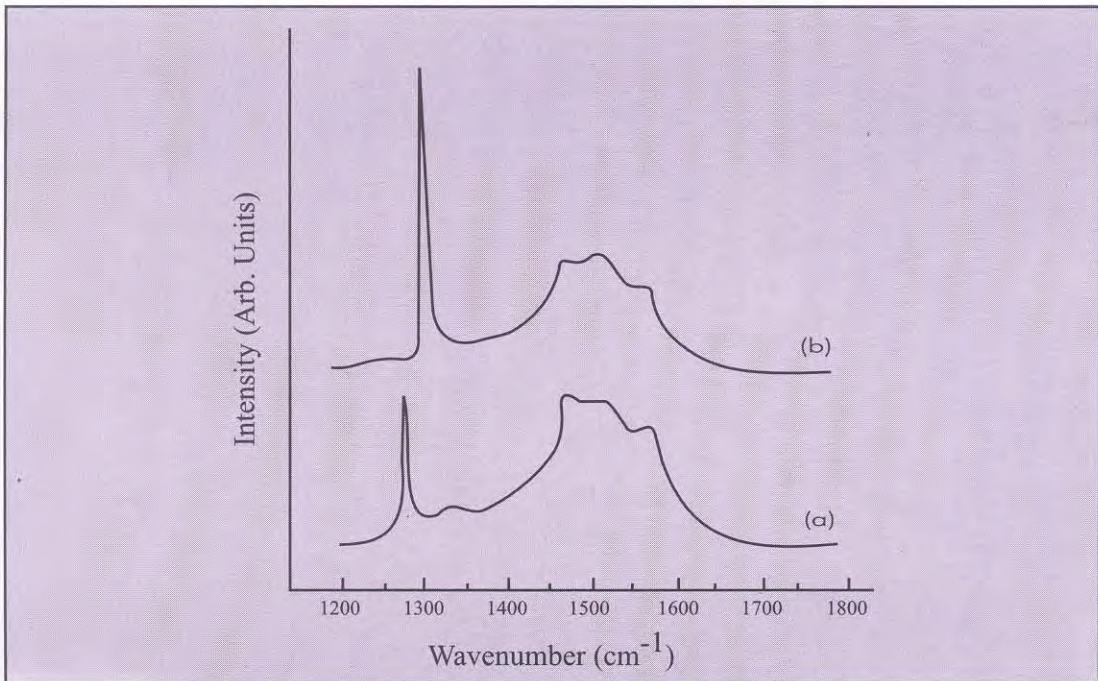


Fig 4.7 Raman Spectrum of the nano diamond films deposited with (a) -250 V RF bias only (b) -250 V RF bias + MW power of 25 W

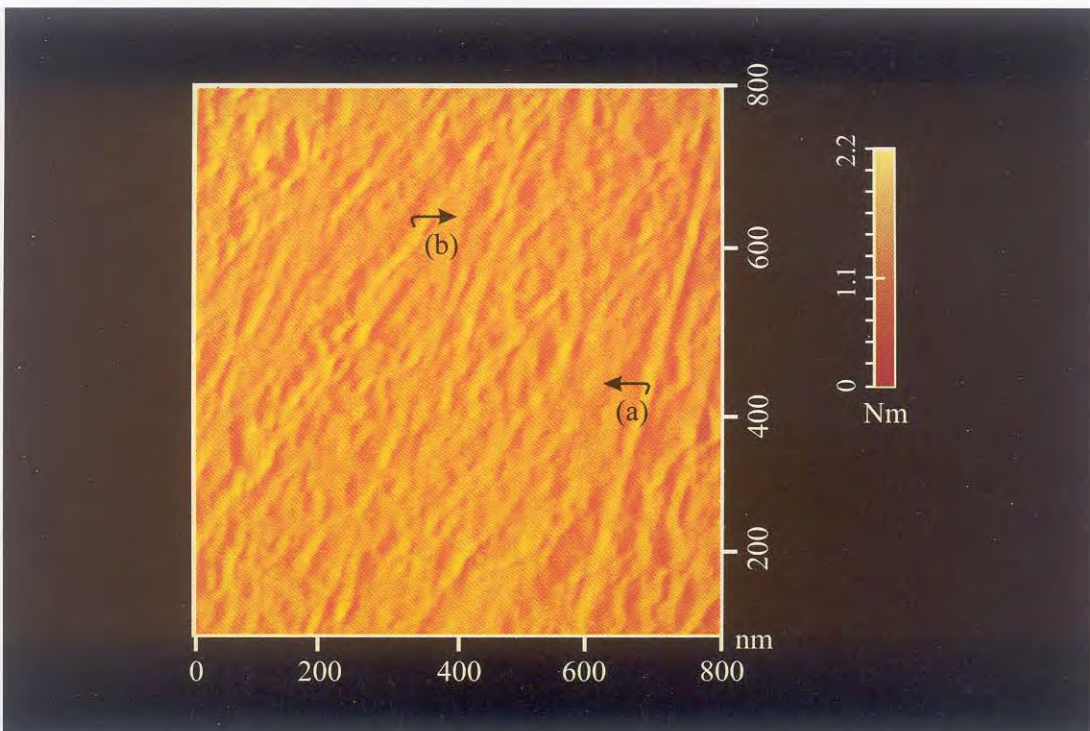


Fig 4.8 AFM micrograph of a - C: H films consisting of CNTs (diameters 23-30 nm), deposited at -200 V RF bias + 25 W microwave power (x,y and .. axes in nm)

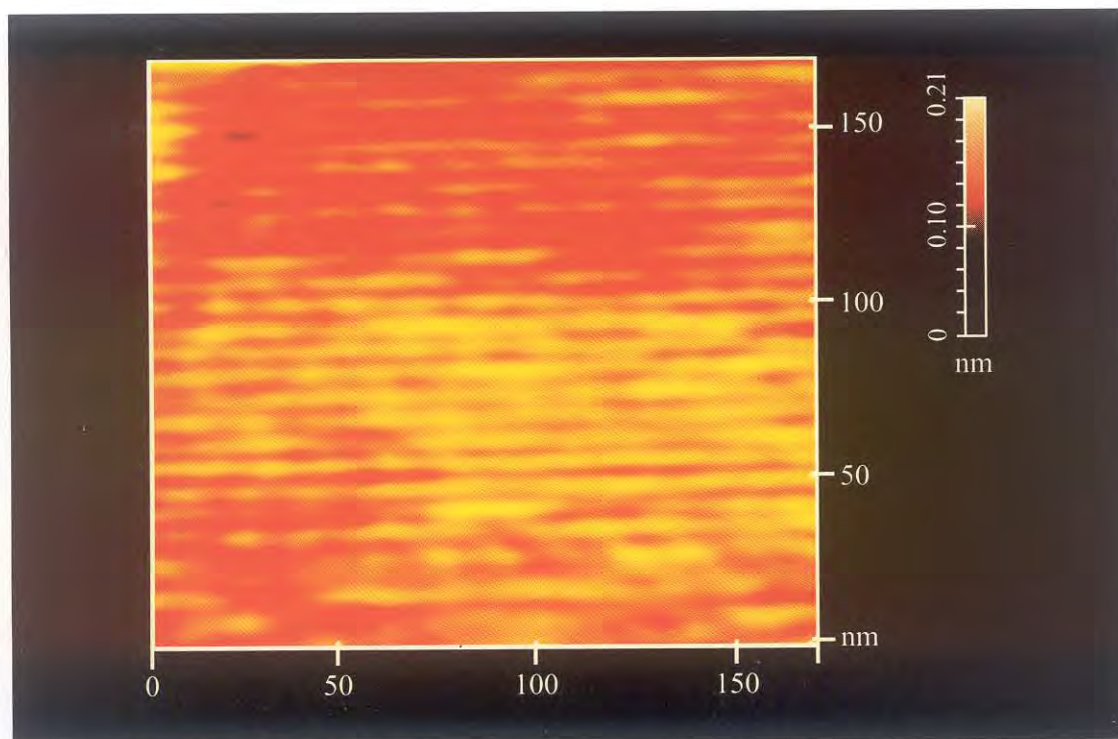


Fig. 4.9 AFM micrograph of the CNTs in a sample deposited at -200 V RF bias and 25 W microwave power on silicon substrate treated with Nickel nanoparticles. Tube diameter is ~ 5 nm

For producing high sp^3 content diamond like carbon films (ta-C) under another DST sponsored project, complete design of a filtered cathodic arc system has been arrived and the system is being fabricated by a reputed vacuum equipment manufacturer. With this development, it is hoped, a preferred coating process and required equipment for tribological coatings can be indigenously made available.

Working with another group in this laboratory OASLM in different configurations are being developed, meeting exacting specifications of our sponsors.

Special Ceramics

High Temperature Superconducting Compounds (HTSC) due to their loss less electrical power transport (I_c) at 77K and high magnetic field tolerance (H_{c2}) at relatively high temperature become the first choice to explore their commercialisation in the high field applications. Among HTS Compounds Bi based BiPSCCO (Bi2223/2212) have been found most

suitable to make devices to meet above requirements. For high magnetic field production and high current transmission a long length multi filamentary tape of HTSC and high super conducting parameters like T_c , J_c , H_{c2} etc. and reproducibility is required. The special ceramic group has been working on this project and has achieved a significant success as a HTSC Bi2223 Ag clad tape up to 20 meter with 32 filaments has been made which is end to end super conducting and having $J_c \sim 10^4$ A/cm² at 77K and 4.2K in a spool form which has been made by wind and react method. The gauge length variation and magnetic field studies are in progress. (Fig.4.10) Apart from multi filamentary HTSC tape of Bi2223, development of a new generation tube conductors of HTSC Bi2223 for loss less high current transport is being done. Tube conductors 10cm long with 2.6cm I.D. and 2.9cm O.D. have been successfully made. The process parameters of these tube conductors are optimized and contact resistance for 120A at 77k and 4.2K has been found $\sim 10^{-5}$ and 10^{-6} Ω respectively which is comparable with international bench mark. Effect of impurities and Ag addition is being studied to reduce contact resistance.

These are the first time achievement on national scenario. Fig.4.11

In house project "Development of graded porosity ceramics for particulate filters" candles for 10BHp diesel engine with 10hrs of continuous operation was developed. Their composition (47 mol % SiO_2 , 23 mol % MgO and 30 mol % Al_2O_3), processing were standardized. Graded porosity was achieved by sponge infiltration. Sponge is taken in layers and dipped in slurry with different solid content

and microwave dried to form a required preform. These preforms are sintered at $1250 \pm \text{C}$ to get the ceramic body. Figure 4.12 shows these candles. Feasibility study on $\beta\text{-Al}_2\text{O}_3$ tubes from "fly ash" was under taken with powders supplied from Central Power Research Institute, Nagpur. These powders received from them show high level of sodium. We have adjusted their composition to suit $\beta\text{-Al}_2\text{O}_3$ preparation. Works on microwave sintering of $\beta\text{-Al}_2\text{O}_3$ was initiated to reduced sintering time.

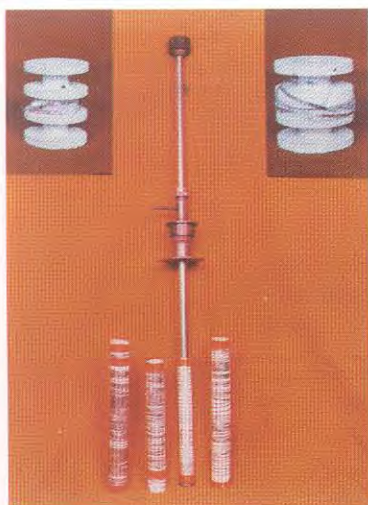


Fig. 4.10 : Superconducting multifilamentary long length Ag clad HTSC (Bi2223) tapes and spools with $J_c \sim 10^4 \text{ A/cm}^2$ at 77K and 4.2K at zero magnetic field



Fig. 4.11: HTSC (Bi2223) tube conductors of OD 2.9 cm, ID 2.6 cm and length 10 cm with $I_c > 120 \text{ A}$ at 77K and 4.2 K at zero magnetic field

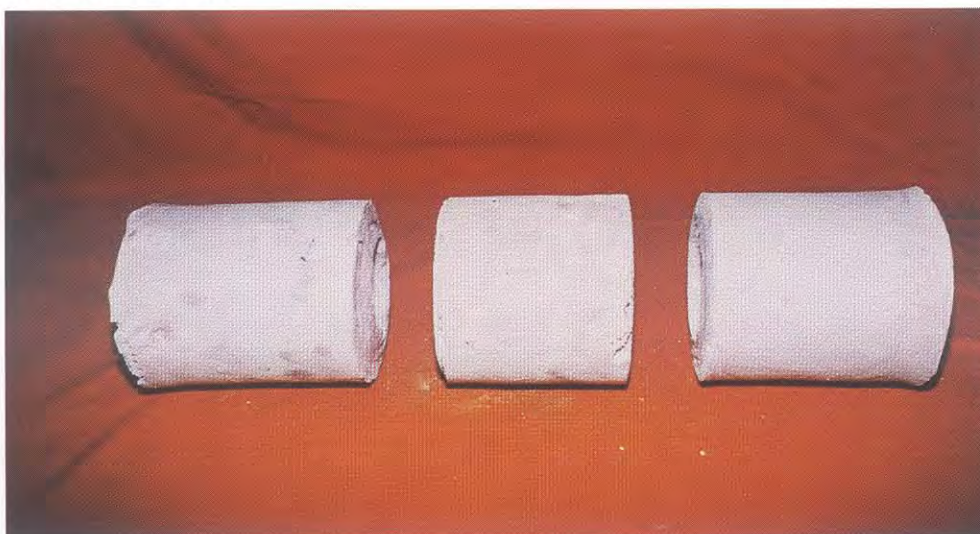


Fig. 4.12: Graded Porosity Candles

बहुलक तथा मृदु पदार्थ

POLYMERIC & SOFT MATERIALS

बहुलक तथा मृदु पदार्थ

बहुलक तथा मृदु पदार्थ प्रभाग में – द्रव क्रिस्टल प्रदर्श साधन, जैव संवेदक तथा एकसरे विकिरण चित्रण सहित बहुलक इलेक्ट्रॉनिक साधन शामिल हैं। यह प्रभाग बहुलक तथा कार्बनिक पदार्थों के प्रयोग जिसमें द्रव क्रिस्टल, फेराइलेक्ट्रिक द्रव क्रिस्टल, चालन बहुलक, रूढ़ परावैद्युत बहुलक, रसायन परिष्कृत अर्धचालक तथा नैनोक्रिस्टलीय अर्धचालक शामिल हैं जैसे विषयों में कार्यरत है। यह प्रभाग पशु चिकित्सा अनुप्रयोगों और अनाशक संपरीक्षण इत्यादि के लिए कुछ प्रतिनिधि अनुप्रयोगों में फेरोइलेक्ट्रिक द्रव क्रिस्टल जिसमें द्विस्थितिक तथा माइक्रोसेकण्ड रेस्पांस, ऑप्टिकली एडरेस्ड स्पेशियल लाइट माड्युलेटर्स, टॉक्सिक गैसों के लिए बहुलक संवेदक तथा सूक्ष्मजैविकी जीव, ग्लूकोस के लिए जैव संवेदक, कोलेस्टेरॉल, यूरिक एसिड, यूरिया तथा 1-लैक्टेट शामिल हैं के कार्यों में जुटा हुआ है।

POLYMERIC & SOFT MATERIALS

The division of Polymeric & Soft Materials comprises of liquid crystal display devices, bio-sensors, polymeric electronic devices , and xeroradiography. The activity involves the use of polymeric and organic materials, which involve liquid crystals, ferroelectric liquid crystals, conducting polymers, conventional dielectric polymers, chemically modified semiconductors and nanocrystalline semiconductors. Some of the representative applications include ferroelectric liquid crystals having bistable and microsecond response, optically addressed spatial light modulators, polymeric sensors for toxic gases and microbiological organisms, bio-sensors for glucose, cholesterol, uric acid, urea and l-lactate and xeroradiography for veterinary applications and non-destructive testing etc.

Liquid Crystal / Display Devices

Liquid Crystals : Basic and Applied Aspects

The liquid crystals, particularly ferroelectric liquid crystals have been studied extensively due to both their large electro-optic effects, which make them appear promising for optical displays and their interesting basic properties. Ferroelectric liquid crystals (FLCs) due to their fast switching response have a great advantage over nematic liquid crystal displays. However, they are not widely used because there are a number of difficulties in their applications, including the understanding and control of alignment, switching mechanisms etc.

The most widely studied liquid crystal displays based on ferroelectric liquid crystals is the surface stabilized (SSFLC), in which all the LC molecules are aligned parallel to the substrate and the helix is suppressed by means of a binding glass substrates. The bistability is inherent in this configuration. Typical SSFLC devices require long pitch liquid crystal materials and small cell gaps. Recently, a new type of ferroelectric liquid crystal material is studied at NPL, called distorted helix ferroelectric liquid crystals (DHFLC) which is in many ways complementary to the SSFLC effect and uses

short-pitch FLC materials where the smectic planes are perpendicular to the glass substrates of the cell. It has no inherent bistability. DHFLC exhibit no inherent optical threshold voltage and so gray scale can be easily obtained by using these materials. The switching and molecular dynamics of DHFLC materials is being vigorously studied by electro-optical and dielectric spectroscopic method at NPL.

The applied aspect of liquid crystal materials being carried out at NPL is the spatial light modulators (SLM) which is the key component for a variety of optical and opto-electronic systems, such as optical computing, image processing and information display applications. The SLM impresses wavefront modulation on an optical read out beam thereby facilitating the propagation and manipulation of information in the optical domain. We at NPL have prepared optically addressed spatial light modulators using a wide variety of liquid crystal materials for the IRDE, Dehradun, (DRDO) Organization. Nematic liquid crystal based SLM's have been prepared and ferroelectric liquid crystal based SLM's are being prepared for them (IRDE, Dehradun). A liquid crystal based SLM configuration is shown in Figure 5.1, which consists of non-alkaline flat glass substrates, covered with transparent electrodes, photoconductor

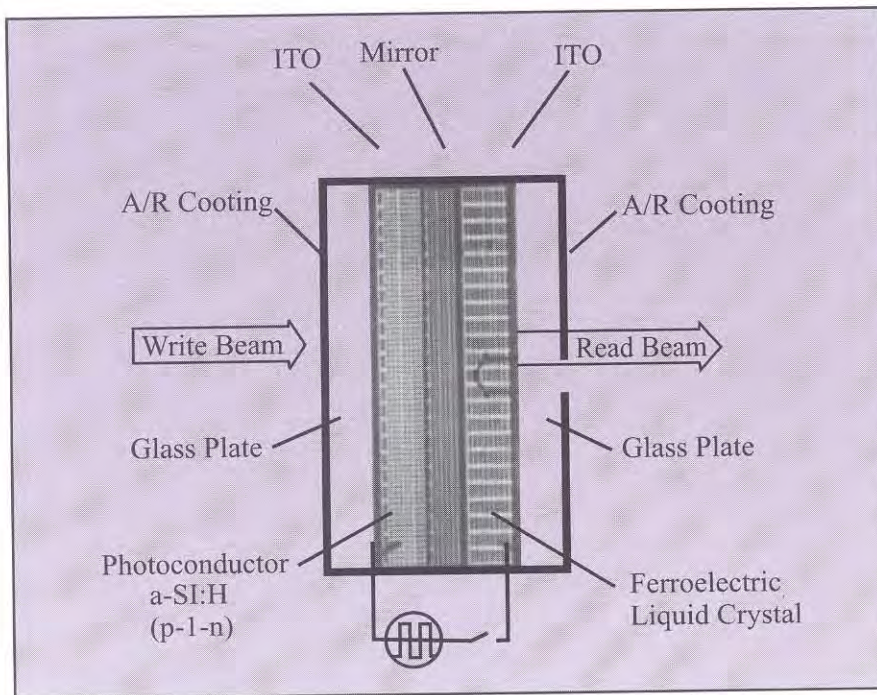


Fig 5.1: A schematic diagram of Optically Addressed Spatial Light Modulator

and mirror coatings over the transparent electrodes and then the alignment layer is given on both the electrodes and then the LC material is sandwiched between the two electrodes.

Liquid Crystalline Materials & Devices

Growth and Characterization of Self-assembled Monolayers and Multilayers

The field of self-assembled molecular assemblies of organic molecules with planned structure and properties has witnessed phenomenal growth in last two decades. It offers unique opportunities to improve fundamental understanding of self-organization, structure property relationship and interface phenomena. The self-assembled monolayers (SAMs) are excellent systems for understanding the phenomena like ordering and growth, wetting, adhesion etc. affected by competing intermolecular, molecule-substrates and molecule-substrate interactions. The SAMs provide the needed designed flexibility both at individual molecular and at material levels. Their study is of great relevance to science & technology and are likely to play a pivotal role in molecular engineering, supra - molecular machines for information processing communication systems, energy conversion etc.

As a part of the ongoing activity on creating

highly ordered polymeric-solid interfaces (under the Indo-US collaborative project), monolayers of amino propyl triethoxy silane (APTES) with high structural integrity have been grown on glass and quartz substrates and investigated by i) contact angle measurement, ii) ATR-FTIR, and iii) XPS. The attachment of the cinnamoyl moieties to the APTES molecules was monitored with a UV-spectrophotometer by monitoring the corresponding absorption band at $\sim 278\text{nm}$. Figure 5.2 shows the variation in the absorbance (area under absorption band) as a function of time of immersion of the quartz substrates in the cinnamoyl chloride solution (0.05M). The absorbance attains saturation after some time and corresponding to the full coverage of the APTES molecules with cinnamoyl moieties. The time of immersion depends critically on the concentration of cinnamoyl chloride and TEA in the solution and temperature and humidity of the surrounding. The quartz substrates deposited with molecular assemblies were irradiated with linearly polarized UV-light to create anisotropic surface structure. The irradiation leads to a strong decrease in the UV-absorption band at 278nm .

The interface structure thus created on the glass/quartz substrate is highly ordered and shows a strong surface anisotropy as is shown by our Atomic Force Microscope (AFM) studies. A typical AFM

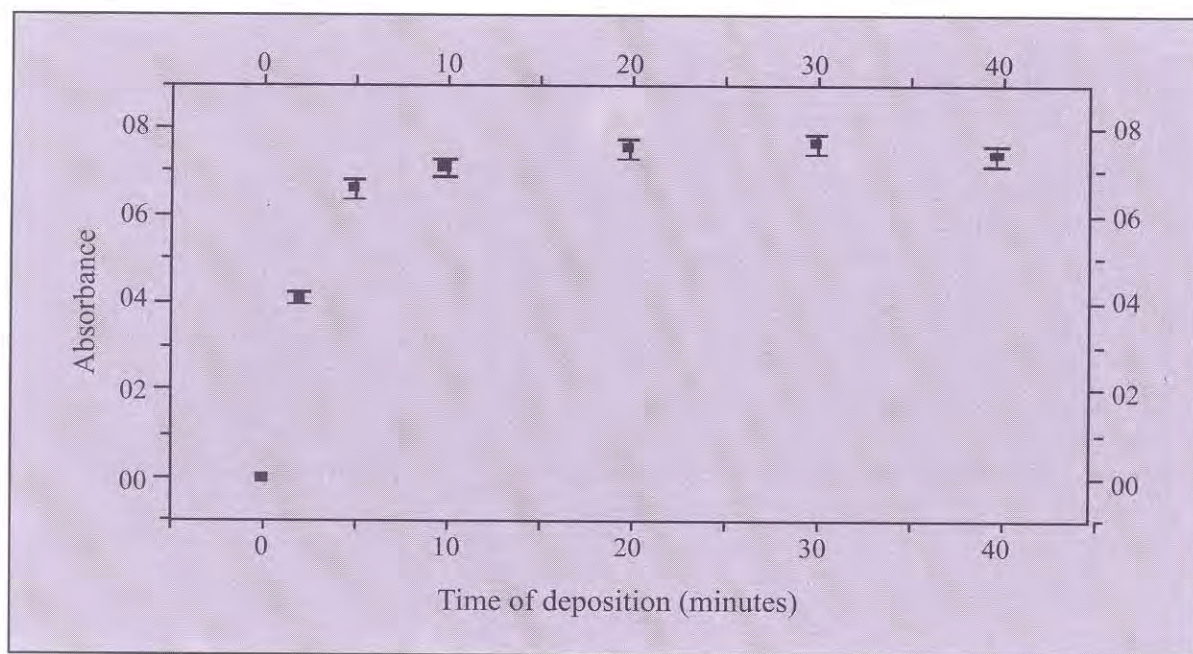


Fig 5.2: Plot of absorbance of 278nm band as a function of time of immersion of APTES coated substrate in cinnamoyl chloride solution (0.05M).

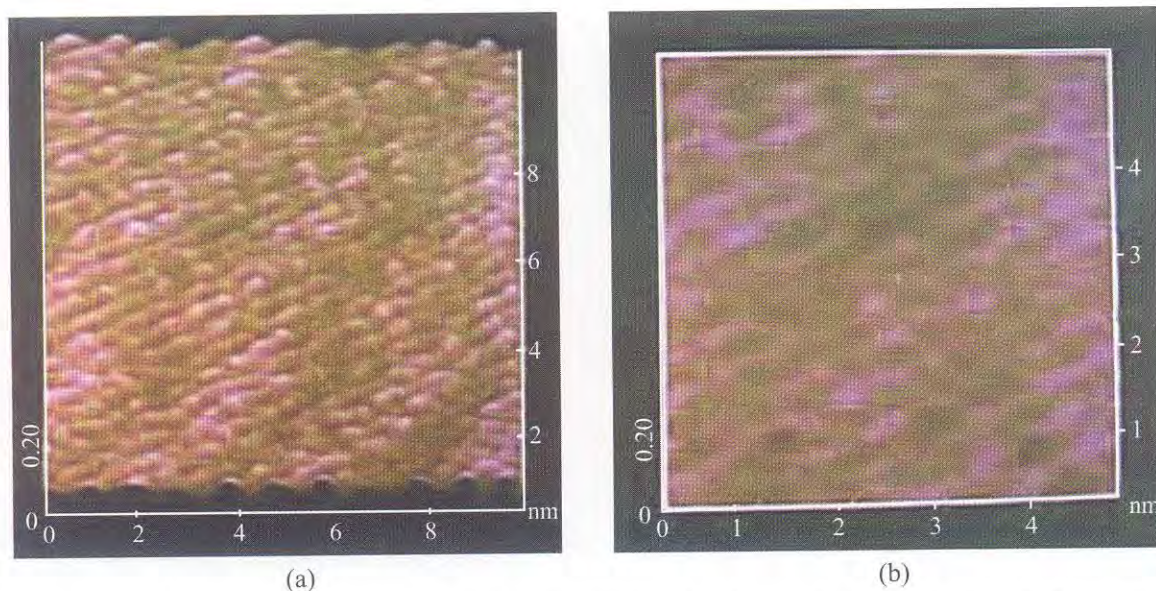


Fig. 5.3 (a) An AFM image at 60° pitch of dimerized APTES molecules attached with cinnamoyl chromophores on ITO coated glass substrate (scale $10 \times 10 \text{ nm}$), (b) higher magnification view of Fig.5.3 (a) (scale $5 \times 5 \text{ nm}$).

image of such a surface over an area of $10 \times 10 \text{ nm}$ is shown in Fig.5.3a. The contrast arises due to imaging of the benzene rings attached to the APTES molecules. The gray scale corresponds to an apparent height range of $\sim 0.15 \text{ nm}$ where the white is higher than the black. The molecules are closely packed in parallel arrays. It was confirmed that the change in the scanning direction did not change the observed structure. The arrays are inclined to horizontal edge of the surface and the inclination angle ($25\text{-}30^\circ$ in the present case) is related to the direction of the electric field vector of the linearly polarized UV-light with respect to the horizontal edge of the glass plate, used for photo-dimerization of the molecular assembly. The similar ordered molecular arrangement was seen in different regions of the sample with some variation in the orientation angle of the arrays. The spread in the inclination angle was $< 10^\circ$. The surface of the non photo-dimerized molecular assembly was also imaged with the AFM to assess the effect of UV-irradiation. No such ordering could be seen in the above molecular assembly. Though the molecules on the surface could be imaged but no parallel arrays could be seen. It was safely concluded that the ordering in the molecular assembly arises due to irradiation by UV-polarized light. Fig.5.3 b is the magnified AFM image (scan area: $5 \times 5 \text{ nm}$) of the same surface (Fig.5.3a) showing individual APTES molecules. It can be seen that the

surface exhibits in addition to ordered arrangement of the molecules, a surface corrugation leading to surface anisotropy. It has been measured that the average distance between the two side by side arranged molecules in arrays is $\sim 6.5 \text{ \AA}$, and the average inter row spacing is $\sim 4 \text{ \AA}$. The size of the ensemble was 20 molecules. Such an interface structure at the polymer-solid surface produces uniform planar orientation of liquid crystals. The direction of planar orientation is controlled by the direction of the electric field vector of the linearly polarized UV-light and is at right angle to it. Efforts are under way to produce planar orientation of ferroelectric liquid crystals by this technique and characterize them for their electro-optic response properties.

Biosensors

Urea Biosensor

Urease was immobilized in mixed monolayers of poly-N-vinyl carbazole (PNVK) and stearic acid (SA) formed at an air-water interface. The monolayers were transferred onto ITO coated glass plates using Langmuir-Blodgett (LB) film deposition technique. Potentiometric measurements on these urease electrodes were carried out using an ammonium ion analyzer. A linear correlation between potential sensed by an ammonium ion selective electrode and urea concentration was obtained in the range 0.5 mM to

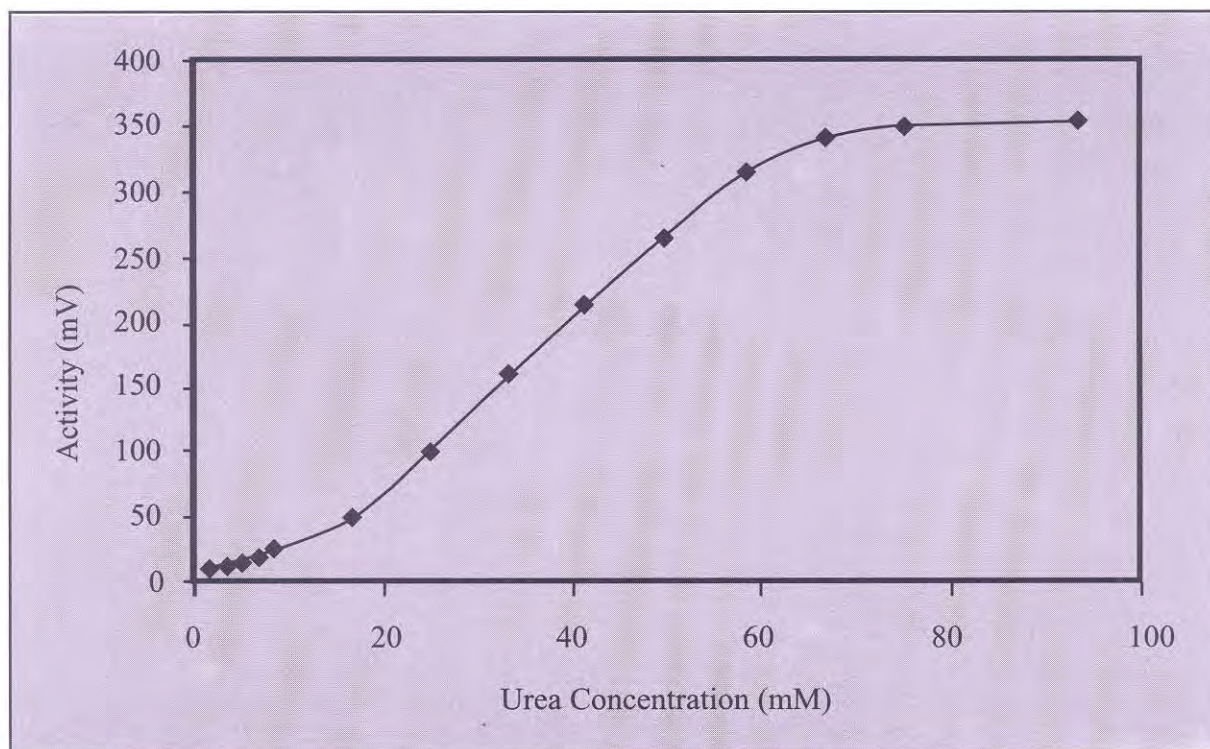


Fig. 5.4 : Response curve of PNVK/SA/urease LB films as a function of urea concentration

93mM (Fig.5.4) when this electrode was used. Two linear ranges were obtained viz. 0-10mM and 10-68mM. The response time of the urease/PNVK/SA LB electrode was about one minute.

Glucose Biosensor

A glucose biosensor based on glucose oxidase(GOX) coupled to poly-o-aminobenzoic acid has been fabricated. Amperometric response measurements conducted via unmediated and mediated (with ferrocene carboxylic acid and tetrathiafulvalene) reoxidation of GOX show that glucose can be detected over a wide range of concentrations. The optimal response of enzyme(GOX)conducting polymer(PAB)-mediator (ferrocene carboxylic acid/tetrathiafulvalene) system has been observed at pH5.5 and 300K to lie in 1-40 mM range. The operation stability of the PAB-based biosensor has been experimentally determined to be about six days.

Lactate Biosensor

The immobilization of lactate dehydrogenase(LDH) on electro-chemically polymerized polypyrrole-polyvinylsulphonate(PPY-PVS) films has been accomplished via cross-linking technique using

glutaraldehyde. The characterization of the LDH-immobilized PPY-PVS films has been carried out using FTIR and cyclic voltammetry. These PPY-PVS-LDH electrodes have been found to have a detection limit of 1×10^{-4} M, response time of 40s and a shelf-life of about two weeks. It has been seen that these electrodes can be used to estimate l-lactate concentration from 0.5 to 6mM (Fig.5.5).

Cholesterol Biosensor

The dodecylbenzene sulphonate (DBS) doped polypyrrole conducting polymer films were electro-chemically deposited onto the indium-tin-oxide(ITO) coated glass plates in aqueous medium. The enzyme cholesterol oxidase(ChOx) was immobilized on these DBS-PPY films by physical adsorption technique. These ChOx immobilized DBS-PPY films were characterized by UV-visible and FTIR spectroscopy. The enzyme activity in the ChOx/DBS-PPY film was assayed as a function of cholesterol concentration. The results of amperometric measurements conducted on ChOx/DBS-PPY/ITO electrodes (Fig.5.6) exhibit response time of about 60 seconds and are stable up to about three months at 4°C.

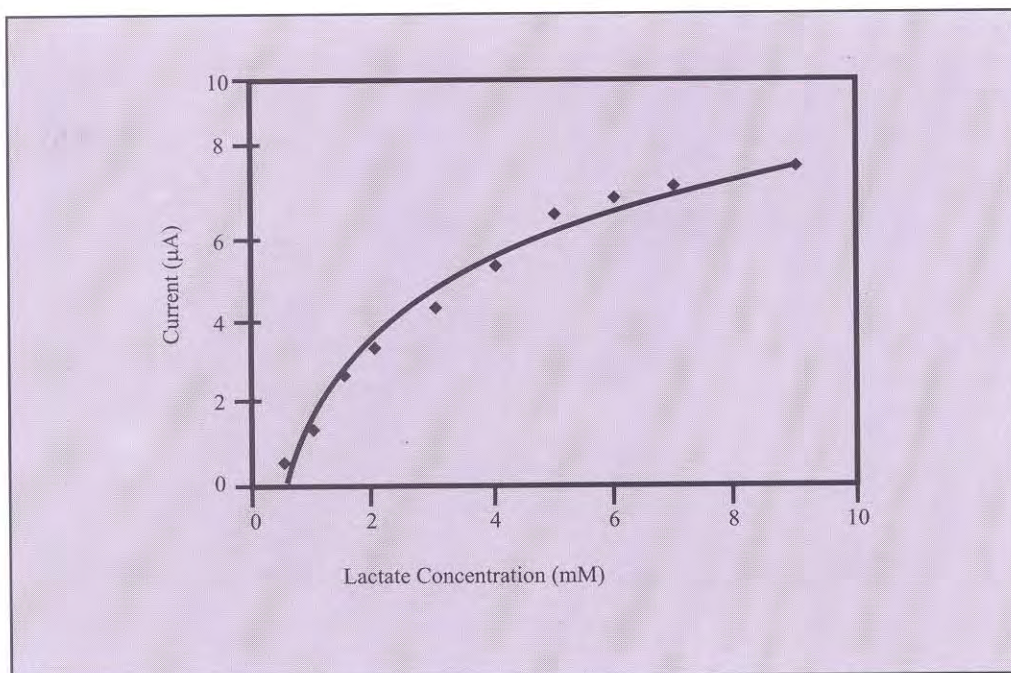


Fig.5.5 Amperometric response of Ppy-PVS-LDH electrodes at 0.2 V (bias voltage) in the presence of lactate and NAD (0.02 M) in phosphate buffer (0.1 M, pH 7.2).

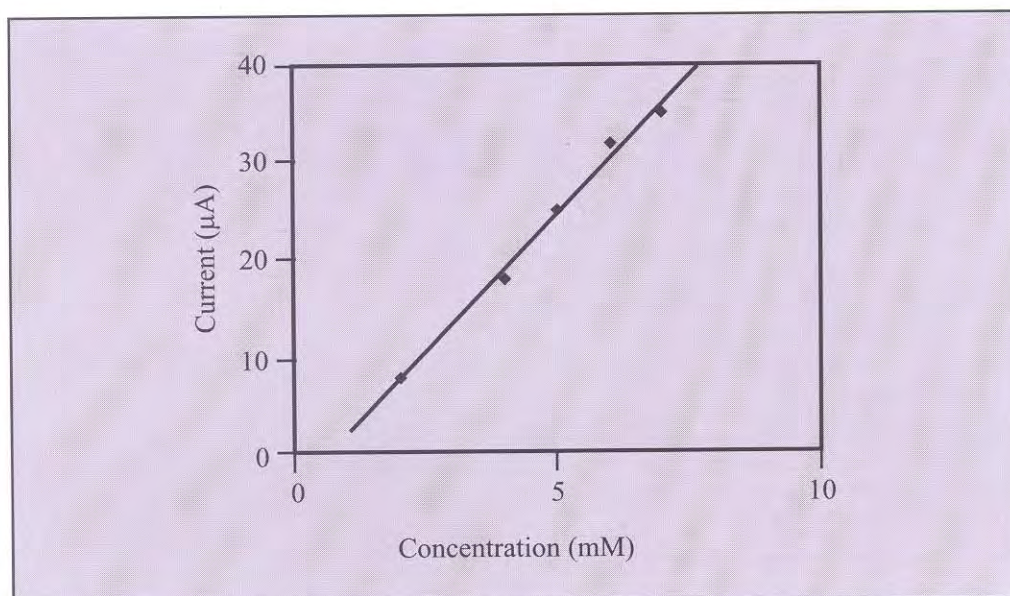


Fig. 5.6 : Amperometric response obtained with ChOx/DBS-PPY electrode in phosphate buffer (pH 7.0) as a function of cholesterol concentration

Langmuir-Blodgett Films of Poly (3-Dodecyl Thiophene)

Monolayers of poly-3-dodecyl thiophene (P3DT) have been obtained on indium-tin-oxide (ITO) coated glass plates by dispensing mixed solution of poly-3-dodecyl thiophene and stearic acid prepared in chloroform onto

water subphase by a microsyringe. These P3DT-SA monolayers transferred onto indium-tin-oxide (ITO) glass plates were characterized by FTIR, atomic force microscopy (AFM) (Fig.5.7) and cyclic voltammetry experiments. The desired enzyme monolayers were fabricated by dispensing glucose oxidase mixed with P3DT/SA in chloroform and transferred onto desired

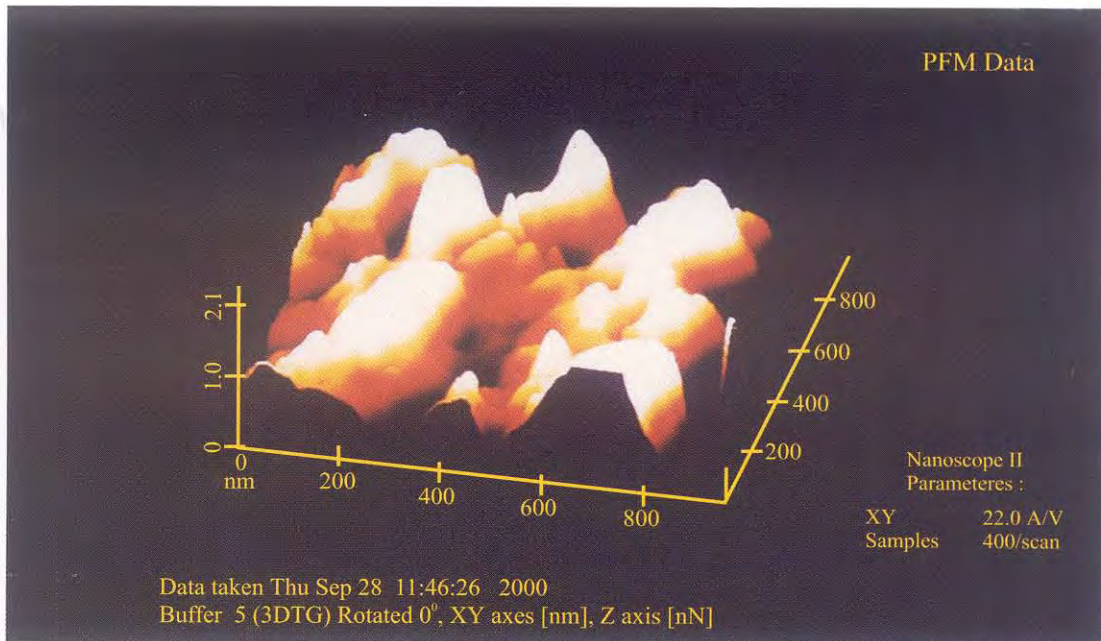


Fig. 5.7 AFM image of glucose oxidase immobilized poly-3 Dodecyl Thiophene LB film

indium-tin-oxide (ITO) glass. These GOX immobilized P3DT/SA films can be used for the estimation of glucose from 100 mg/dL to 400 mg/dL (Fig.5.8). These electrodes are stable up to 40°C and the shelf life of these electrodes is 40 days under 4°C.

With a view to facilitate the testing of the biosensing electrodes, attempts were made to write

software for the coupling of the Keithley multimeter and the Electro-chemical interface with PC.

Polymeric Electronics Devices

Conducting Polymers

The potential usefulness of conducting polymers has

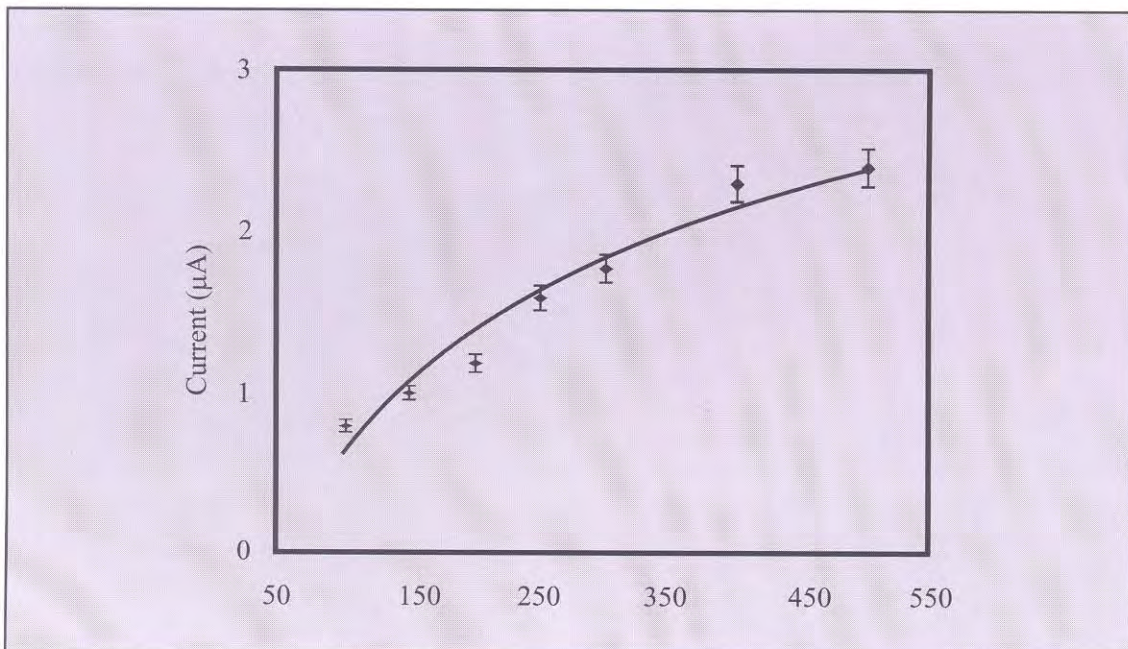


Fig. 5.8 : Amperometric response of P3DT/SA/GOX LB film in phosphate buffer (pH 7.0) at 0.4V (bias voltage)

been increased dramatically by the discovery that the electrical conductivity of these materials could be increased by several orders of magnitude by doping i.e. addition of electron acceptors or electron donors lead to sudden rise in electronic conductivity. Electromagnetic interference (EMI) shielding conducting plastics in our country is a stage of dynamic growth because of sustained growth of the electronic equipments in our country which are susceptible to electromagnetic pollution. To avoid EMI, conductive composites were developed that would not only drain the static charge from the plastically dressed operator but would also provide a barrier to the radiation generated from inside or outside the source. Certain specific conductive polymer composites were developed which shows a shielding effectiveness of the order of 20-60 dB depending upon the loading level of the conducting polymer in the host polymer matrix. Conducting polymer coated high silica fabrics were also developed which shows a shielding effectiveness of 35 dB at 101 GHz range. The conducting fabrics were also examined in the microwave range from 8-12 GHz and UV-Visible-NIR range. The reflectance/transmission tests of the conducting fabrics in 8-12 GHz range shows that that the conducting fabrics gives a value of -3 to -11 dB in the above range whereas a transmission value of 5 to 10 dB is obtained. The response of the conducting polymer coated fabrics in UV-Visible-NIR range shows that 98 % of the energy is absorbed by the conducting polyaniline coated fabrics and 2 % is reflected back. In polypyrrole coated fabrics, 95.16 % of energy is absorbed and 4.84 % is reflected back. In polythiophene coated fabrics, 81.8 % of the energy is absorbed and 18.2 % is reflected back.

Conducting polymer composites were also tested as sensor material for aqueous ammonia. The resistance change of the composite film on exposure to different concentrations of aqueous ammonia shows its utility as a sensor material. The composite film on exposure to 10^{-4} to 10^{-5} aqueous ammonia shows a well defined response behaviour and this aspect has been utilized in designing the ammonia sensor. Studies were also done to observe the response behaviour of conducting polymer on exposure to HCl vapours.

A water-soluble polyaniline was synthesized which shows interesting corrosion inhibition behaviour for iron and mild steel. It was observed that compensated sulphonated polymer shows a crystalline behaviour whereas the parent polymer polyaniline is

amorphous in nature as observed by the x-ray diffraction studies. Figure 5.9 shows the x.r.d. Pattern of various forms of polyaniline. Whereas x.r.d. behaviour of emeraldine base (curve a), doped polyaniline (curve b), sulphonated polyaniline (curve c) shows amorphous behaviour, compensated sulphonated polyaniline response (curve d) shows crystalline behaviour. The synthesized polymer shows a sharp melting point and crystallization temperature whereas it has been observed that the parent polymer polyaniline does not have sharp glass transition temperature or melting point. The scanning electron microscope of the water-soluble compensated polyaniline also showed needle shaped morphology as compared to globular morphology observed for the parent polymer polyaniline. The compensated polymer was tested as a corrosion inhibitor for iron and mild steel in highly corrosive medium like HCl or saline water and a corrosion inhibition efficiency of 90-94 % was observed for iron and mild steel.

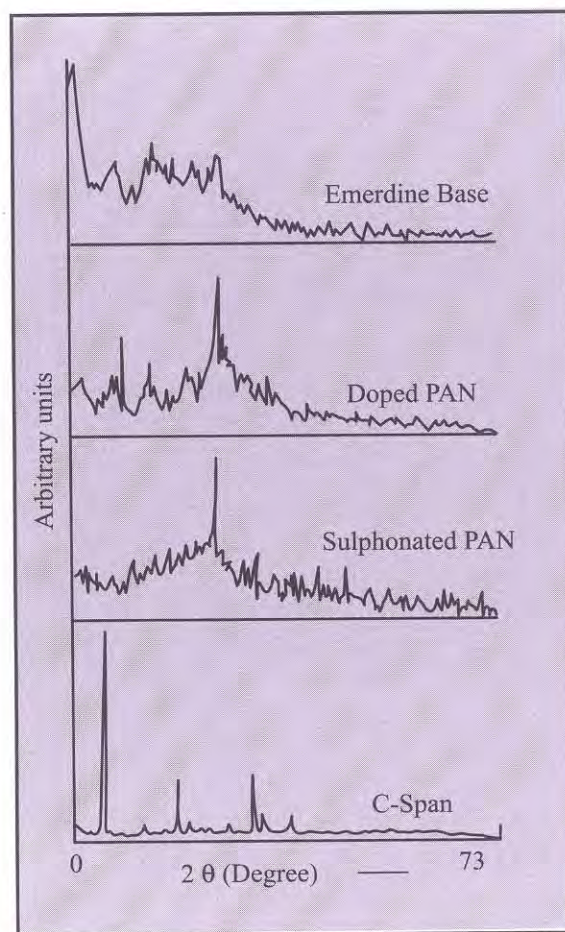


Fig. 5.9 : xrd behaviour of various forms of polyaniline and water soluble polyaniline

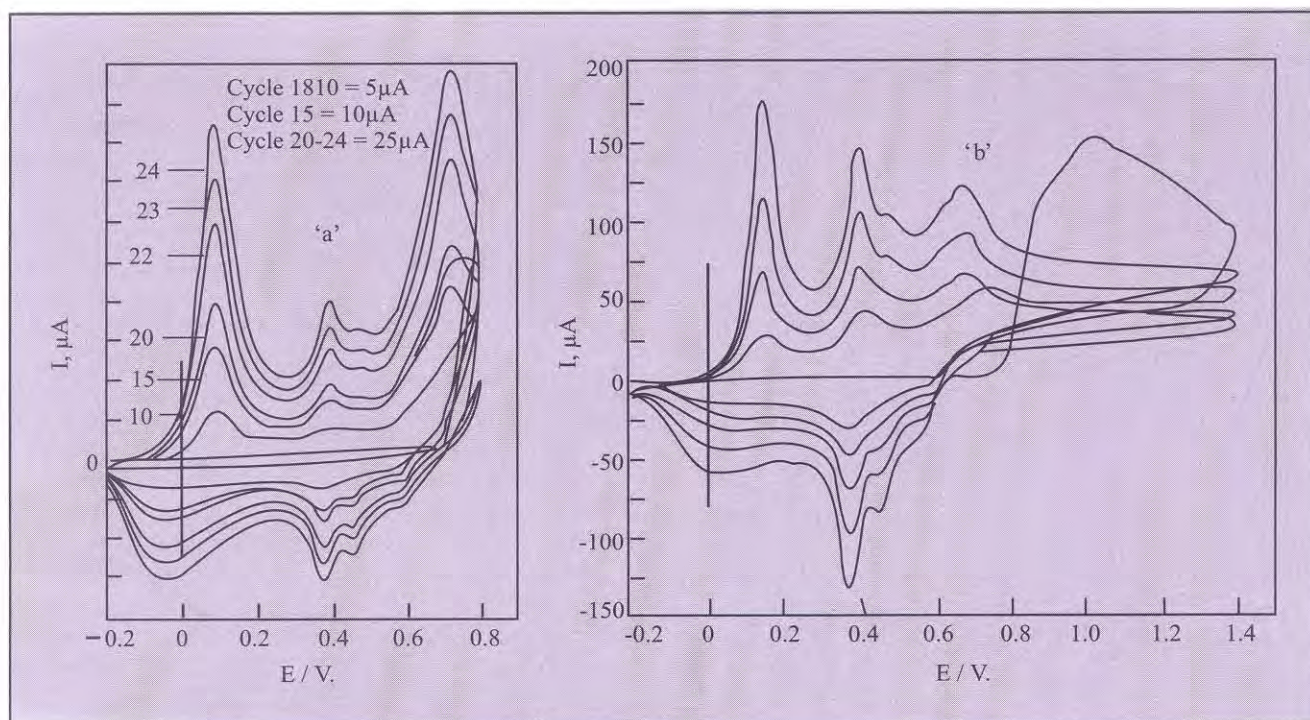


Fig. 5.10 : Growth C V curves of polyaniline growth in 1.0 M organic acid + 0.1 M aniline
 (a) On sweeping potential between -0.2 V to +0.8 V and (b) 1.4 V, at a scan rate of 50 mV/sec on Pt electrode

Substituted poly-p-phenylenes were also synthesized in the laboratory which shows electro-luminescence and can find applications in LED devices. It was observed that whereas Poly-p-phenylene, PPP, is insoluble in organic solvents and intractable, the introduction of a substituent brings about solubility in the polymer. The resultant polymer so obtained was found soluble in common organic solvents like toluene, chloroform, methanol etc.

The electrochemical growth studies of aniline in protonic acid medium was also carried out on either platinum or indium tin oxide electrodes by cyclic voltammetry technique by cycling the potential between negative and positive potentials at a scan rate of 20-50 mV/sec vs. saturated calomel electrode (SCE). Fig. 5.10 shows the cyclic voltammogram recorded during anodic polymerization of aniline by potential sweeping between 0.2 V to +0.8 V (curve a) and 0.2 V to 1.4 V (curve b) versus SCE. Electrochromic response studies of conducting polyaniline and its analogues were also carried in the potential range of 0.2 volts to +0.8 volts and a response time of 50 msec was observed on going from reduced state to oxidized state and back. A life cycle of polymer film on electrode surface shows that the conducting

polymer film is stable up to 1×10^6 cycles and 80 % of the electroactivity of the polymer film is retained provided the upper potential range is restricted to +0.4 volts. It was also observed that the electrochromic response time is dependent upon the thickness of the polymer film on electrode surface. The 1.0 micron Polyaniline film shows a response time of 50 msec whereas a 100 micron polymer film shows a response time of 480 msec.

Development of Polymeric Thin Films by Vacuum Deposition

Nanocrystalline polymers with a variety of dopings for fabrication of fast response polymer based solid states and sensing devices have been prepared. The dopants were used as combination of Al, Fe, Ni, Co, Cu, and Mn etc in various stoichiometric combinations to make specific and selective sensors for toxic gases and microbiological detection. The nanocrystalline polymer composite thin films were deposited on various substrates like mica, silicon and glass. The structural characterization of these thin films was carried out with the help of X-ray diffraction, scanning electron microscopy, surface topography etc. The scanning electron micrograph of polymer thin film

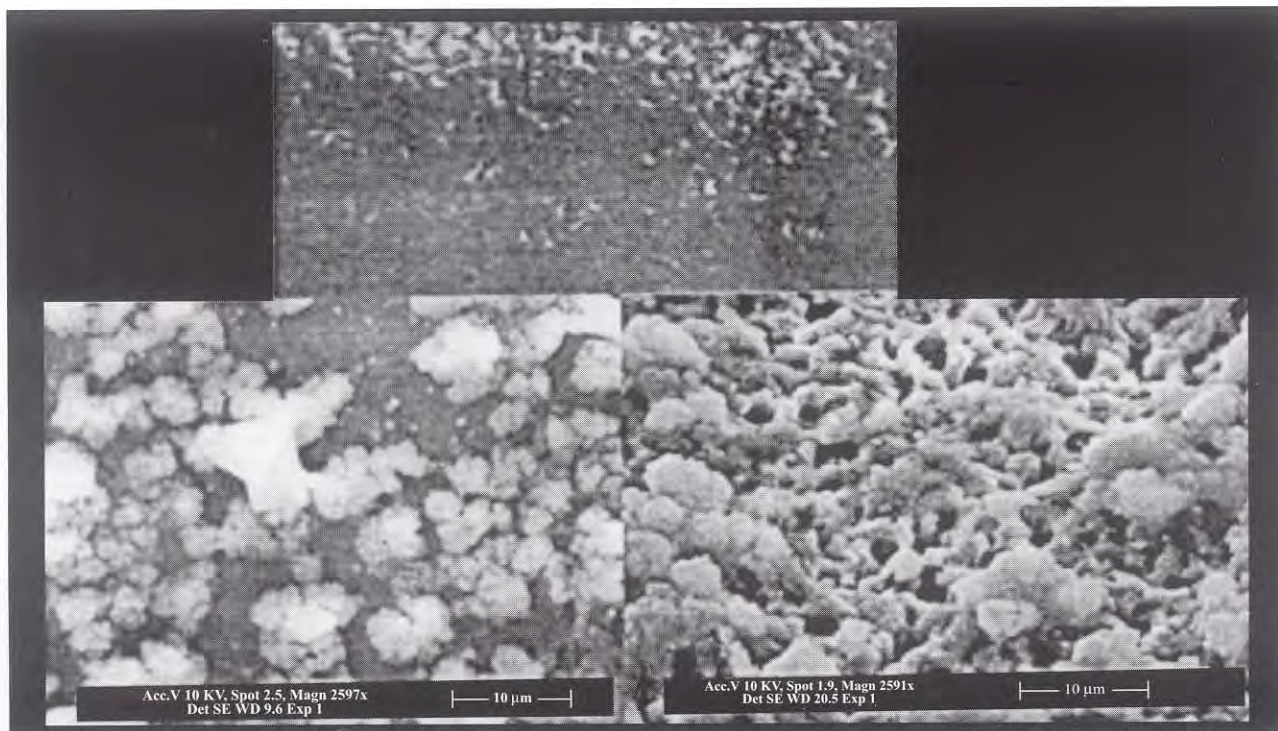


Fig. 5.11 Scanning electron micrograph of polyaniline thin film vacuum deposited on mica, flat silicon and macroporous silicon substrate

deposited on mica and flat silicon and macroporous silicon is shown in Fig.5.11.

Preparation of Hybrid Sensors for Detection of E Colii

Integration of polymeric thin films with porous n-type (100), 0.05 Ωcm resistivity double side polished silicon has been used to fabricate microsensors that are superior in performance. Such devices include sensors for detection of microbiological organisms like E Colli. The particular doping combination in the polymer makes the sensor specific for detection of E. Coli. The response time of the sensor is about 10 seconds. The macroporous silicon substrate allows obtaining a polyaniline thin film with high specific surface area and good crystallinity, as shown by SEM. These sensors were prepared in collaboration with CNR Lamel, Italy. The device schematic of this configuration is shown in Fig.5.12.

Development of Polymeric Thin Films Sensors for Environment

Highly specific and selective sensors having high sensitivity were prepared for detection of Aspergillus terreus, Aspergillus Flavus, Aspergillus Fumigatus, Aspergillus Nidulans and Aspergillus Niger.

Aspergillus is a genus that gives rise to many diseases in human body like which causes mycotic sinusitis, otitis, fungal sinusitis, cerebral aspergillosis, necrotizing pneumonia, tuberculosis abscess cavities and other pulmonary cavities, pulmonary aspergillom and Peritonitis. These polymeric thin film sensors prepared at NPL have shown excellent sensitivity towards aspergillus with varying sensitivity towards its different species. The sensitivity graph for various sensors is shown in Fig.5.13

Polymeric Non Linear Optoelectronic Devices

Polymeric thin films of poly (methylmethacrylate) with aminobenzophenone polarizable side chain groups, which may be oriented by several techniques, have been prepared. These films exhibit strong electrical and optical non-linearity. These films have strong potential for use as frequency doubler for optoelectronic applications. An essential characteristic of these second order non-linear optical materials is a non centro-symmetric structure. The use of these materials for efficient frequency conversion requires phase matching, large band gaps (that means optical transparency at $W(\omega)$ and $2W$) and high optical damage threshold under continuous long-term

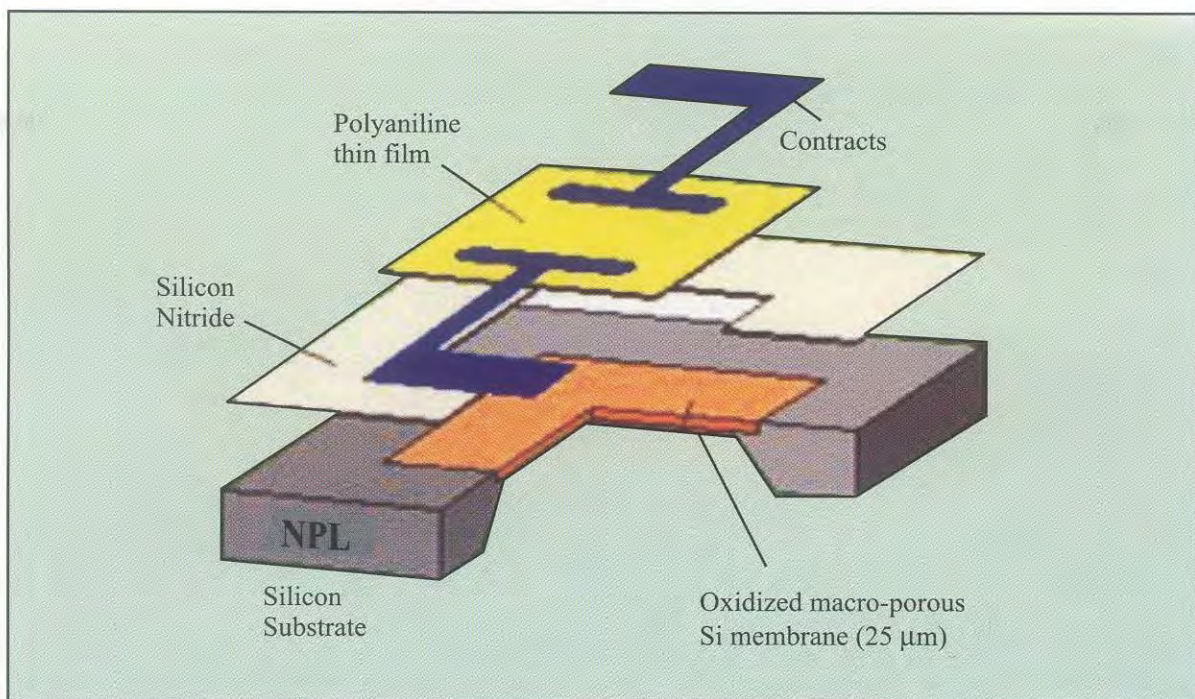


Fig.5.12 Schematic of Hybrid Polymer/ Macroporous Silicon Sensor

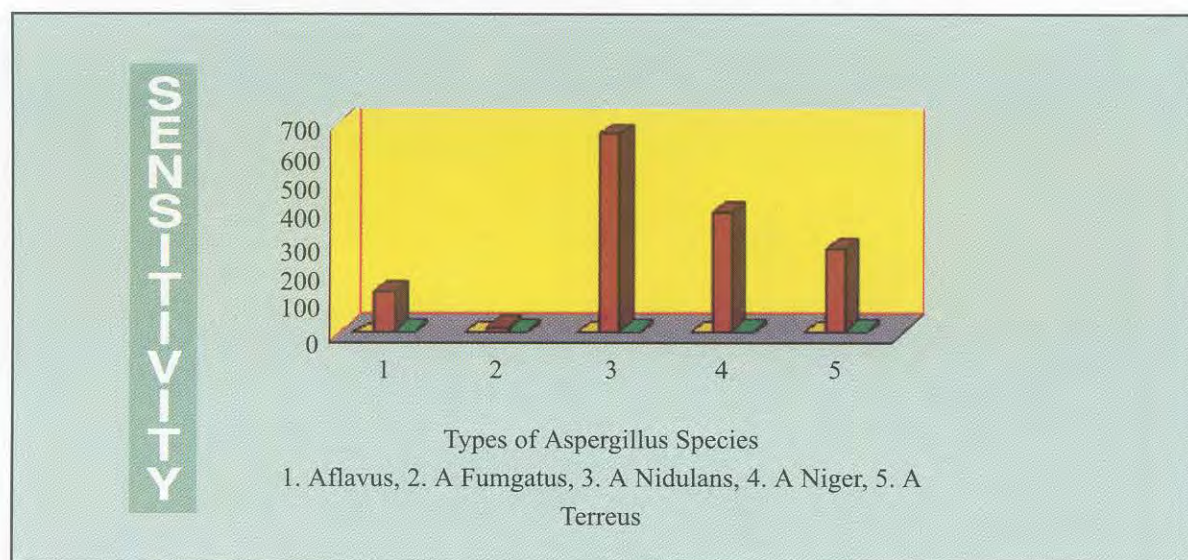


Fig.5.13 The Sensitivity of Polyaniline Thin Film Sensors for Various Forms of Aspergillus

irradiation. These polymeric thin films have been prepared to be highly anisotropic and the behavior of non-linear output is modified critically by the details of the linear dielectric tensors at the fundamental and second harmonic frequencies. An attractive feature of these organic materials is the virtual unlimited potential of organic synthesis which allows subtle changes in molecular structure to be made in order to

enhance the behavior. The synthesis of aminobenzophenone was carried out in two phases. First, a poly (methamethacryloyl chloride) was synthesized, which was converted into poly (amino benzophenone methacrylate). The I R spectra, glass transition temperature of the films was determined. The NLO films were poled at temperatures just below the T_g, to create a directional locking of the polymer

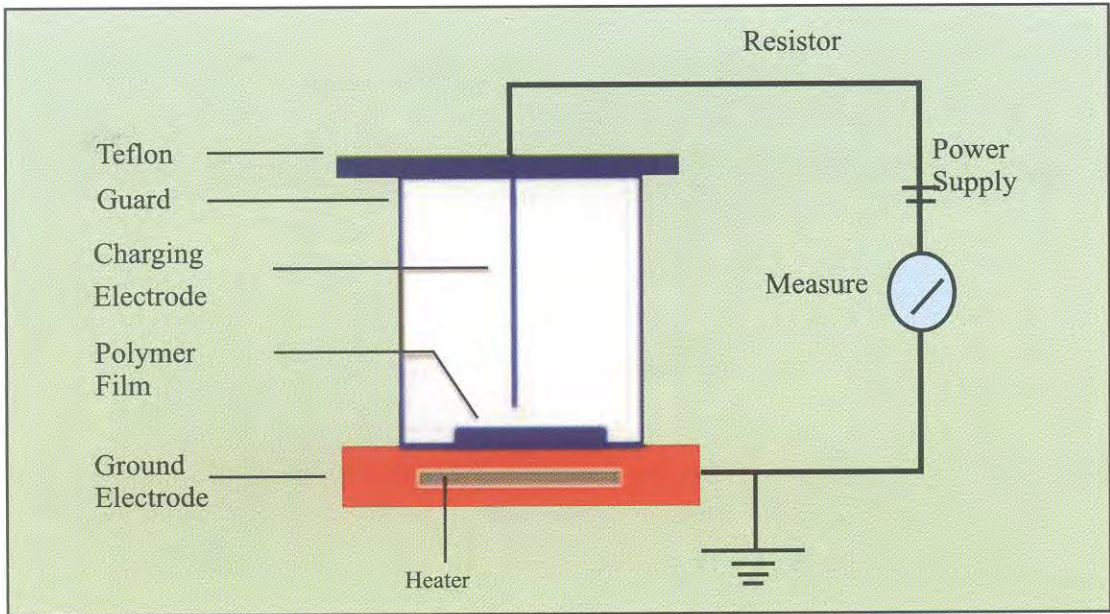


Fig. 5.14 Polymer Poling setup

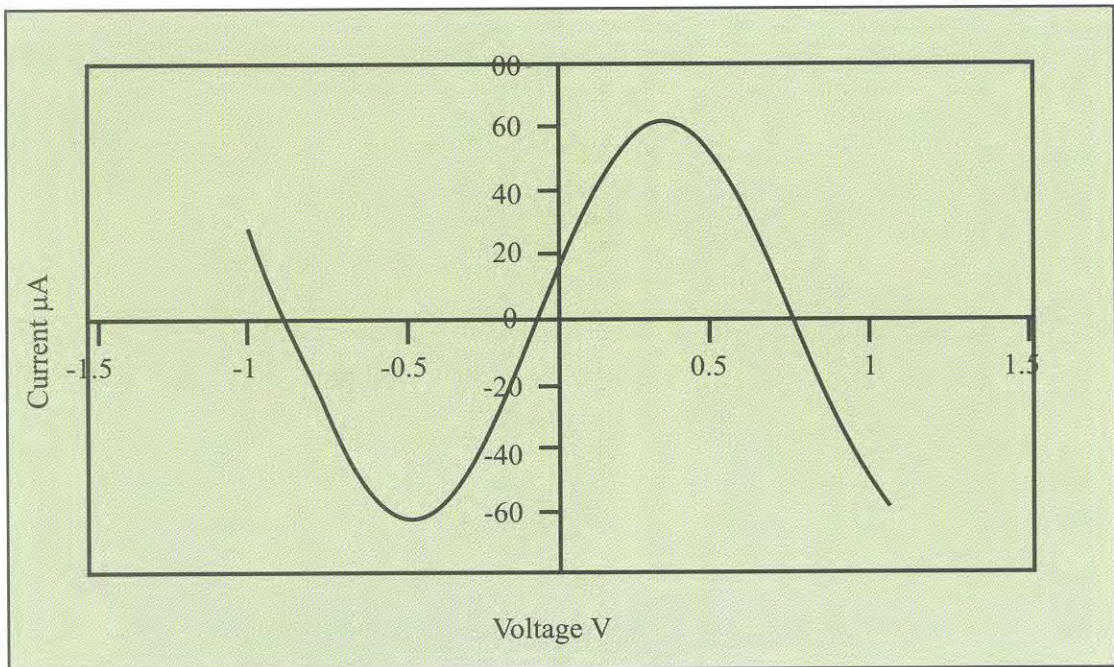


Fig 5.15: I V Characteristics of ABP films

chains. Maker's fringes were used for the measurement of optical non-linearity. A poling set up was fabricated for directional poling of the NLO polymer thin films (Fig.5.14). This work was done under UISTRF in collaboration with University of Strathclyde, Glasgow UK. The poled films of aminobenzophenone were tested for electrical non-linearity.

Fig. 5.15 shows the I-V characteristics of aminobenzophenone films. The clear indication of non-linear I-V characteristics suggests the presence of favored orientation of the polymeric molecular chains in the thin film. This oriented structure creates a structure suitable for creation of space charge in aminobenzophenone films.

Inorganic Alloy Thin Films

Preparation of films by sintering technique has become a widely spread technique of thin film preparation due to its simplicity and versatility. The advantage over conventional methods is its excellent maintenance of stoichiometry, highly ordered films at low temperatures and wide control over film thickness. The technique is particularly suitable for alloys and compounds, which have a tendency to disintegrate and their stoichiometry is disturbed by temperature variation, thereby affecting their electrical, optical properties and energy band gap. For photovoltaic applications, the stringent requirements are regarding the stoichiometry and the thickness of the film. The optical and electrical characterization of ZnSe and ZnTe films prepared by sintering technique has been carried out. These films have been found suitable for photovoltaic applications, and the technology can be economically exploited for preparation of large photovoltaic panels.

Binary alloys of Zn, Se and Te have been prepared for fabrication of devices for conversion of light energy into electrical energy and photo sensitive devices and photo detectors. The II-VI compound semiconductor ZnSe and ZnTe having a wide bandgap 2.70 eV and 2.26 eV respectively are promising materials for use in photo voltaic devices, blue light emitting diode and laser diodes. To attain a high efficiency in photovoltaic and optoelectronic applications a high bandgap material is required. This

allows the maximum transmission of solar spectrum to the low energy bandgap material, which in turn provides a larger open circuit voltage. Alloy Thin Films have also been prepared using $Cd_{1-x}Zn_xTe$ thin films with varying optoelectronic energy band gap with a variety of associated properties required for efficient solar cell fabrication. The thin films of alloys of $Cd_{1-x}Zn_xTe$ have been found to be suitable materials for fabrication of devices for conversion of light energy into electrical energy as photosensitive devices and photo detectors. This technology is simple, inexpensive and holds potential for commercial exploitation as energy conversion devices. The films have polycrystalline structure and the direct energy band gap varies from 1.45 to 2.15eV depending upon the value of x, which can be controlled by modifying the stoichiometry of the evaporating source. The conductivity of the films varied from 3.16×10^{-7} to $1.77 \times 10^{-10} W^{-1} cm^{-1}$.

Polymeric Thin Film Optical Waveguides

Fabrication and characterization of metal doped polyaniline thin film optical waveguide was carried out. The waveguide parameters: refractive index, propagation losses of optical waveguides prepared from vacuum deposited polyaniline thin films have been determined. Vacuum deposited polyaniline synthesized as planar optical waveguide exhibit low optical attenuation having refractive index 1.590, which make this promising for integrated optical

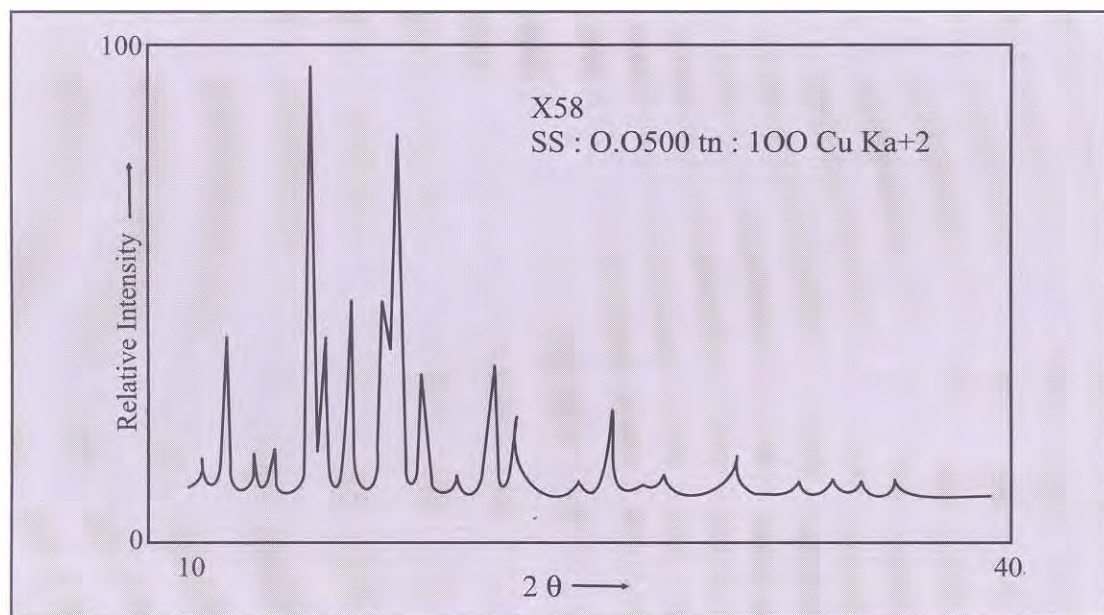


Fig.5.16 Reflected Pout from NLO films of ABP (Pout=Output Power)

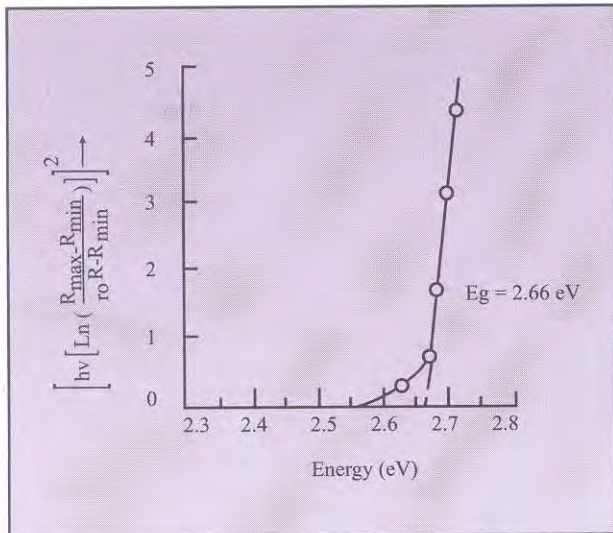


Fig. 5.17 Bond gap determination of ZnSe Sintered Film

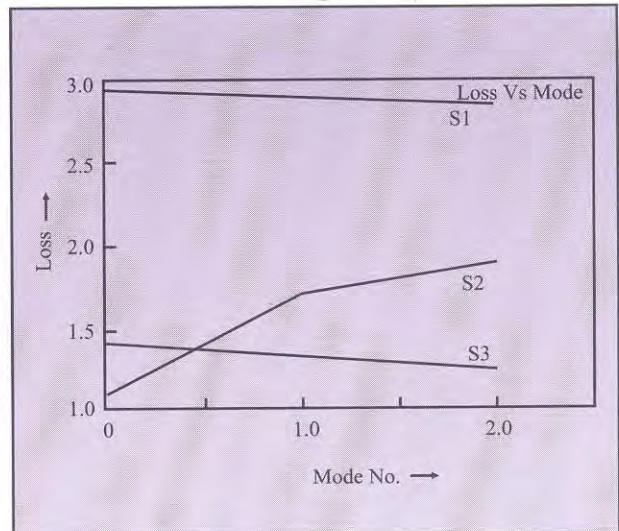


Fig.5.18 Variation of optical propagations losses with modes

devices. The variation of propagation losses with modes is shown in Fig.5.18.

Xeroradiography

In order to develop economic and better sensitive x-ray imaging materials for xeroradiography photoreceptors, fundamental and applied investigations were carried out in a variety of materials such as selenium, polymers, polymer- selenium combinations etc. This work was done under a DST sponsored research program entitled "Intensifying screen-a new dimension in X-ray xerography" Effect of polymer interface layer on charge storage and x-ray sensitivity of a-Se films was investigated. Polymers, such as polyvinyl carbazole (PVK), polyvinyl fluoride (PVF), were incorporated as barrier layers in association with amorphous selenium in the xeroradiographic electrostatic mode. The charge transport and charge decay characteristics of these combinational materials were investigated using the thermally stimulated discharge current (TSD) and

potential decay techniques. These results have shown a promise in terms of improvement in the x-ray sensitivity of a-Se films with the incorporation of PVK and PVF interface layers. In fact, the x-ray sensitivity of $\sim 18.5 R^{-1}$ has been achieved in a-Se films using polymer interface barrier layer. This is about 20% improvement in the x-ray sensitivity over the previously reported highest international value of $\sim 15.5 R^{-1}$ in conventional combinationally doped a-Se films.

In addition to the above we have worked on another DST sponsored project entitled, "Development of a portable analytical x-ray imaging instrument for biomaterials". In this program we have developed a xeroradiography machine comprising of constituents such as Corene Sensitiser, aerosol and developer. We have also procured other components of the instrument such as diagnostic x-ray unit and power generator etc. The testing of this portable instrument is currently in progress.

पदार्थ अभिलक्षणन

MATERIALS CHARACTERIZATION

पदार्थ अभिलक्षणन

एन.पी.एल. का पदार्थ अभिलक्षणन प्रभाग पदार्थों का अभिलक्षणन करने में यथा पदार्थों का संघटन करने, शुद्धता लाने, संरचनात्मक विश्लेषण करने तथा क्रिस्टल दोषों आदि का अध्ययन करने में कार्यरत है। यह प्रभाग चुने हुए पदार्थों जिनमें सिलिकॉन, गैलियम आर्सेनाइड, एम.सी.टी. कैल्कोजनाइड्स, तनु फिल्मों, कांच तथा यौगिक (पदार्थ) शामिल हैं, के अनुसंधान तथा विकास कार्यों में भी लगा हुआ है। एक क्रिस्टल से वृद्धि संबंधी परियोजना पर भी कार्य चल रहा है। एक अंतर्प्रयोगशाला सहयोजित कार्यक्रम के अंतर्गत योजना तैयार करने तथा प्रमाणित संदर्भ पदार्थों को (वांछित व्यक्तियों तक) पहुंचाना इस प्रभाग का एक महत्वपूर्ण कार्यकलाप है। पदार्थ अभिलक्षणन प्रभाग द्वारा एन.पी.एल. की विभिन्न अनुसंधान तथा विकास परियोजनाओं तथा अन्य अनुसंधान संगठनों/उद्योगों को सुविधाएं प्रदान की जा रही हैं। पदार्थ अभिलक्षणन प्रभाग ने जिन पदार्थों का अभिलक्षणन किया है वे इस प्रकार हैं – कैडमियम जिंक टेलुराइड, बी.जी.ओ. क्रिस्टल्स, ओफ्थैलमिक ग्लास, ग्रेफाइट, पोलि एल्युमिनियम क्लोराइड, इनडेलीबल इंक, सिंथेटिक डायमण्ड्स, मिल्क एडल्टरेन्ट्स, फ्लाई ऐश, ऐरोसोल्स तथा ग्रीन हाउस गैसों, हाई ज्व वायर्स एण्ड टेप्स, एलॉय स्टील, कार्बन नैनोट्यूब्स, SiC-C/C कम्पोजिट्स, रोलर मैटीरियल्स तथा डेसीकेन्ट्स, नैनो पार्टिकल्स, ऐपीटेक्सीयल लेयर्स तथा इंटर फेसिस, टरनरी ऑक्साइड ग्लासिस, ऑयन इंप्लांटिड सिलिकॉन वेफर्स आदि पदार्थ।

पूर्व विकसित मौजूदा फाइव क्रिस्टल डिफेक्टोमीटर के कुछ हिस्से का उन्नयन (अपग्रेड) करके एक ग्रेजिंग इंसीडेन्स एक्स-रे डिफ्रैक्शन टांचे (सेट-अप) का विकास किया जा रहा है। वर्ष के दौरान मोनो एलीमेंटल सॉल्यूशन्स के तीन नए तथा छः भारतीय द्रव्यों को तैयार कर प्रमाणित किया गया तथा उन्हें जनता के समक्ष समादृत किया गया। रासायनिक मापों के संबंध में आयोजित अंतरराष्ट्रीय मुख्य अंतर्तुलना संगोष्ठी में इस प्रभाग के वैज्ञानिकों ने बढ़-चढ़कर अपनी भूमिका निभायी। परामर्श तथा प्रायोजित संविदा अनुसंधान परियोजनाओं का कार्य भी आगे बढ़ाया गया। वर्ष के दौरान दो अंतरराष्ट्रीय कार्यशाला भी सफलतापूर्वक आयोजित की गईं।

MATERIALS CHARACTERIZATION

Materials Characterization Division of NPL is engaged in characterizing the materials regarding their composition, purity, structural analysis and crystal defects. It also conducts R&D work on selected materials including silicon, gallium arsenide, MCT, chalcogenides, thin films, glasses and composites. A crystal growth project is also been pursued. Planning, preparation and dissemination of certified reference materials under an inter-laboratory collaborative programme is an important activity. The facilities for materials characterization are being provided to various R&D projects of NPL as well as to other research organizations/industries. The materials characterized includes cadmium zinc telluride, BGO crystals, ophthalmic glass, graphite, poly aluminium chloride, indelible ink, synthetic diamonds, milk adulterants, fly ash, aerosols and green house gases, high Tc wires and tapes, alloy steel, carbon nanotubes, SiC-C/C composites, roller materials and desiccants, nanoparticles, epitaxial layers and interfaces, ternary oxide glasses, ion-implanted silicon wafers etc.

A grazing incidence X-ray diffraction set up is being developed by upgrading some part of the existing five crystal X-ray diffractometer developed earlier. Three new and six Bharatiya Nirdeshak Dravyas of mono-elemental solutions were prepared, certified and released during the year. Scientists of the division have actively participated in international key inter-comparison involving chemical measurements. Consultancy and sponsored contract research projects were pursued. Two successful international workshops were organized during the year.

Characterization of materials regarding determination of elemental composition, estimation of trace impurities, identification of crystalline phases and information on crystal defects play an important role in the development of advanced materials and their use in devices. A strong group equipped with advanced materials characterization facilities exist at the laboratory. The facilities for the analysis of chemical composition and purity includes atomic absorption spectrophotometers, ICP emission spectrometer, chromatographs, FTIR and EPR spectrometers, UV-Vis spectrophotometer, X-ray fluorescence spectrometer, EDS attachment to SEM. X-ray diffraction and electron microscopy/diffraction facilities are employed for the structural characterization of bulk and thin film materials. Microstructural studies of the surface and interface of the materials are characterized by state-of-art scanning electron microscope. The facilities for characterization of single crystals, thin films and interfaces regarding perfection, defects and stress studies include indigenously developed multicrystal X-ray diffractometers with state-of-the-art level resolution.

The specialized techniques and facilities mentioned above are being provided to in-house R&D projects, academic institutions and industries on various types of materials. Sponsored contract research, consultancy and collaborative research projects have been pursued. A number of research papers in reputed international and national journals, were published. Several invited talks were delivered and one patent was filed. Two international conferences were organized at NPL and their proceedings were published.

Analytical Chemistry

Samples of different types received from industries, research organizations and sister divisions of NPL were analyzed for their major and minor constituents by chemical methods, which include both classical and instrumental methods like UV-Vis spectrophotometry, atomic absorption spectrophotometry and gas chromatography etc.

A number of poly-aluminum chloride samples received in batches from Delhi Jal Board were analyzed for their aluminum content. This chemical plays very important role in purification of water. Samples of indelible ink were received regularly from Election Commission of India for election purposes. These were analyzed for their important constituents

like AgNO_3 and performance test was also carried out.

A number of synthetic diamond samples received in fine powder form from different firms were analyzed for major constituents like carbon, aluminum etc. by gravimetry and other impurities like Na, Mg, Ca and Fe by flame atomic absorption spectrophotometry (FAAS). In addition, a number of ferrous and non-ferrous alloys were also analyzed for industries.

Water samples received from IIT, Delhi were analyzed for toxic elements like mercury and arsenic by flame AAS method using hydride generation kit to monitor the affectivity of polymer membrane prepared by them. NPL-DMS have been jointly working on a project on development of spot testing kit for the identification of milk adulterants for which new methods for urea, hydrogen peroxide, neutralizer etc. have already been developed.

Fly ash samples to be used as reference materials received from NCCBM were analyzed for major constituents like alumina, silica, iron oxide, calcium and magnesium oxide by gravimetric and volumetric methods and phosphorous pentoxide and titania by UV-Vis spectrophotometry.

Minor constituents like Mn, Cr, Cu, Ni and As were analyzed by FAAS and ICP-AES etc. The analysis of As was done by hydride generation using a kit attached to AAS. The analysis was done a number of times and uncertainty of measurements was calculated as standard deviation. In the case of minor elements fly ash certified reference materials of NIST (1633 b) was used for calibration purposes.

Water samples were collected from different locations of Delhi and nearby regions like Ghaziabad and Gurgaon and some preliminary tests like pH, TDS and hardness were carried out. The ground water hardness was found to be above threshold limit in most of the cases.

In the area of reference materials, evaluation of solutions of Ni, Cu and Zn in the 1ppm range provided by IRM section was carried out by flame AAS method against standards prepared in the section. The measurements were carried out from time to time to study their stability for their use as reference materials.

The group has contributed and collaborated significantly for various intra-laboratory and inter-laboratory research projects in the field of atmospheric chemistry and global climate change. Studies were

carried on the emission and mitigation of various greenhouse gases like N_2O , CH_4 and CO_2 from agricultural ecosystems/wetlands/forests ecosystems etc. by gas chromatography (GC) and gas analyzers (CO , CO_2 , NO_x etc.). Field studies on emission of trace gases from different sources like bio-mass burning (shifting cultivation, agricultural residues, fuel, wood etc.), transport sector, aerosols including soot carbon and precursor gases, GHGs inventorization and their budget estimates. PAHs emission measurements from bio-mass burning in improved cook-stoves and urban pollution etc. were performed. Also, preparation of gas CRM under NPL's IRM programme was undertaken.

Scientists from the section helped NABL under DST for the accreditation of testing and calibration laboratories in the country for improvement in the quality of their measurements to enable the country to prepare itself against changing scenario of WTO regime and removal of trade barriers.

EPR Spectroscopy

Electron Paramagnetic Resonance (EPR) spectroscopy is a very sensitive and specialized technique to detect and characterize paramagnetic centres/point defects/impurities in different substances to get information about their concentration, valency states, site symmetry and nature of interaction with nearby molecules of the material. Characterization of different materials for paramagnetic centers/impurities was provided to different NPL research groups and outside organizations. In collaboration with Physics, Department, MD University, Rohtak, EPR study of microstructure of different ternary oxide glasses was continued. In alkali borate glasses having composition $2x MCl (0.3-x) M_2O.0.7B_2O_3$ ($M = Li, Na$ or K) and containing 2 mole % of V_2O_5 , the site symmetry around V^{4+} ions was found to be octahedral with tetragonal compression. In $NaCl. Na_2O. B_2O_3$ glass systems, the tetragonal distortion remained unaltered with the increase of mole % of $NaCl$ content whereas it has increased with the increase in $LiCl$ content in $LiCl. Li_2O.B_2O_3$ glasses. Further, the increase in $LiCl : Li_2O$ ratio has resulted in the expansion of $3d_{xy}$ orbital of the vanadium ion in lithium chlorate glasses whereas it has contracted for $x < 0.07$ for potassium chlorate glasses.

In continuation of our work on ion-implanted silicon wafers in collaboration with CEERI, Pilani,

EPR spectra of silicon wafers implanted by Ge^+ ions were analyzed. The spin density of dangling bonds formed during implantation was found to increase with increase in energy and dose of the Ge^+ ions beam similar to BF_2^+ ions implantation process. A detailed ESR study of conducting polymer polyaniline doped with hydrochloric, sulphuric and phosphoric acids in the temperature range 77-300 K undertaken in collaboration with the Polymer physics group NPL was completed. A rapid rise in dc conductivity in certain pH range was found to be accompanied with rise in spin concentration determined by ESR. The spin concentration was found to be crucially dependent upon the nature of dopant ions and the doping level. Further, ESR data has given support in favour of the polaron formation at low doping level and for polaron bipolaron equilibrium in higher doping region along with enhanced mobility of charge carriers for observed electric transport behaviour. Infrared spectra of these samples were also analyzed to understand the bonding behaviour of different organic and ionic groups present in the polymeric chain and to study their structural variations due to protonation and doping. The vibrational peaks pertaining to benzenoid ring, quinoid ring, semiquinone unit, chloride ion, sulphate ion and phosphate ions were observed and assigned. These studies revealed the para coupling of deformed benzenoid (B) and quinoid (Q) rings in the polymeric chains with ends capped predominantly by B4Q1 type oligomer units. This analysis also conformed that protonation takes place at the sites of quinoid ring and new structural groups have been formed in polymeric chain due to doping.

X-Ray Analysis

Research work was continued on synthesis and structural characterization of technologically important semiconducting materials. The semiconducting compound $ZnGa_2Te_4$ had been synthesized and X-ray diffraction data collected earlier was analyzed. The compound was found to crystallize in a defect tetrahedral structure with possible space group $I\bar{4}$ with $Z = 2$ and $a = 5.929(1)A^\circ$, $c = 11.857(3)A^\circ$, $D_x = 5.70$ g/cc. The figure of merit was found as $M_{20} = 37$; $F_{30} = 12$ (0.029,82). Also, a series of solid solutions of Ga_2Te_3 with Zn and In_2Se_3 in the range of $0 \leq x \leq 0.5$ at equal interval of 0.1 were synthesized by quenching technique since the direct fusion of elements with furnace cooling do not yield a single phase compound. Using XRF technique a calibration curve was drawn between $ZnK\alpha/GaK\alpha$ Vs

Zn wt. % which revealed a straight line. To increase the crystallinity of the compounds the powders were annealed at 350° C for over 80 days.

Thin films of water base ferrofluid under the influence of magnetic field (~1000G) and without field had been synthesized. Orientation of nano-scale magnetic domains leads to change in the physical properties of the films. The films were characterized by XRD, SEM, VSM, Optical reflection and polarization techniques and the study revealed that there is a change in magnetic, optical reflectance, crystallite size and polarization when grown under the influence of magnetic field. Work has been initiated for the development of ferrofluid-conducting polymer composite films which can be used as an EMI shielding in the microwave region. It was also observed that in the presence of magnetic field the induced scattered intensity of light through the ferrofluid sample is extremely high as compared to the induced intensity in the absence of magnetic field. A possibility of using ferrofluids as an optical switch device may be explored on the basis of this study.

In continuation of our work on uncertainty of measurement in quantitative analysis as per ISO guidelines, chemical analysis of some important minor constituents such as Mn, Cr, Ni and Cu of steel was carried out using matrix matched steel CRM by AAS in collaboration with Chemical Analysis Group. The uncertainty of measurement was estimated by taking into account the contribution of all relevant factors and the results were found as Mn = $1.026 \pm 0.019\%$; Cr = $0.109 \pm 0.009\%$; Ni = $0.125 \pm 0.009\%$; Cu = $0.124 \pm 0.014\%$, where the reported uncertainty of measurement is the standard uncertainty of measurement multiplied by a suitable coverage factor which gives a coverage of approximately 95%. Similarly uncertainty of measurement was estimated for determination of Mn content in manganese oxide by standard EDTA titrimetry method.

X-ray diffraction pattern of LiFe_3O_8 nano particles showed broad peaks, which is typical of nano particles nature. The sample decomposed at 200° C had the $\beta\text{-LiFe}_3\text{O}_8$ phase, which on annealing at 350° C transforms to $\alpha\text{-LiFe}_3\text{O}_8$ phase. Also, XRD data of $\text{Y}_1\text{Ba}_2\text{Cu}_3\text{O}_{7-x}$ films recorded earlier were analyzed and it has been observed that the substrate temperature plays an important role in the orientation of the films.

X-ray fluorescence analysis was carried out on

about 10 samples, which included ophthalmic glass, graphite, peacock feathers, wire etc.

Electron Microscopy

Electron microscopy group is equipped with sophisticated micro-structural characterization facilities which include Jeol 200 Cx Transmission Electron Microscope (TEM) and state of the art Leo 440 Scanning Electron Microscope (SEM) with attached Oxford link ISIS-300 microanalysis (EDS) system. The group is providing service to various NPL groups, academic institutions and outside industries. This year more than 500 specimen were analyzed using SEM and EDS system for various NPL groups in their efforts to prepare new and advance materials. The materials include: CdTe, Mn-In-Te, Mn-In-S, Bi-Fe-Mo-O, Ba-Sr-Ti-O, CdTe-TiO systems, polyaniline conducting polymers, polyvinyl carbazol solgel thin films, Bi-Pb-Sr-Ca-Cu-O+Ag superconducting wires and tapes, alloy steel, carbon nanotubes, SiC-C/C composites etc.

The micro-structural characterization using SEM and elemental analysis by EDS on a wide variety of materials which include glass fibre sheets, sunglass frames, silica gel, molecular sieves, filter papers, roller material bearings (Figs. 6.1 and 6.2) and desiccants were analyzed for M/s Bry-Air Pvt. Ltd., Gurgaon, M/s Bausch & Lomb India Ltd., Bhiwadi, M/s Arctic India Engg. Pvt. Ltd. Gurgaon, M/s NTTF Industries Ltd., Bangalore, M/s Agarwal Sicheem Pvt. Ltd., Delhi, M/s GKN Drive Shaft Ltd., Dharuhera, M/s Gabriel India Ltd., Parwanoo and M/s Desiccants Rotors International, Delhi.

A variety of materials such as ZnO and In_2O_3 nano-particles, microcrystalline silicon etc. were analyzed for their microstructure and phases using TEM facilities for IIT, Delhi, Delhi University, IACS, Calcutta, Nuclear Science Centre, Delhi.

Some of the materials like thin films of Al-Mn, Cu_2O , diamond like carbon (DLC), carbon nanotubes (CNT), Al-CNT composites, Fe-Bi-Si, GaAs/Ge semiconducting layers were characterized for their microstructure and electron diffraction by TEM for different NPL projects in their efforts to develop new and advance materials.

The research and development work was carried out in the area of InSb, AlSb, Bi_2Te_3 , Al-CNT composites, Sn thin films and aluminum induced crystallization of amorphous silicon. Crystalline InSb,

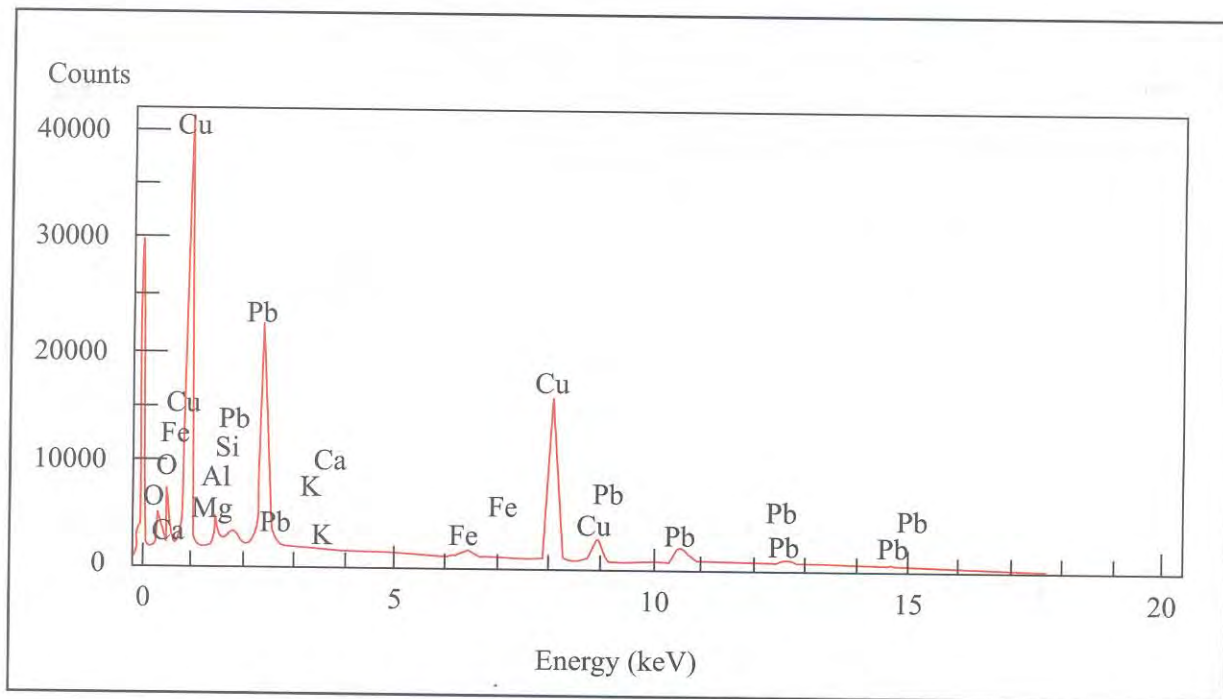


Fig. 6.1 X-Ray peaks of various elements in an alloy using EDS system

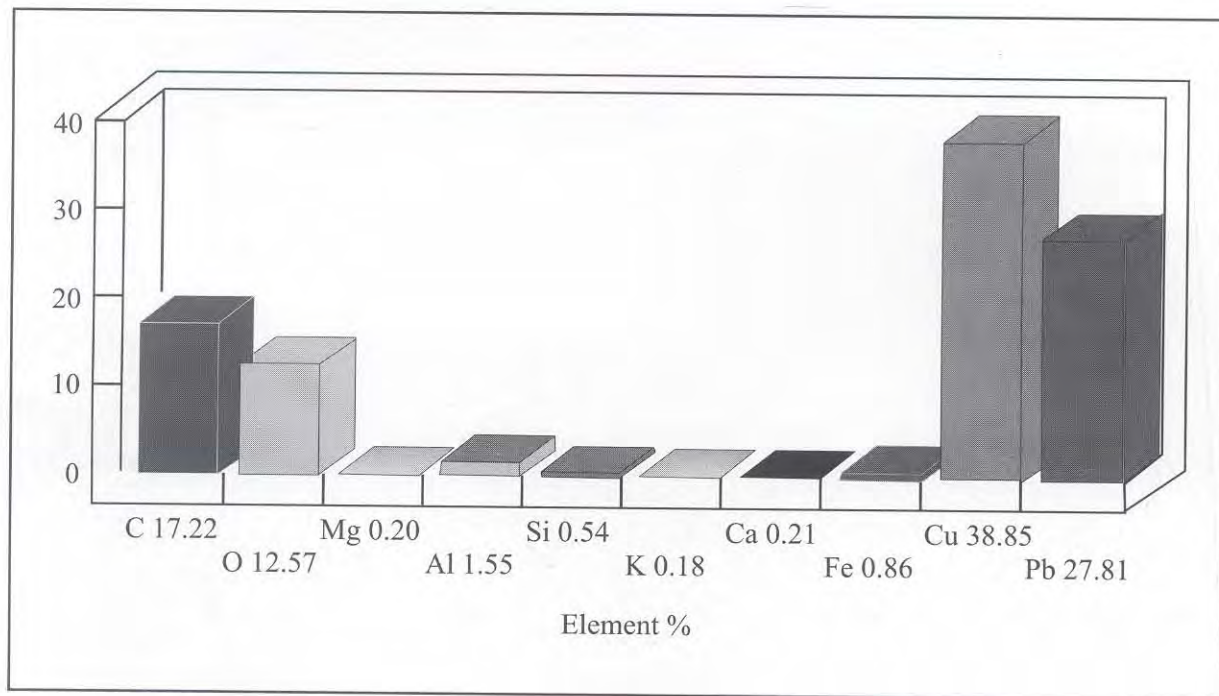


Fig 6.2 Bar diagram of percentage of elements of an alloy as shown in figure 6.1

AlSb, Bi₂Te₃ were grown by Bridgman technique and characterized for their composition and surface morphology using SEM and EDS facilities. Thin films of these compounds were deposited using vacuum evaporation and these films were characterized for their microstructure and phase using TEM. The thin film growth parameters were optimized to grow epitaxial quality InSb thin films using crystalline InSb compound as source material. AlSb films were also grown and the problems encountered in the growth of good quality AlSb films were analyzed. The efforts were made to get uniform stoichiometric AlSb films with some initial success. Bi₂Te₃ films were deposited and investigations regarding their microstructural characterization and electrical behavior were carried out. Sn and Au films were deposited in order to get high resolution test samples for TEM and SEM studies.

Aluminum induced crystallization of amorphous silicon was studied using SEM and EDS in cross sectional mode to see the interaction of aluminum with PECVD grown amorphous silicon. It

was observed (Fig. 6.3) that the interface between crystalline silicon and crystallized amorphous silicon (annealed at 250° C) was reasonably smooth and can be utilized for fabricating semiconducting devices from it.

Indian Reference Materials

Work on planning, preparation, certification and dissemination of Bharatiya Nirdeshak Dravyas (BNDs) or Certified Reference Materials (CRMs) was continued. The scope of BNDs has been enhanced by including pesticides and gases. In the changing scenario of globalization of trade the use of BNDs or CRMs is essential for global acceptance of industrial produces and test and calibration reports. These are being used for calibration of analytical equipment and validation of test methods to get precise, accurate and traceable values. These also provide traceability to the national and international measurement systems. Their use is also a mandatory requirement for accreditation of the laboratories under ISO-9000, ISO/IEC-17025 etc.

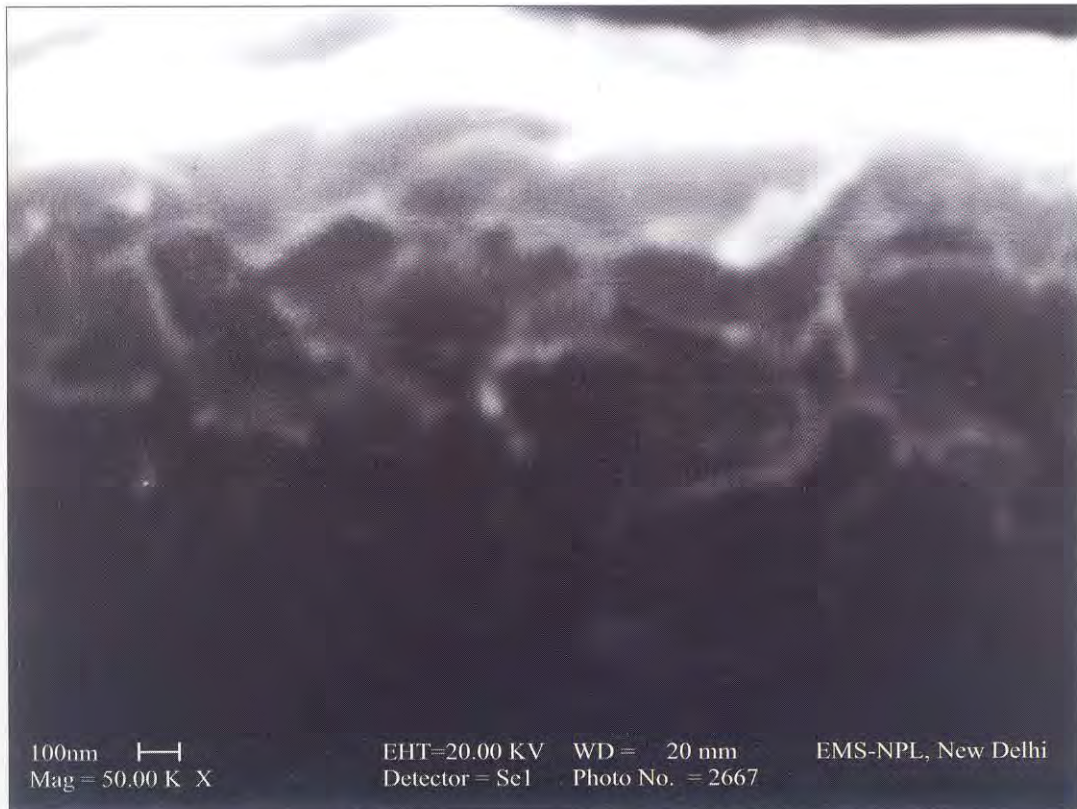


Fig 6.3 SEM image of Si/crystallized α-Si/Al interface

The following nine BNDs of mono-elemental solutions had been prepared, certified and released. These had been released by Dr. R.A. Mashelkar, Director General, CSIR on May 01, 2000. (Fig. 6.4).

Eighteen top national laboratories including Bhabha Atomic Research Centre, R&D Centre Indian Oil Corporation and R&D Centre National Thermal Power Corporation had participated in this programme. The values of concentration of these elements had been certified after statistical analysis of the measurement data generated at the participating laboratories at an interval of fortnight for six months. Outlier laboratories were identified by calculations of their two Z-scores namely within the laboratory and between the laboratories. Data provided by the laboratories having the value of Z-scores more than one was not considered for statistical calculations. These BNDs will be used for calibration of various analytical equipments for example atomic absorption spectrometers, ICP-emission spectrometers, ICP-mass spectrometers etc. and validation of analytical methods. The BNDs released were:

Third Batch of earlier BNDs

1.1.1 BND 101.03 Lead Solution - Certified

concentration 1.00 ± 0.02 mg/l

1.1.2 BND 102.03 Lead Solution - Certified concentration 2.01 ± 0.02 mg/l

1.1.3 BND 201.03 Cadmium Solution - Certified concentration 1.00 ± 0.02 mg/l

Second Batch of earlier BNDs

1.1.4 BND 301.02 Arsenic Solution - Certified Concentration 1.00 ± 0.02 mg/l

1.1.5 BND 401.02 Chromium Solution - Certified concentration 1.00 ± 0.02 mg/l

1.1.6 BND 402.02 Chromium Solution - Certified concentration 2.00 ± 0.02 mg/l

New BNDs

1.1.7 BND 1301 Iron Solution - Certified concentration 1.01 ± 0.02 mg/l

1.1.8 BND 1401 Copper Solution - Certified concentration 1.00 ± 0.02 mg/l

1.1.9 BND 1501 Zinc Solution - Certified concentration 1.01 ± 0.02 mg/l

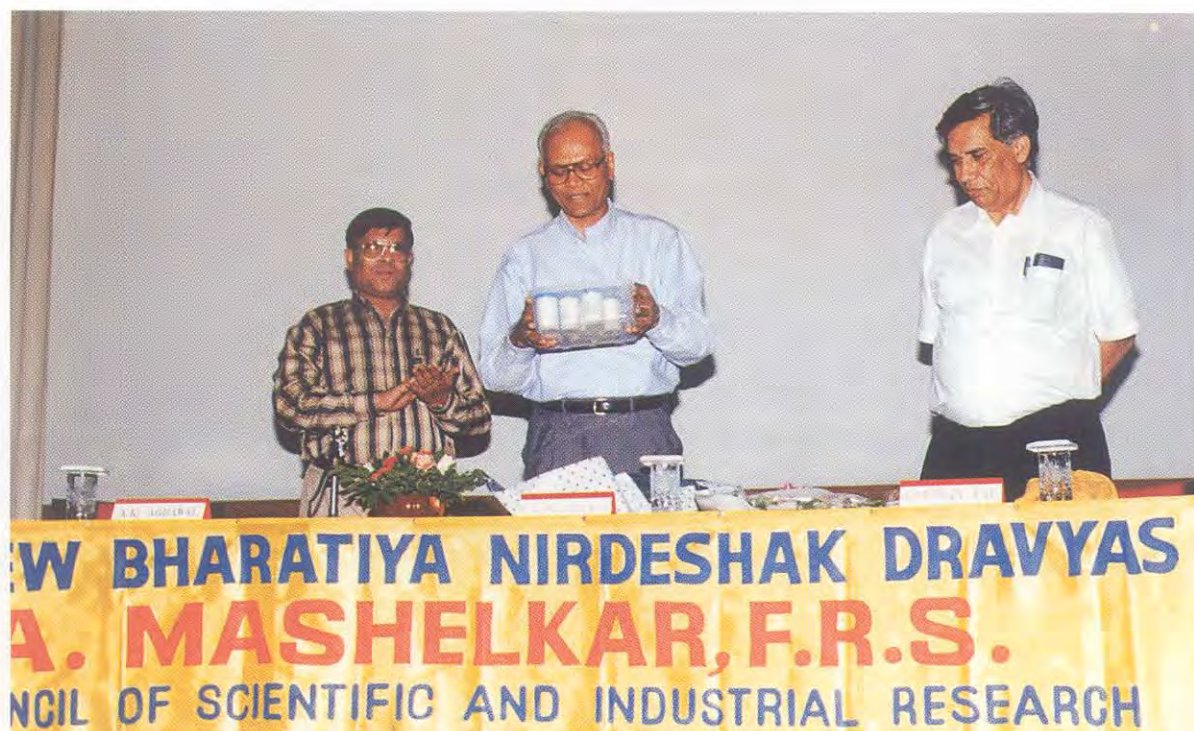


Fig. 6.4 Dr R.A. Mashelkar, Director General, CSIR releasing Bharatiya Nirdeshak Dravyas on May 1, 2000 . Seen on his left is Dr Krishan Lal and right Dr. A. K. Agrawal

A BND of methane in nitrogen with nominal concentration 10 ppmv is under preparation. After completion of the pilot studies, materials have been dispatched to the participating laboratories for round-robin tests. Pilot studies had been completed for the BND of pesticide Chlorpyrifos. The material has been dispatched to the participating laboratories for round-robin test.

Rajeev Gandhi National Drinking Water Mission (RGNDWM) has initiated a program "Long Term Evaluation of Filter Tablet System for Removal of Arsenic" to solve the problem of arsenic toxicity of underground water in West Bengal. NEERI Zonal Laboratory, Kolkata, School of Environmental Studies, Jadavpur University, Kolkata and Public Health and Environment Department Laboratories, Barasat (W.B.) are participating in the programme. NPL is monitoring and controlling continuously the quality of measurements being carried out at these laboratories. Following steps had been taken for quality checks:

i) Bharatiya Nirdeshak Dravyas of arsenic (BND 301) and diluting medium had been prepared and given to all the three laboratories for calibration of their equipment and validation of method of analysis of arsenic. This BND was used as a reference for analysis of arsenic. By its use the values of the arsenic determined at three laboratories came close to each other.

ii) Conducted a proficiency test for arsenic and iron measurements of these three laboratories for inter-comparison of test results and development of quality system.

iii) Prepared a database of the analytical values of arsenic in underground water generated at these three laboratories. Concentration of arsenic was measured before and after the removal of arsenic by use of the tablets developed jointly by CSIR, New Delhi and SOES, Kolkata for more than one year at an interval of a fortnight. 150 sites of the West Bengal were identified for this study.

Active participation in an international key-comparison in chemical measurements coordinated by Swiss Federal laboratories for Materials Testing and Research, Switzerland for CCQM was an important activity. Eight water samples had been received, under this programme, for analysis of elements Fe, Cu, Al and Mg, were analyzed. Results of all the samples have already been communicated to the coordinating laboratory.

Crystal Growth And Characterization

Efforts are being made to establish facilities for grazing incidence X-ray diffraction for characterization of thin films with thicknesses in the nanometer range. Since, a commercial system is very expensive, attempt is being made to modify the existing five crystal X-ray Diffractometer with state-of-art level resolution developed earlier in the group for performing grazing incidence experiments. The recently acquired rotating anode X-ray generator with small focal size would be particularly useful. The new X-ray generator is a high brilliance source with small source size (after fore-shortening of $0.1 \times 0.1 \text{ mm}^2$). A provision of variable source size at different foreshortenings is to be kept for varying requirements of different experiments. Keeping this in mind, modifications in the first collimator stage and the first two monochromators stage of the five crystal X-ray diffractometer are being incorporated. The designs of these subassemblies are being changed substantially. Further, due to high brilliance and very small source size of the new X-ray generator, shield of the monochromator stage and the mechanism for precise slit orientations of the first collimator have to be modified. A special attachment for measurable and precise rotation of the monochromators stage has been designed. The length of the first collimator has been extended to $\sim 500 \text{ mm}$. A new setup has been designed to enclose the first two monochromators setup. A second slit and collimator assembly has been designed with improved orientational capabilities.

High resolution X-ray diffractometry and topography have been used to evaluate crystalline perfection of $\text{Cd}_{1-x}\text{Zn}_x\text{Te}$ (CZT) single crystals. CZT crystals with diameter $\sim 55 \text{ mm}$ have been grown at SSPL by an indigenously developed asymmetric Bridgman method (ABM). A variety of samples prepared from different ingots and different regions of the same ingot have been characterized. A multocrystal X-ray diffractometer set in (+,-,+) geometry using $\text{MoK}\alpha_1$ radiation and a double crystal X-ray diffractometer set in (+,-) configuration with $\text{CuK}\alpha_1$ exploring beam have been employed. Low angle and very low angle boundaries have been observed in most of the samples. The diffraction curves show several peaks with angles between peaks ranging from ~ 10 to ~ 200 arc sec. (Fig. 6.5). The half widths of the diffraction peaks were in the range: 10 to 250 arc sec. The diffraction curves and the stationary topographs revealed some interesting features. In the topographs,

crystal regions responsible for different peaks could be identified and their degree of perfection could be directly observed. It may be mentioned that individual small regions of such samples are often quite perfect and give sharp diffraction peaks.

Preliminary experiments have been performed to study the scintillating property of BGO crystals for X-rays. The output light intensities were compared with those observed with commercially available NaI (Tl) scintillators. The variations of output light intensity from the BGO crystal for different incident X-ray intensities were measured.

The intensity of the incident beam was varied by changing both anode current and anode voltage separately keeping one of them constant.

The automation of powder X-ray diffractometer (sponsored project by DST) was completed with the help of M/s Vinytics Peripherals, New Delhi. The diffractometer (Fig. 6.6) has been realigned on the new Rigaku X-ray generator and XRD pattern of Si powder has been taken in the auto mode. Fabrication of three more goniometers was completed.

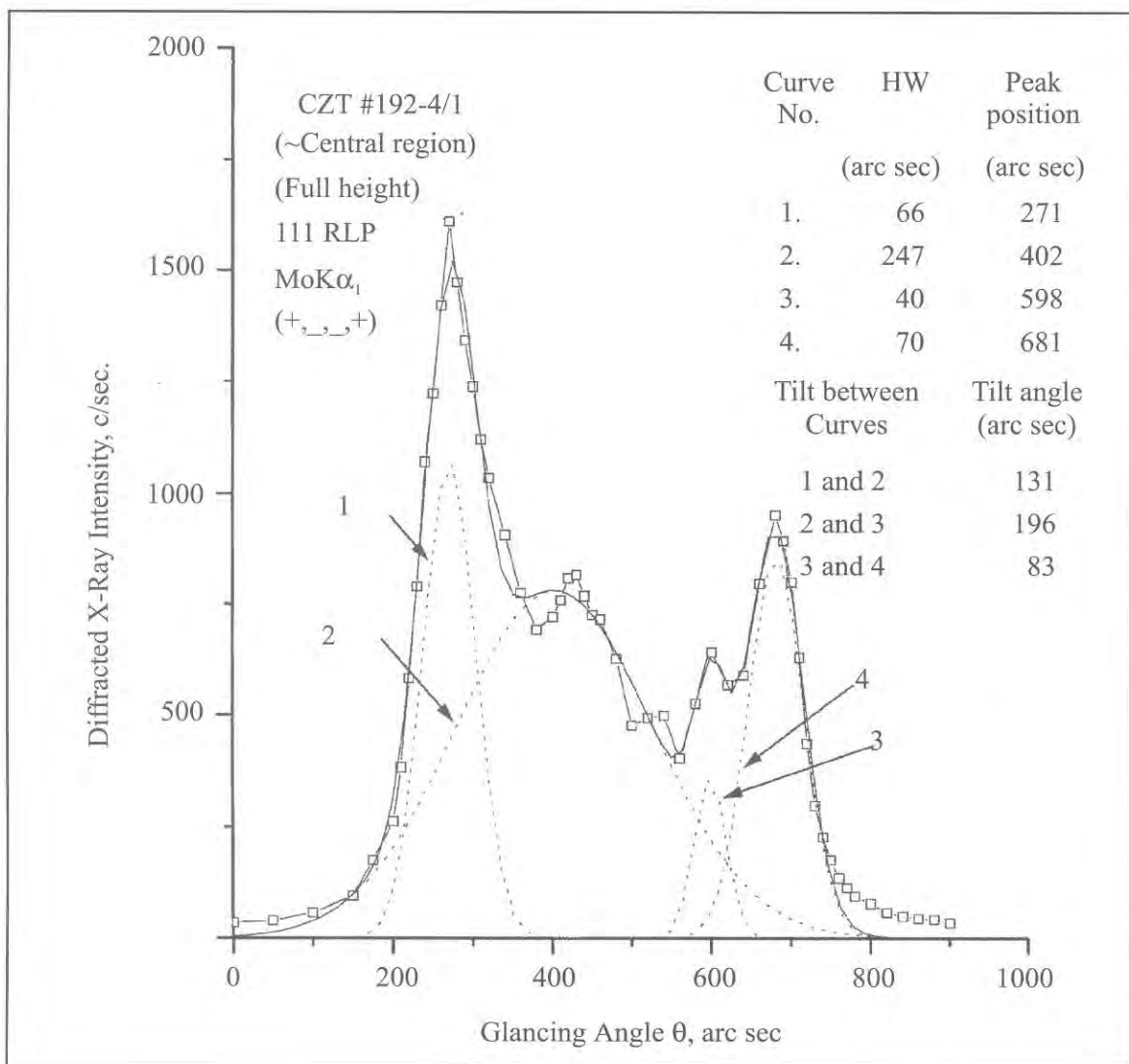


Fig. 6.5 A typical diffraction curve of the CZT specimen recorded with (111) diffraction planes

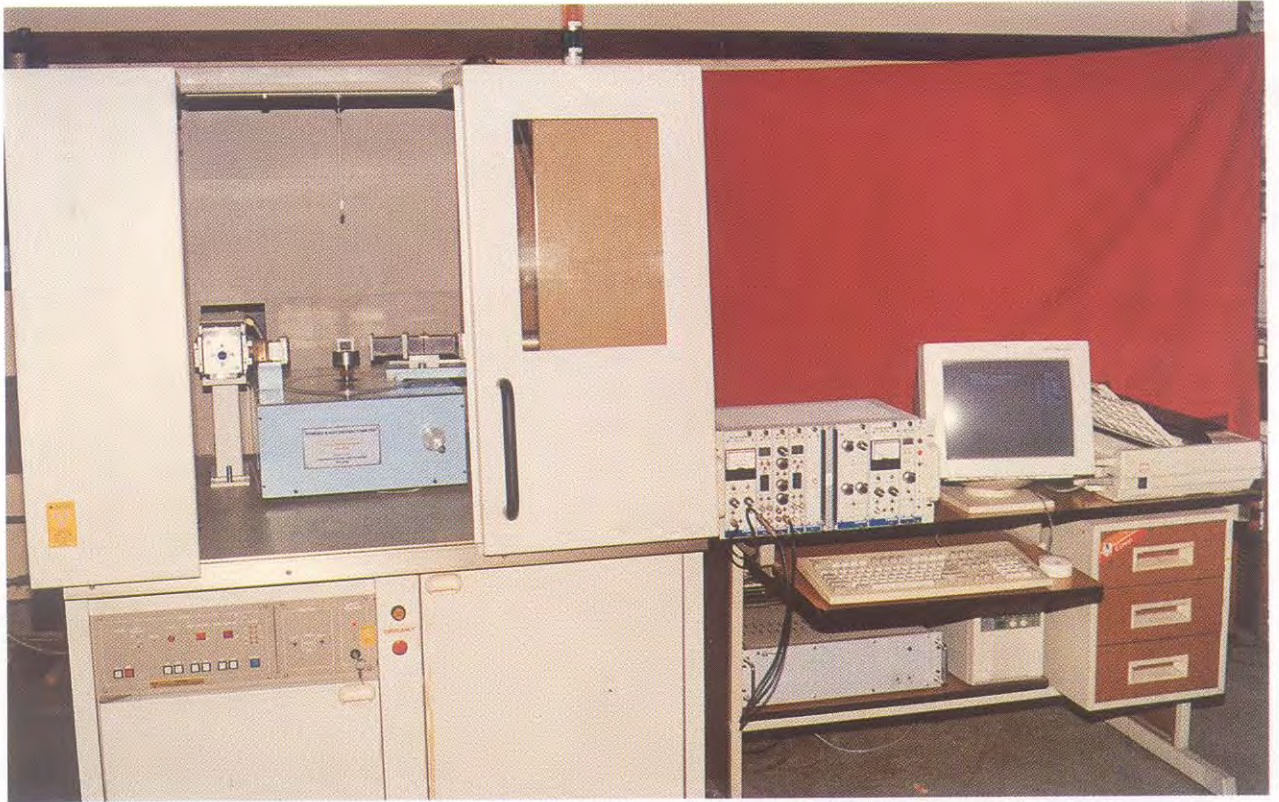


Fig. 6.6 The powder X-ray diffractometer designed, developed and fabricated at NPL

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इस वर्ष केन्द्रीय प्रदूषण नियंत्रण बोर्ड के सहयोग से दिल्ली में कोहरे सम्बन्धी विभिन्न पहलुओं/मापदण्डों पर निगरानी के लिए एक नये प्रमुख कार्यक्रम की शुरुआत की गई है। इसका मुख्य उद्देश्य विभिन्न वायुमण्डलीय प्रदूषक पदार्थों के प्रभाव का अध्ययन करना है।

पिछले दो वर्षों में इंडियन ओशियन एक्सपेरीमेंट (इण्डोएक्स), जिसमें कि कई देश व संस्थायें सम्मिलित हैं, के दौरान एकत्र किए गए आंकड़ों के विश्लेषण से यह पता लगा है कि उत्तरी भारतीय महासागर एवं उससे जुड़े हुए भूभाग के ऊपर एक प्रकार की धुन्ध के बादल की मोटी परत हर साल छा जाती है। राष्ट्रीय भौतिक प्रयोगशाला पर सतही ओज़ोन तथा लददाख क्षेत्र में लेह एवं हेनले स्थित अधिक ऊँचाई वाले स्टेशनों पर उपस्थित वायुमण्डलीय पर्यावरण को जानने के लिए अभियानों का सिलसिला जारी रहा। सतही ओज़ोन पर होने वाले बायोमास बर्निंग के प्रभाव का अध्ययन करने के लिए एक अन्य अभियान मई महीने में आंध्र प्रदेश के पूर्वी गोदावरी क्षेत्र में किया गया। एक द्वि-आयामी फोटो कैमिकल गतिक मॉडल का भी विकास किया गया जिससे बड़े ज्वालामुखी के फटने के बाद कोडायकनाल में स्ट्रेटोस्फेरिक ओज़ोन में हुए परिवर्तन का विश्लेषण किया जा सके। कुछ विशिष्ट फसलों में वनस्पति एवं वायुमंडल के बीच ऊष्मा विनिमय का अनुमान लगाने के लिए भी एक मॉडल बनाया गया।

इस वर्ष रेडियो पर्यावरण के अध्ययन में अति आधुनिक डिजिटल आयनोसोन्डे (आई पी एस 71), जो कि भारत में अपने प्रकार का एक अनूठा यन्त्र है, की स्थापना एक बहुत बड़ी उपलब्धि है। फेराडे रोटेसन के कारण आवश्यक, उपग्रहों द्वारा आंके गये समुद्र की सतह के तापमान में संशोधन के आंकलन के लिए एक संख्यात्मक तकनीक का विकास आर.ए.एस.डी. ने किया है।

सॉस सी-2 उपग्रह में संचालित राष्ट्रीय भौतिक प्रयोगशाला के आर पी ए यन्त्र से आंकड़ों की प्राप्ति छठे वर्ष में पहुँच गई है। इन आंकड़ों के विश्लेषण से एफ-रीजन क्षेत्र में प्लाज़्मा घनत्व ह्रास होने (Depletion) का पता लगा है। पश्चिम बंगाल के सोनारपुर और जादवपुर के बीच गैगा हर्ट्ज़ (GHz) आवृत्ति पर वर्षा के प्रभाव का अध्ययन भारतीय मौसम विभाग के सहयोग से किया गया। वी एच एफ और यू एच एफ बैंडों के चलते फिरते (मोबाइल) संचार से पाई गई पथहानियों का अध्ययन एस वी विश्वविद्यालय तिरुपति के साथ मिलकर किए गए अध्ययन का अंग था। उच्च सौर गतिविधि के दौरान आई आर आई मॉडल की विधिमान्यता एवं वी एच एफ सिंटीलेशन का प्रयोग करते हुए लियोनिड उल्काओं का अध्ययन अभी चल रहे हैं।

आर. एस. डी. ने इस वर्ष निम्नलिखित तकनीकों का विकास किया : (i) उच्च CO₂ मात्रा युक्त वातावरण में फसलों के उत्पादन पर पड़ने वाले प्रभाव के अध्ययन हेतु एक मध्यम आकार की फ्री एअर CO₂ एनरिचमेन्ट (मिड-फेस) फेसिलिटी, (ii) विद्युत चुम्बकीय तरंगों पर आधारित एक संयंत्र जिससे भू-स्खलन के पश्चात् मलबे में दबे जीवित मनुष्यों का पता चलाया जा सके, एवं (iii) हवा में मिश्रित जलवाष्प, सतही ओज़ोन, आमोनिया एवं इथीलीन गैसों की मात्रा का मापन करने हेतु एक अंतरात्मक अवशोषण लीडर जिसे डायल (DIAL) भी कहते हैं।

रेडियो वेब संचार से संबंधित रीजनल वार्निंग सेंटर (RWC) एवं भूमण्डलीय परिवर्तन के अध्ययन के लिए स्थापित साउथ एशियन रीजनल रिसर्च सेंटर (SAS-RRC) की गतिविधियाँ भी वर्ष भर संचालित की गईं।

RADIO & ATMOSPHERIC SCIENCES

A new major programme has been started this year in collaboration with the Central Pollution Control Board involving monitoring of various parameters of fog in Delhi with the objective to understand various atmospheric processes responsible for its onset and disappearance and the impact of anthropogenic pollutants on its intensity and longevity. Analysis of data gathered during multi-country multi-institutional Indian Ocean Experiment (INDOEX) over the last two years has revealed presence of a thick continental scale haze over the Northern Indian Ocean and adjoining landmass. Observational campaigns have been continued for the surface ozone over NPL and atmospheric environment over high altitude stations at Leh and Henle in the Laddakh region. Another campaign to study impact of bio-mass burning on surface ozone in the month of May was conducted in East Godavari district of Andhra Pradesh. A 2-dimensional photo chemical dynamical model has been developed to explain change in stratospheric ozone observed at Kodaikanal following major volcanic eruptions. A model has been also developed to estimate heat exchange between vegetation and atmosphere for specific crops.

Establishment of a state-of-art advanced digital ionosonde IPS-71, the only one of its kind in India, is a major progress in the study of radio environment this year. RASD has developed a technique for computing correction in satellite derived sea surface temperatures caused due to Faraday rotation. Acquisition of ionospheric data from NPL's RPA payload flying onboard SROSS-C2 satellite has entered the sixth year. Analysis of the data by RASD has revealed large scale F-region plasma density depletions. Effect of rain on GHz frequency link between Sonarpur and Jadavpur in West Bengal was studied in collaboration with IMD. Study of path losses in mobile communication in VHF and UHF bands was part of another study conducted along with SV University, Tirupati. Studies for validation of IRI model during high solar activity and that of tracking trails of Leonid Meteors using satellite VHF scintillations have continued.

RASD has developed (i) the first South Asian Medium-size Free Air CO₂ Enrichment Facility (Mid-FACE) for enabling crop growth under elevated CO₂ conditions, (ii) an electromagnetic system for detection of victims trapped under debris after earthquakes for field trials and (iii) a Differential Absorption LIDAR (DIAL) for monitoring water vapour, surface ozone, ammonia and ethylene concentrations in atmosphere near ground.

RASD has continued operation of Radio Warning Centre (RWC) and the South Asian Regional Research Centre for study of Global Change (SAS-RRC).

Atmospheric Environment and Global Change

Surface Ozone as a Secondary Pollutant

Ozone concentration found in the atmosphere near earth surface normally ranges from 5 to 100 ppb at different places and under different environmental conditions. Above 80 ppb it is considered unsafe for human beings. Surface ozone is a secondary pollutant as well as a non-radical oxidizing compound, formed as a result of atmospheric photochemical reactions in presence of sunlight involving oxides of nitrogen and hydrocarbons already available from anthropogenic emissions. High densities of population, industrial activities and automobiles in cities lead to high emission of air pollutants injected into the atmosphere and thereby increasing surface ozone. Prolonged exposure to high concentrations of surface ozone can affect human health, animals and vegetation adversely and, therefore, low concentration of ozone near earth surface is desirable. On the other hand, at stratospheric heights higher ozone concentration is desirable; since there it blocks harmful UV-A, UV-B and UV-C

radiations from sun reaching the earth's surface.

Surface ozone is being monitored on round the clock basis at NPL since 1997 using Dassibi make ozone analyzer. A typical diurnal variation (Fig. 7.1) shows minimum concentration of surface ozone during nights. It starts increasing after sunrise and peaks at noon time. During post noon hours it starts decreasing and reach low level after sunset. Minima during nights and maxima during daytime observed in surface ozone during the three Calendar Years 1997 - 99 are plotted in Fig. 7.2. It is seen that annual variation in peak values has two maxima (during April, May and October) and two minima (during monsoon months and December). The measurements indicate presence of higher concentrations of ozone during April and October which are dry months over Delhi. The low value of ozone in the monsoon months of July, August and September is attributable to lower production rate of ozone owing to cloudy conditions and also to higher ozone loss rate by HOx. Low values of ozone during December - January can be attributed to lower intensity of UV radiation available for photo-dissociation. During maxima periods, i.e., April, May and October, surface ozone concentrations in Delhi

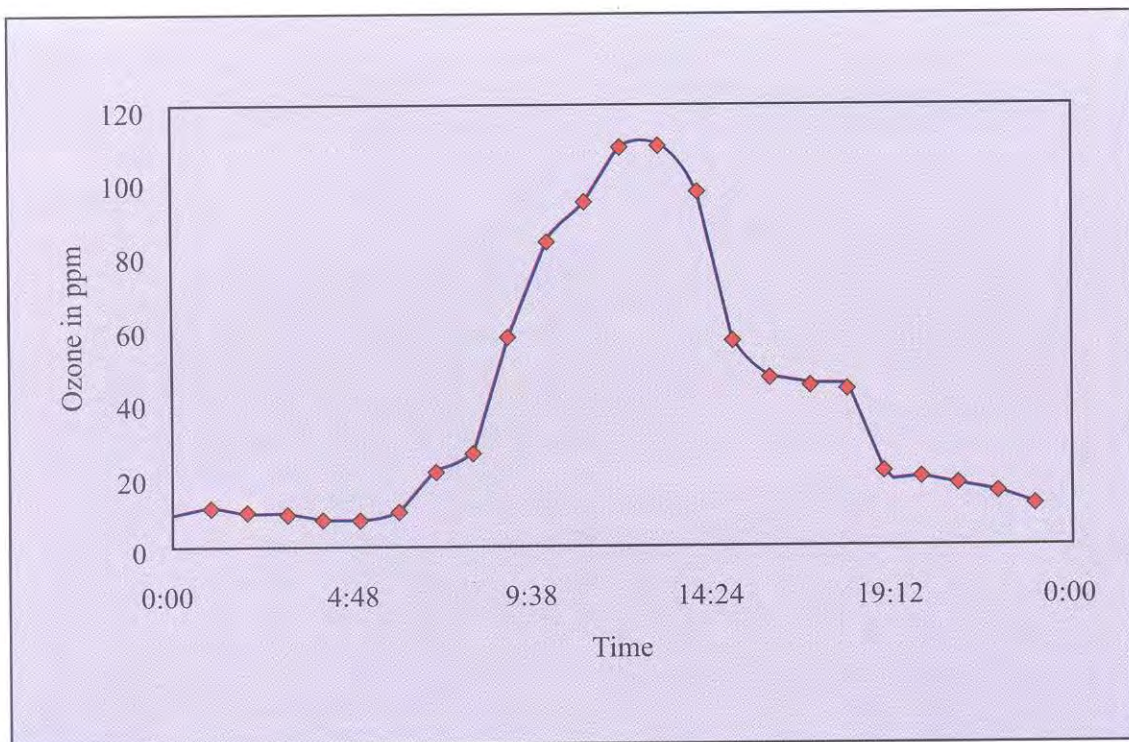


Fig 7.1: Diurnal variation of surface ozone observed over New Delhi on 18 April 2000.

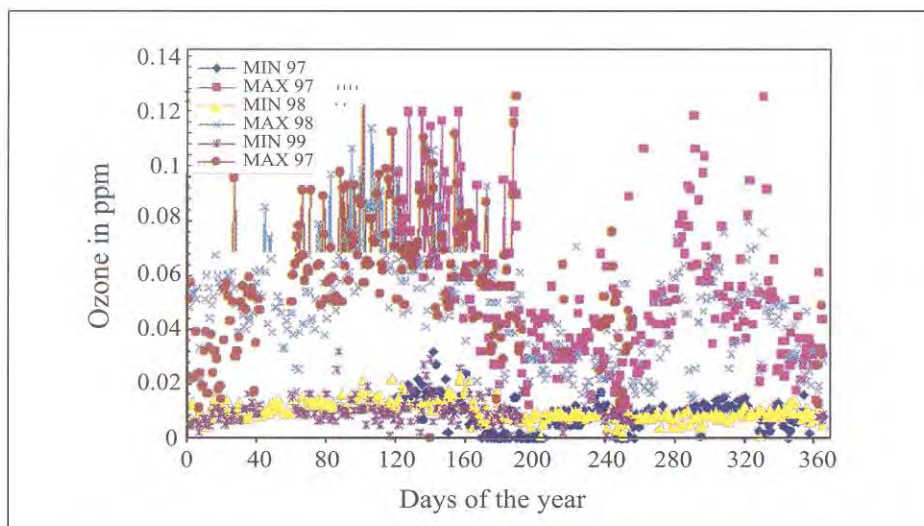


Fig. 7.2 : Minima and maxima in surface ozone observed during the three calendar years 1997-99 over New Delhi.

often cross the WHO and USA prescribed safe levels (see Fig. 7.2) and may be a health hazard affecting humans, vegetation and animals exposed to it.

Environmental Monitoring in the High Altitude Laddakh Region

The second observational campaign for environmental monitoring at high altitude stations Leh (altitude 3300 meters) and Hanle (altitude 4500 meters) was conducted during the period 28 May to 13 June 2000.

It involved measurement of solar UV-B, aerosol optical depth, column water vapour, column ozone (O_3), surface ozone (O_3), carbon monoxide (CO), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and surface aerosol size distribution. The trend and anomalies observed in UV-B dosages, aerosol optical depth and surface ozone are found to be similar to those observed in earlier campaign in May 1999 and reported in 1999-2000 NPL Annual Report. Further, it was observed that there is very good anti-correlation

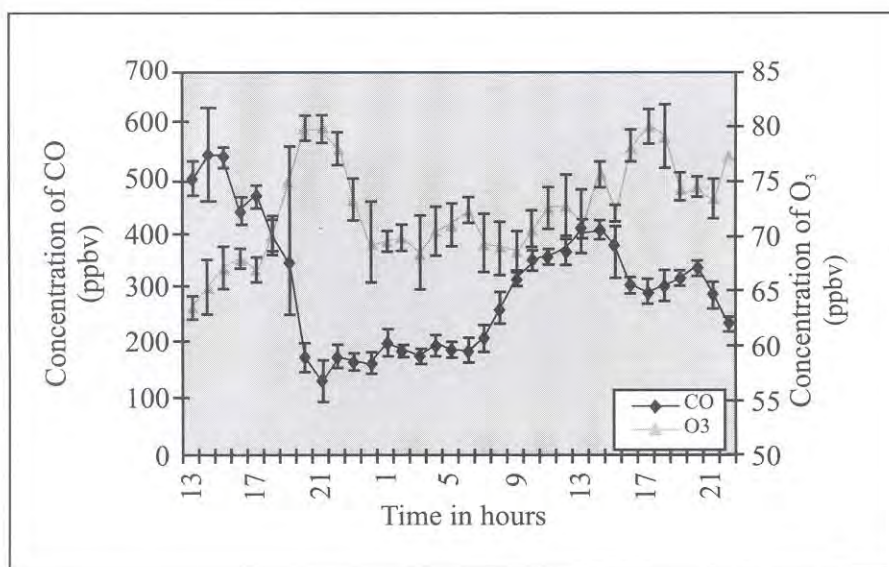


Fig.7.3 : Carbonmonoxide (CO) and ozone (O_3) concentrations in ambient air at Mount Sarswati, Hanle (Laddakh) on June 2 & 3, 2000

between CO and O₃ concentrations (Fig. 7.3). The CO and O₃ concentrations are found in the range of 200-600 ppbv and 60-80 ppbv respectively and both seem to be on the higher side than those expected presuming that a pristine environment prevails at such high altitude locations. This indicated that polluted air-mass is being transported from the surrounding land-masses through wind trajectories resulting in increase of CO concentration at these higher altitudes.

Another important feature observed from monitoring of size-wise mass distribution of surface aerosol is that the amount of aerosols in all the eight size ranges, collected separately by Anderson sampler used for the purpose is nearly the same. This may be due to the fact that there are no local sources of pollutants. This scenario is different from the one found in cities like Delhi, where the amount of aerosols maximizes around 2.5 μ m. This peak appears because there are strong local sources of production of particles at these sizes.

Monitoring of Fog in Delhi

Study of fog/smog phenomena witnessed in Delhi normally during winter season and its relationship with anthropogenic pollution was initiated under a collaborative program between CPCB and NPL. The first campaign for monitoring fog parameters was launched by NPL during January 3-20, 2001 from its campus. The monostatic SODAR was used for planetary boundary layer monitoring that gave

information about the inversion layer height, fog thickness, convection within fog layer and dissolution of inversion layer. A set of three matched precision thermisters were placed at 1m, 13m and 30m height above ground to determine temperature gradient in the fog layer. High Volume Samplers and an Anderson Sampler were operated to determine aerosol characteristics. For trial monitoring of the liquid water content in fog layer two experiments, one using 37 GHz radiometry and another using IR absorption technique were set up. Fig. 7.4 depicts the onset and dissolution of fog as observed by IR absorption technique. During clear sunny periods on fog days and also on intervening days when fog did not form, UV-B radiation, aerosol optical depth, total water vapour and column ozone were monitored. CPCB van carrying their normal air ambient quality monitoring instruments was also stationed at NPL for a few days to take supplementary observations. Scientists from the Radio and Atmospheric Sciences Division, from the Analytical Chemistry Section of the Materials Characterization Division, from the Acoustic SODAR Group of the Physico-Mechanical Standards Division and from the Superconductivity and Cryogenics Division took part in this monitoring campaign. The data collected are being analysed.

Impact of Volcanic Eruptions on Stratospheric Ozone

Volcanic eruptions play a major role in changing the Earth's atmosphere and atmospheric constituent

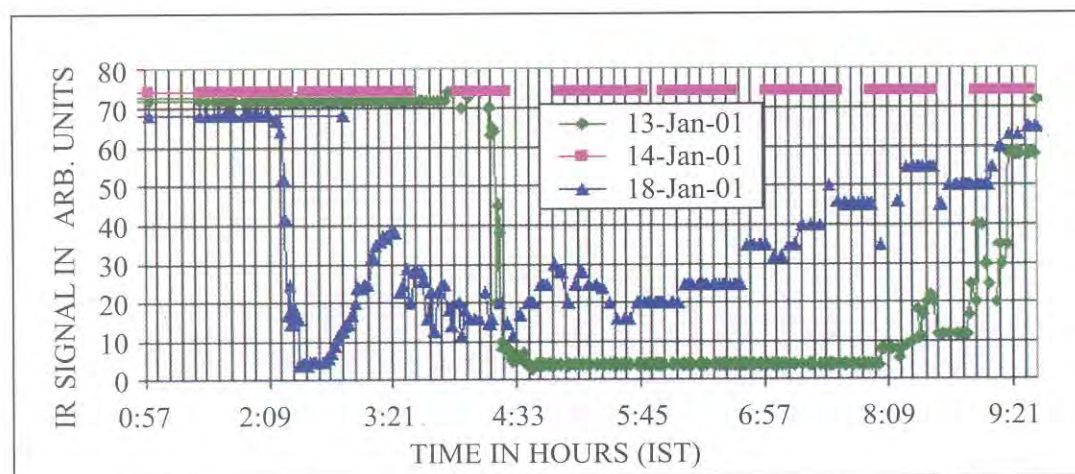


Fig. 7.4 : Temporal variation in the intensity of infrared signal absorbed while traversing 40 metres of fog laden air on Jan. 13 and 18, 2001. Signal levels recorded with same set-up on Jan. 14 which was a non-fog day are plotted for comparison.

budget, specially the ozone. The magma of eruption consists mainly of sulfur-dioxide which is converted into large micron sized hydrated sulfuric acid aerosols that play an important role in the destruction of ozone. A 2-Dimensional photochemical dynamical model that has been developed at NPL was tested to explain the change in stratospheric ozone at Kodaikanal following the two major volcanic eruptions namely, El Chichon on March 1982 in Mexico (17.3N,93.2W) and Mt. Pinatubo in Philippines (15.1N,120E) in June 1991. The model includes about 30 chemical reactions in oxygen-hydrogen-nitrogen atmosphere and methane chemistry. The calculations from present 2-Dimensional photochemical dynamical model depict the depletion of ozone upto 34 km altitude by taking into account the increase in temperature due to volcanic aerosols.

The analysis of Dobson total ozone data obtained from IMD for the period 1979 to 1994 shows disturbed ozone QBO after both the volcanic eruptions (Fig. 7.5). It may be seen from the figure that the broadness of ozone QBO trough remained for more than two years following the eruptions indicating that the disturbance persisted for a fairly long period. A height-wise impact of volcanic aerosols on ozone as calculated using corresponding SBUV data

downloaded from NASA website also shows a depletion of ozone up to 34 km with a maximum impact at 29 km (about 3%). Since there is not enough chlorine present to destroy ozone through heterogeneous chemistry at these altitudes, the depletion from 30 to 35 km may be attributed due to changes in the ozone production and loss rates because of radiative warming by large sulfate aerosols present there after the volcanic eruptions.

Monitoring of Total Column Ozone, Water Vapour etc.

A hand held microprocessor based sun photometer, Microtop-2, has been used to measure solar radiation at 300, 305, 312, 940 and 1020 nm wavelength regions. The first three filter channels are used to derive atmospheric total column ozone while the latter two channels are used for column water vapour content in atmosphere. Hourly observations were taken on all clear cloudless sunny days at NPL and also during field campaigns. Variation of measured column ozone during January-December 2000 is shown in Fig. 7.6. The column ozone measured at NPL was also compared with that monitored by TOMS satellite at the same time and found to be in good agreement as shown in the figure. It has been found that water vapour varies

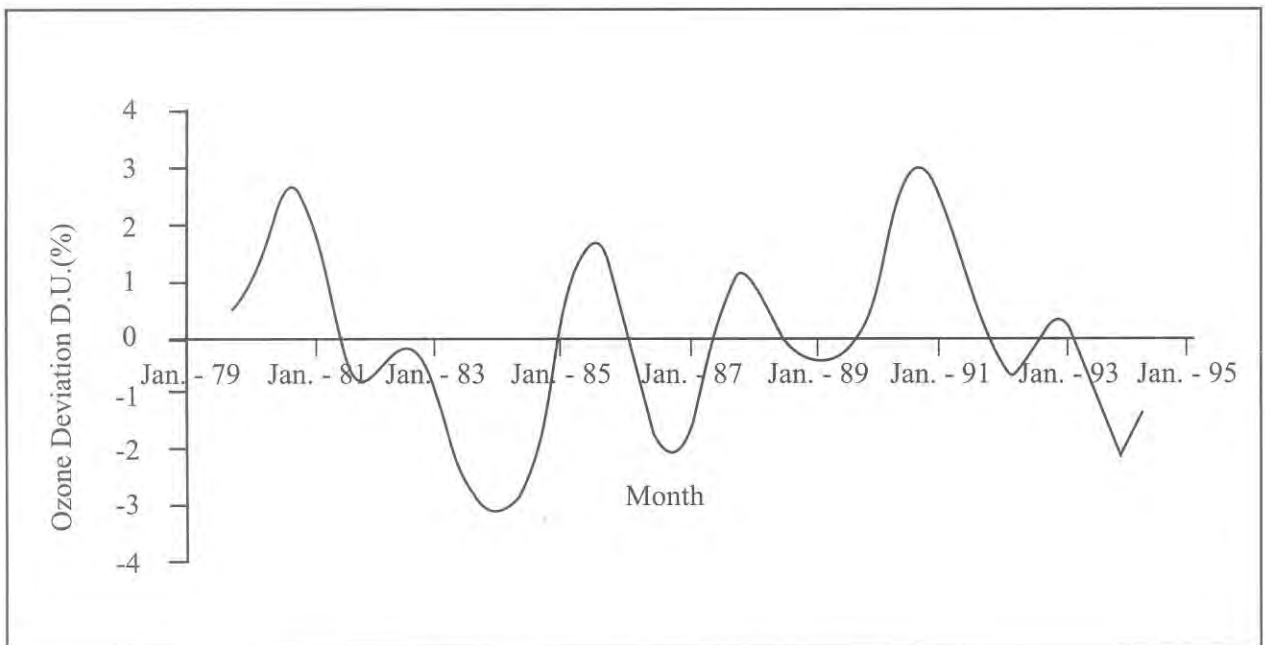


Fig. 7.5 : The ozone QBO derived using Dobson data.

from 0.6 cm to 6 cm during the year and is maximum during summer months (Fig. 7.7).

Biomass Burning Experiment

Measurements of total ozone, surface ozone, water vapour, multi-wavelength aerosol optical depth, UV-B radiation, erythemal dose etc. were made during the local biomass burning period at East Godavari District, Andhra Pradesh from 4-9th May, 2000. The experiment showed that UV-B intensity restored to its normal values after the biomass burning. The average

total ozone column during May 4-9, 2000 was found to be in the range of 262-295 DU. Water vapour content varied from 2.62 cm to 4.62 cm and surface ozone from 30 ppb to 56 ppb during the period of observation. The results obtained in this study suggest that photochemical production of ozone resulting from biomass burning may be responsible for the observed enhancement of the total ozone at this area when strong convection activities occurred over biomass burning regions. Result also showed that within a few days' time total ozone changed from 295 DU on 4th May to

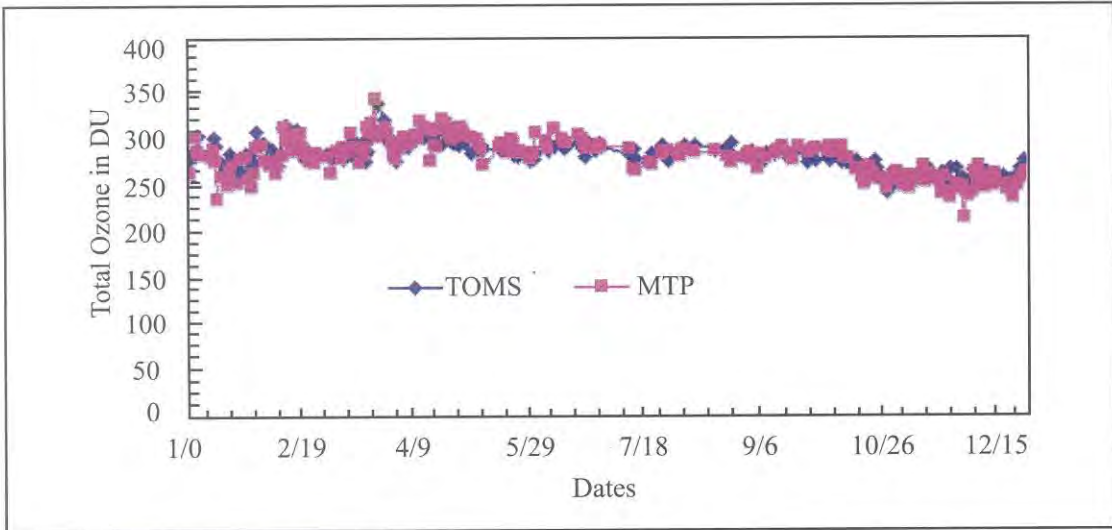


Fig. 7.6 : Comparison of column ozone measured at NPL using Microtop (MTP) with that monitored by TOMS during January-December 2000.

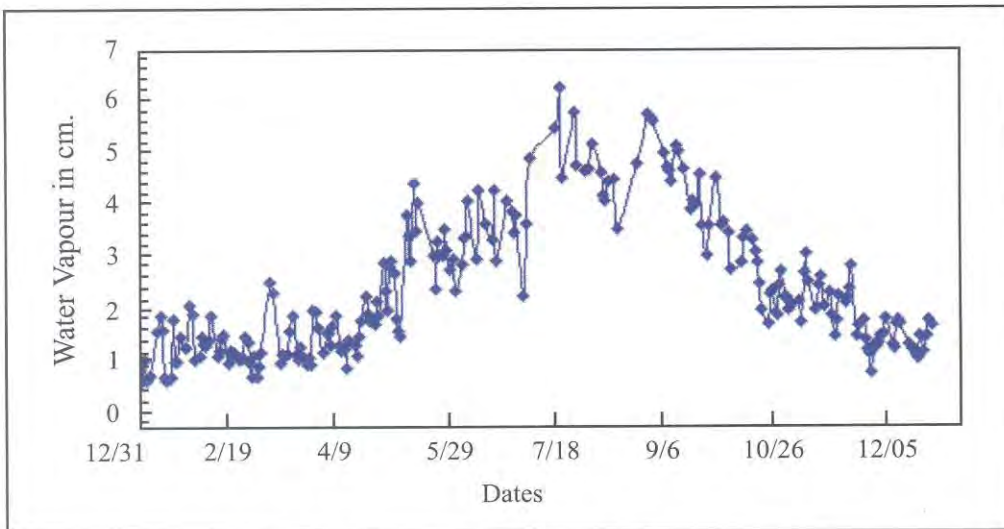


Fig. 7.7 : Water vapour over New Delhi during 2000.

262 DU on 9th May. This is attributable to rain and thunderstorm which occurred on 7th and 8th May, 2000. High water vapour content was observed during observational period. The affect of burning plumes on surface ozone appears to be not significant because of rapid lifting of burning produced pollutants through convection.

Thick Extensive Haze Layer over the Indian Region

The discussions on the implications of results from the analysis of the data gathered during INDOEX over the past years reveal the presence of a thick extensive haze layer extending over some ten million square kilometres over Northern Indian Ocean and the landmass with clear sky south of ITCZ. NPL contribution in the important findings was in terms of measurements of ozone, radiative flux and aerosols composition. A pocket of low ozone ~10 ppbv was observed near the surface in addition to high ozone concentration observed at 8-12 km within the region of 5-15°S. The comparison of marine and continental ozone profiles suggested that the northern side of the ITCZ resembles the continental profiles as observed over the Indian sub-continent and African region rather than East Asian region. Large radiative flux was observed near the equator at the altitude of 12-15 km, which is attributable to the combined effects of aerosols, ozone and cloudy sky. Potential impact of this aerosol haze layer change in monsoon systems, agriculture, health - particularly on respiratory problems and water balance were examined.

INDOEX Data Centre

Additional data pertaining to INDOEX programme particularly from some of the foreign participating groups has been added to the existing INDOEX Data Centre. The archival capacity of Data Centre was also augmented by the introduction of a Silicon Graphic computer. This data is accessible on the NPL Global Change Data Centre web site.

Computing Energy Budget within a Crop Canopy from Penmann's Formulae

Modelling of the heat exchanged between vegetation and atmosphere is being carried out since last year. This can be applied to estimate the influence of increasing atmospheric CO₂ on this heat exchange. Towards this a numerical experiment was performed on the Lhomme's model extending Penmann's formulae to multi-layer model. Suitable calculation algorithms were worked out in order to operate the model more efficiently for computing sensible and

latent heat flux densities. The model was operated for maize crop stand and a good agreement was found with calculations based on observational data from the crop field.

Operation of SAS-RRC

Centre on Global Change of NPL continued to operate the South Asian Regional Research Centre (SAS-RRC) for the Study of Global Change under an MoU signed with the International START Headquarters, Washington. The activities include organization of training courses/workshops for capacity building for global change research and identification and nurturing of regionally cooperative research programmes involving institutions of Bangladesh, India, Maldives, Mauritius, Nepal, Pakistan and Sri Lanka.

SASCOM-APN Workshop to review efforts on Regional CO₂ Enrichment Rice Research Experiments was held at IARI New Delhi during March 16-18, 2001. The outcome of country experiments and the utility of OTC data for modeling and policy studies in all the participating countries was discussed.

New Research Initiatives for National Level Programmes

Several new initiatives were taken in formulating new research programmes. These included organization of a discussion meeting for nitrous oxide and methane campaigns, at NPL, New Delhi Oct. 16-17, 2000. Several participants from the active measurement groups in India participated to formulate proposal and methodology for the study of nitrous oxide emissions from agriculture ecosystems in India. NPL is to act as the nodal cent for the proposed campaign keeping in view the past lead role and expertise of NPL in India's greenhouse gases inventorization, the Union Ministry of Environment and Forests invited NPL's Centre on Global Change to prepare the national document on 'Enabling Activities for Initial Communication' from India for obtaining financial support from the Global Environment Fund and also to take a leading role in implementing 'Good Practices for Inventory Preparation'- an activity in which more than 20 institutions would be taking part.

RADIO COMMUNICATION

Digital Ionosonde Facility

Under the modernization plan, an advanced digital ionosonde IPS-71 of KEL Aerospace, Australia has

been installed in the campus of NPL during July 2000 and since then it is being operated round the clock at 15 minute intervals. This fully computer controlled ionosonde operates in the vertical incidence mode and provides conventional as well as Doppler ionograms. In the high resolution conventional ionograms (frequency vs. height) the intensity of the reflected signal is colour coded. Information on the vertical movements of different layers can be derived from Doppler mode ionograms. IPS-71 also operates in the passive mode to provide spectrum surveillance data in the frequency band 1 MHz to 22 MHz. Online ionograms can be viewed through local area network as well through internet from remote locations. This advanced facility is one of its kind in the country and provides a variety of information on the ionospheric layers over Delhi, which includes apart from critical frequency and layer heights, their vertical movements also. At present, this is the only ionosonde facility located in the northern regions of India and provides crucial ionospheric data pertaining to these latitudes to aid in HF-communications. The ionosonde data from Delhi along with the data obtained from other ionosondes in the country is published regularly from

NPL in the form of "Ionospheric Data Bulletins" and being used to update the existing ionospheric predictions maps for India. Fig. 7.8 shows an ionogram taken in the month of March 2001.

Corrections due to Faraday Rotation in Satellite Measurements of Sea Surface Temperatures

A 6.6 GHz radiometer onboard the Indian Remote Sensing Satellite IRS-P4 is being used to derive the sea surface temperature by monitoring electromagnetic radiations emitted from the sea surface at this frequency. These radiations, as they propagate from sea surface to the satellite, undergo changes in plane of polarization, known as Faraday rotation due to presence of intervening ionized layers. This results in uncertainties in temperature measurements. The uncertainty in the measurement could be as large as 4°C under adverse conditions of the ionosphere against the acceptable limit of 0.5°C.

Estimation of Faraday rotation is done generally by computing the Total Electron Content (TEC) along the ray path by using standard empirical ionospheric models, like International Reference

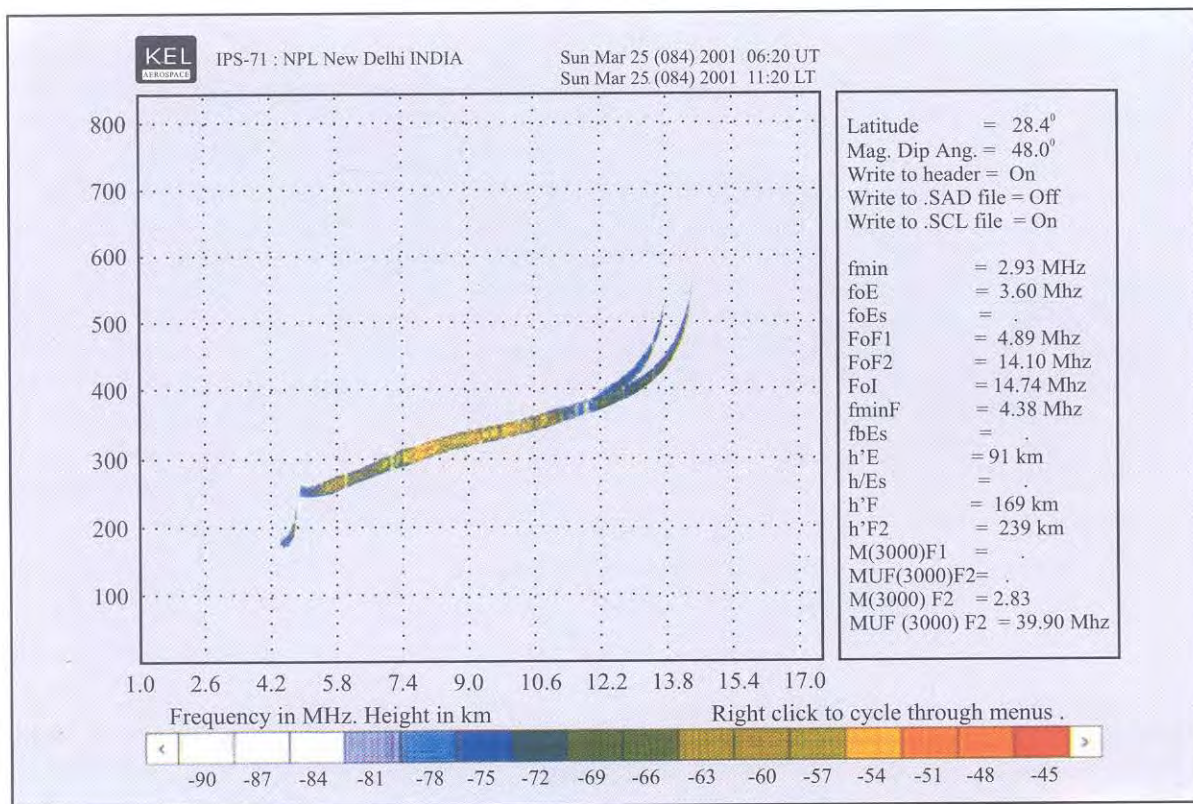


Fig. 7.8 : Ionogram taken at NPL on 25 March 2001 at 06.20 UT

Ionosphere (IRI) for estimation of vertical density profile corresponding to the specific location on earth. But, these models can result in an uncertainty as large as 50% in determining the densities. Hence, in order to improve upon their accuracy, first the TEC observations are made at a location in real time using satellites of opportunity (say GPS satellites) and then model values are updated for a region using real time observations in that location.

At present, Global Positioning System (GPS) satellites transmitting at two coherent frequencies, 1575.42 and 1227.60 MHz, are being used to derive TEC along the ray path using observations from dual frequency GPS receiver located near Bangalore. Both pseudo-range observations and carrier phase observations have been used for determining the TEC accurately. Pseudo-range measurements are absolute but noisy because of the multi-path effect. Carrier phase measurements have good signal to noise ratio, but they suffer from full cycle ambiguity and cycle slips. Full cycle ambiguity is the number of completed cycles while passing through the medium. The cycle slips are due to loss of lock of the GPS signal due to other factors.

An algorithm has been developed by NPL to remove full cycle ambiguity using pseudo-range data and to detect and repair cycle slips. It is then used for

determining the TEC. Another algorithm, also developed at NPL, uses this value of TEC to adjust the IRI parameters so as to minimize the difference between the measured value and that derived using the IRI model. Knowing this modified parameter, Faraday rotation along the satellite receiver ray path is then estimated. Fig. 7.9 shows the comparison between the observed Faraday rotation and that derived from the IRI model before and after adjustment using the available test data obtained at Bangalore using GPS satellite.

RPA Aeronomy Payload onboard SROSS-C2 Satellite: Detection of Large Scale F-Region Plasma Density Depletions

Retarding Potential Analyzer (RPA) aeronomy payload, onboard SROSS-C2 orbiting satellite, has completed more than six years of successful in-orbit operations for ionospheric data collection over the Indian region since its launch from Sriharikota in May 1994. During this period, simultaneous data from electron and ion RPAs has been acquired in more than 3800 orbits at equatorial and low latitudes in the altitude range of 400 to 620 km and covering minimum to maximum solar activity phases of the present solar cycle. During 2000-2001 RPAs were operated in more than 600 orbit crossings over the Indian region and data collected from ISRO Telemetry and Tracking

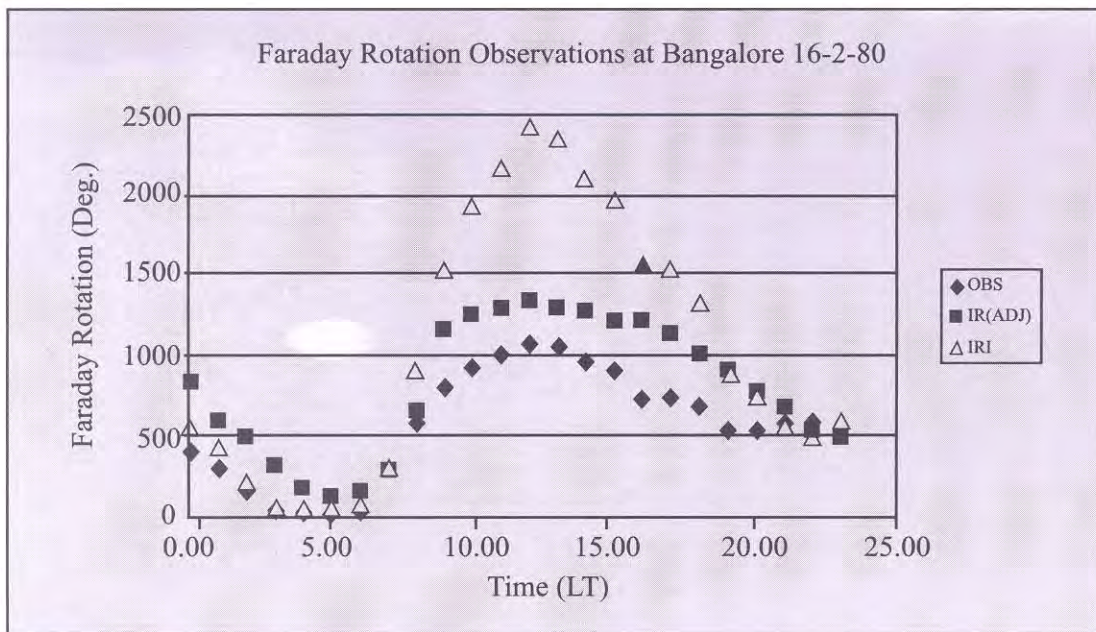


Fig. 7.9 : Comparison between the observed Faraday rotation and that derived from the IRI model (without adjustment) and the one after adjustment using GPS data.

Stations located at Bangalore, Lucknow and Mauritius.

Among the important events detected during the present year of high solar activity are the occurrence of very large scale (several hundreds of km in scale) extensive plasma density depletions at F region altitudes during pre-midnight hours. These depletions were found to be as much as 3 to 4 decades down as compared to the normal densities and contain very sharp latitudinal gradients (Fig 7.10). Smaller scale irregularities (170 m scale size as measured by RPA) are also found embedded within such depletions. These appear to be the signatures of plasma bubbles responsible for scintillations on satellite signals and Spread F on ionograms. Similar depletions had been observed by RPAs during SROSS C mission in 1992 at the F region bottomside.

Due to continuously increasing solar activity, the SROSS C-2 orbit had been decaying at a faster rate during the past two years; it was 380 x 550 km in March 2001. SROSS C-2 orbit perigee was raised once

in June 2000 from 400 to 430 km for increasing the mission life. With the present orbit and decay rate, the remaining life of SROSS C-2 is estimated to be not more than 4 months, i.e., by June July 2001 SROSS C-2 satellite would enter the earth's dense atmosphere and that would be the end of this mission.

Experimental Campaign for Rain Attenuation Studies

In order to understand and quantify the effect of rain on microwave signals at GHz frequencies, an experimental campaign was conducted during monsoon months of the year 2000 to derive (a) rain characteristics using an X - band radar of the Indian Meteorological Department located at Kolkata, (b) rain attenuation by monitoring simultaneously a LOS radio link operating at 18 GHz and (c) rain condition by mounting rain gauges at nearby locations. The horizontal and vertical extents of rain cells were deduced from radar reflectivity measurements. The link was operating between Sonarpur and Jadavpur covering a distance of 8 km. The signals were

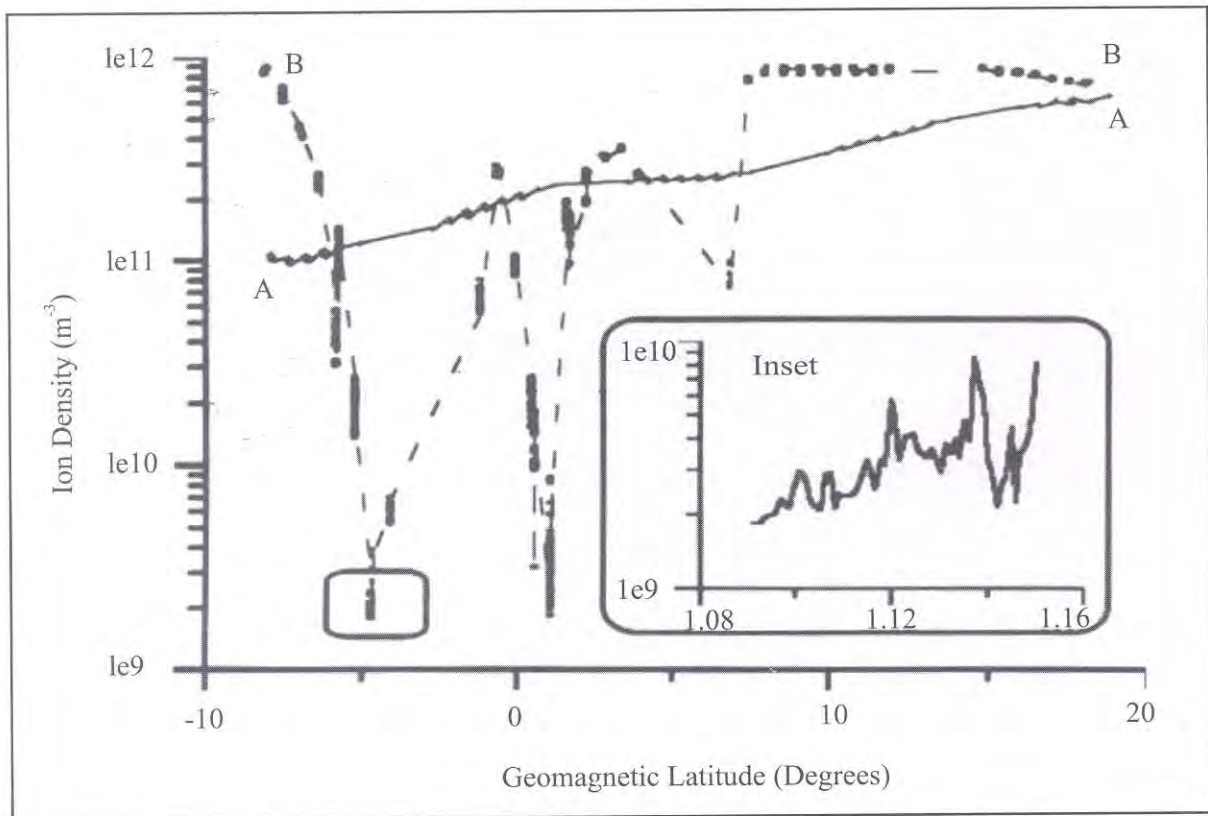


Fig. 7.10 : Large scale depletions in plasma densities (BB) as a function of geomagnetic latitudes compared to the normal time behaviour (AA). Inset shows small scale irregularities embedded within.

attenuated by as much as 18dB even under moderate rain fall conditions of 55 mm/hour intensity (Fig 7.11). Based on the observations made during this campaign rain intensity vs. rain attenuation curves have been obtained which can be used for designing high reliability links at frequencies greater than 10GHz which are capable of large data transmission rates.

Land Mobile Communication Studies

Terrain conditions play an important role in determining the path losses a signal undergoes in mobile communications in VHF and UHF bands. An

experimental campaign was conducted in collaboration with S. V. University, Tirupati to study path losses in regions surrounding Tirupati and Sullurpet. A distance of 90 km was covered in this campaign. Predictions of path losses, computed using two different methods, were compared with the measured values. Hata's method in general showed overall agreement for different regions from rural to urban; however, the COST 231 Walfisch-Ikegami method was found to be more suitable in case of urban areas (Fig 7.12).

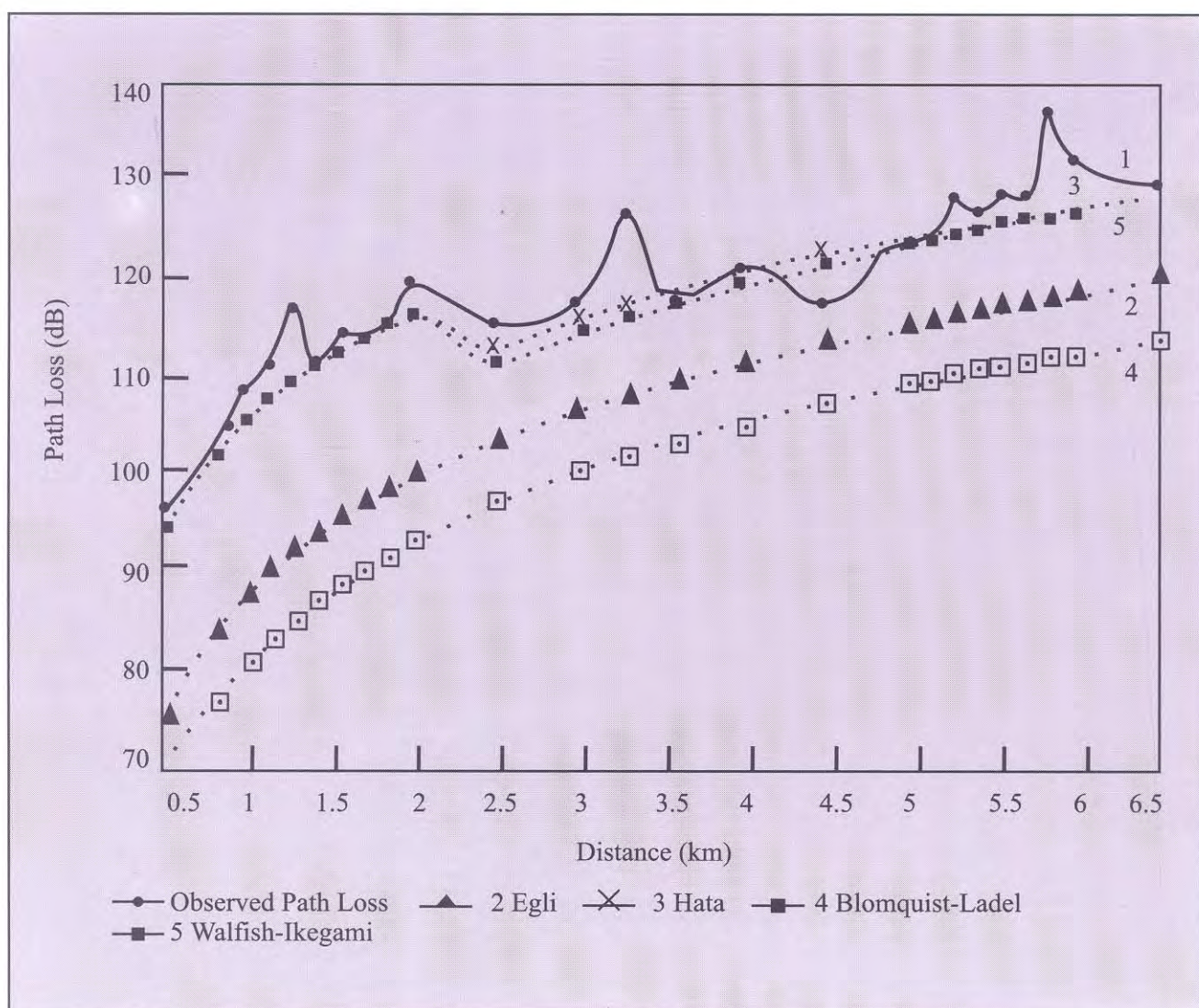


Fig. 7.11 : Variation of observed path loss at Tirupati and its comparison with different predictive methods.

Validation of IRI Model using Incoherent Scatter Radar Observations during High Solar Activity Period

High resolution 0.6 km bottom side electron density profiles observed with the Arecibo incoherent scatter radar are used to validate the International Reference Ionosphere (IRI-95) model for midday (10-14 h), for solar maximum conditions. The electron density profiles are normalized to the peak density of the F-region, NmF2, and are then compared with the IRI-95 model using both the old option (table of values for bottom side thickness parameter, B0) and the new option (Gulyaeva's thickness parameter based on half density height). The analysis indicates that during summer and equinox, in general, the values of electron densities at all the heights obtained by the new option of IRI model are higher than the measured values. However, the older option of the IRI model provides a better agreement with the observed profiles. During winter there appears better agreement between either

of the options of IRI and measured electron densities (Fig. 7.13).

Tracking the Trails of Leonid Meteors using Satellite VHF Scintillations at Delhi

In continuation of efforts to understand Leonid meteors shower effects on Fleetsat 250 MHz signals which were reported earlier, the digital data of 18 November 1999 have been further analyzed and some new results obtained regarding the finer features of Leonid meteor trails. Firstly, the standard S_4 -index computed from the scintillation data ($S_4 \sim 0.3$) indicates that these scintillations belong to the weak scattering regime. Also, from the power spectrum analysis (Fig. 7.14), the so-called Fresnel-oscillations could be noticed which validates thin-screen approximation to the scattering medium. Fixing the average height (z) of these irregularities at 100 km the first Fresnel-zone scale (F_z) of 644 m. has been obtained. This

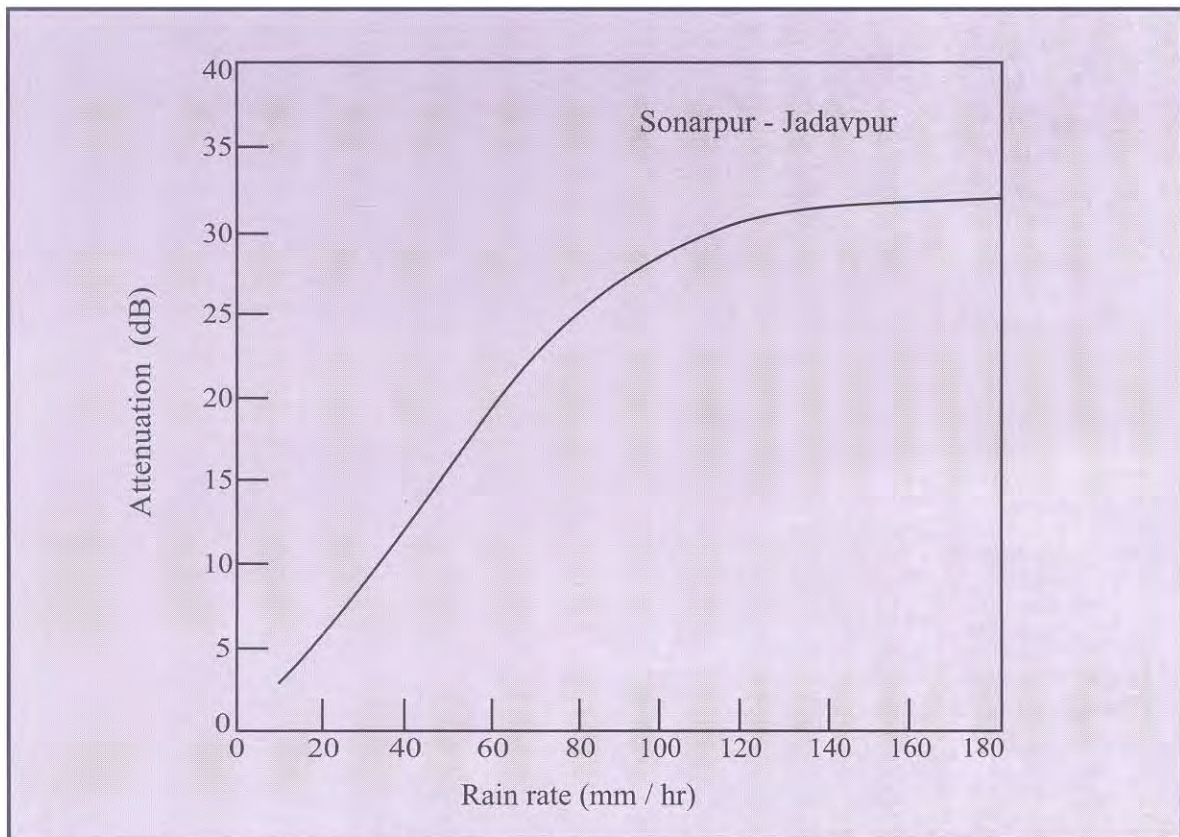


Fig. 7.12 : Observed attenuation due to rain at 18 GHz for different rain rates.

corresponds to an identifiable break-frequency (F_b) in the (temporal) power spectrum. The irregularity drift speed (u) is then obtained from the simple relation $u = F_z * F_b$ which is computed from the power spectrum to be of the order of 13 m/s. This value of drift is further validated by noting that the frequency minima, in the

power spectrum showing Fresnel oscillations, are seen to be in the ratio $v_1:v_2:v_3$. Also, this drift value is in agreement with the zonal component of tidal wind motion at the meteoric heights. Next, the scintillation data is processed through a standard 8th order Butterworth digital filter from which it has been

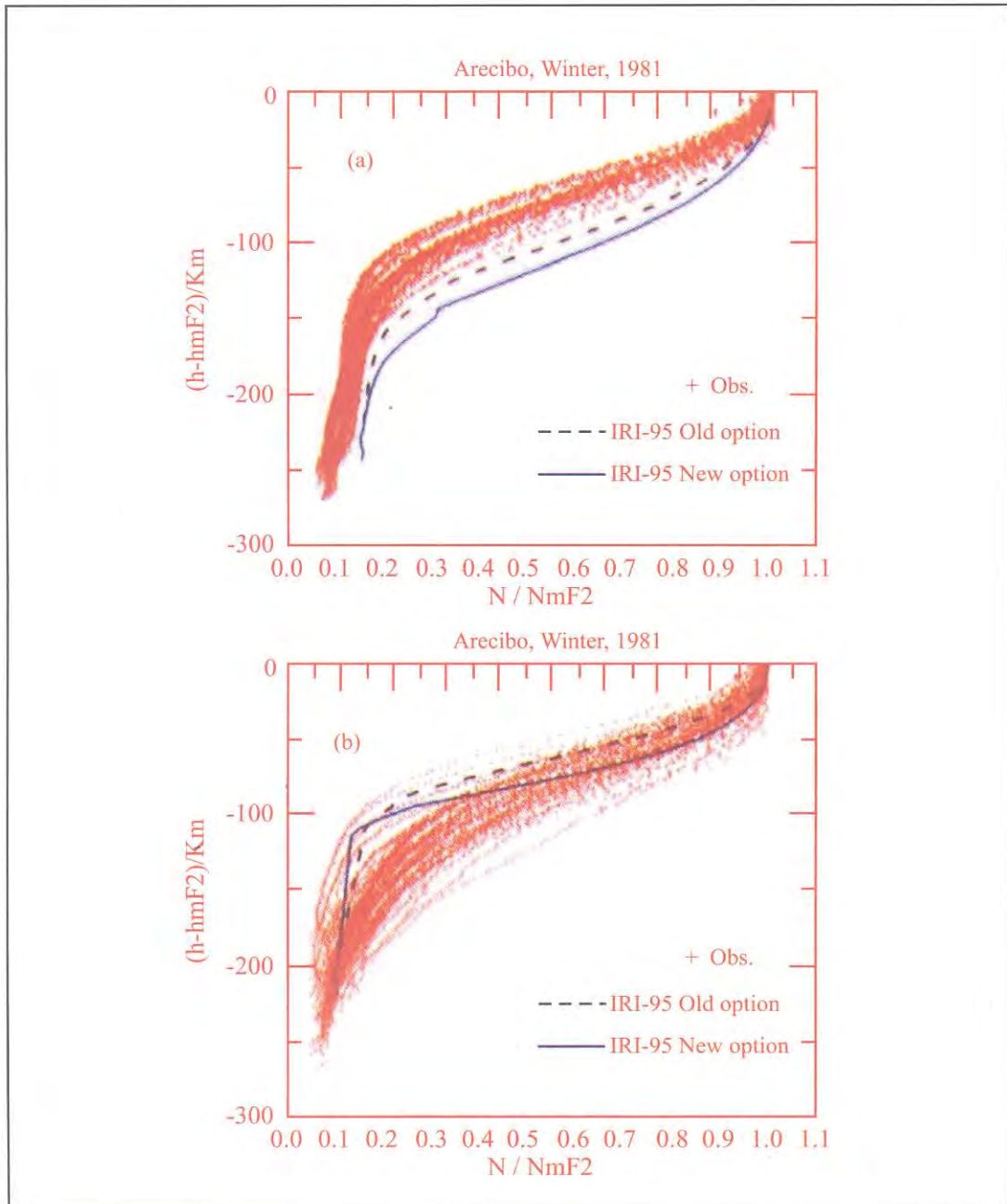


Fig. 7.13 : Mass plots of N/NmF_2 against $(h-hmF_2)$ for summer and in winter during midday (11-14 hrs.) along the IRI normalised profiles using both the old and new options

possible to identify the edge-signatures in the scintillation data. These edge-signatures (Fig. 7.15) are explained as caused due to a carpet-like electron density enhancement region, which is a foot-print of the Leonid meteors, and which is seen drifting at the meteoric heights with the ambient medium. These carpet edges depict vertically extending regions of strong horizontal gradients in electron density. While one edge corresponds to positive gradient, the other represents negative gradient. This fact is also reflected in the data wherein it is seen that the edge-signatures are mirror-images of each other. Lastly, by using the experimentally determined drift value for making the time-to-space conversion, the spatial extent of the meteor-trail is derived to be of the order of 71 km, while the spatial extent of each of the edges is seen to be about 12 km.

Regional Warning Centre-India

The Regional Warning Center, New Delhi being operated under International Space Environmental Services (ISES) at National Physical Laboratory is now designated as RWC-India. It is the only center in India under ISES responsible for exchange of recent observational data on solar and geophysical conditions from other centers and observatories and for its dissemination to the users in the country. It also has the responsibility of issuing forecasts on solar-geophysical conditions to aid in radio communications, satellite tracking, planning of scientific experimental campaigns etc. During the current year RWC India continued its activities which includes, apart from issuing daily messages on solar and magnetic activities, special messages during

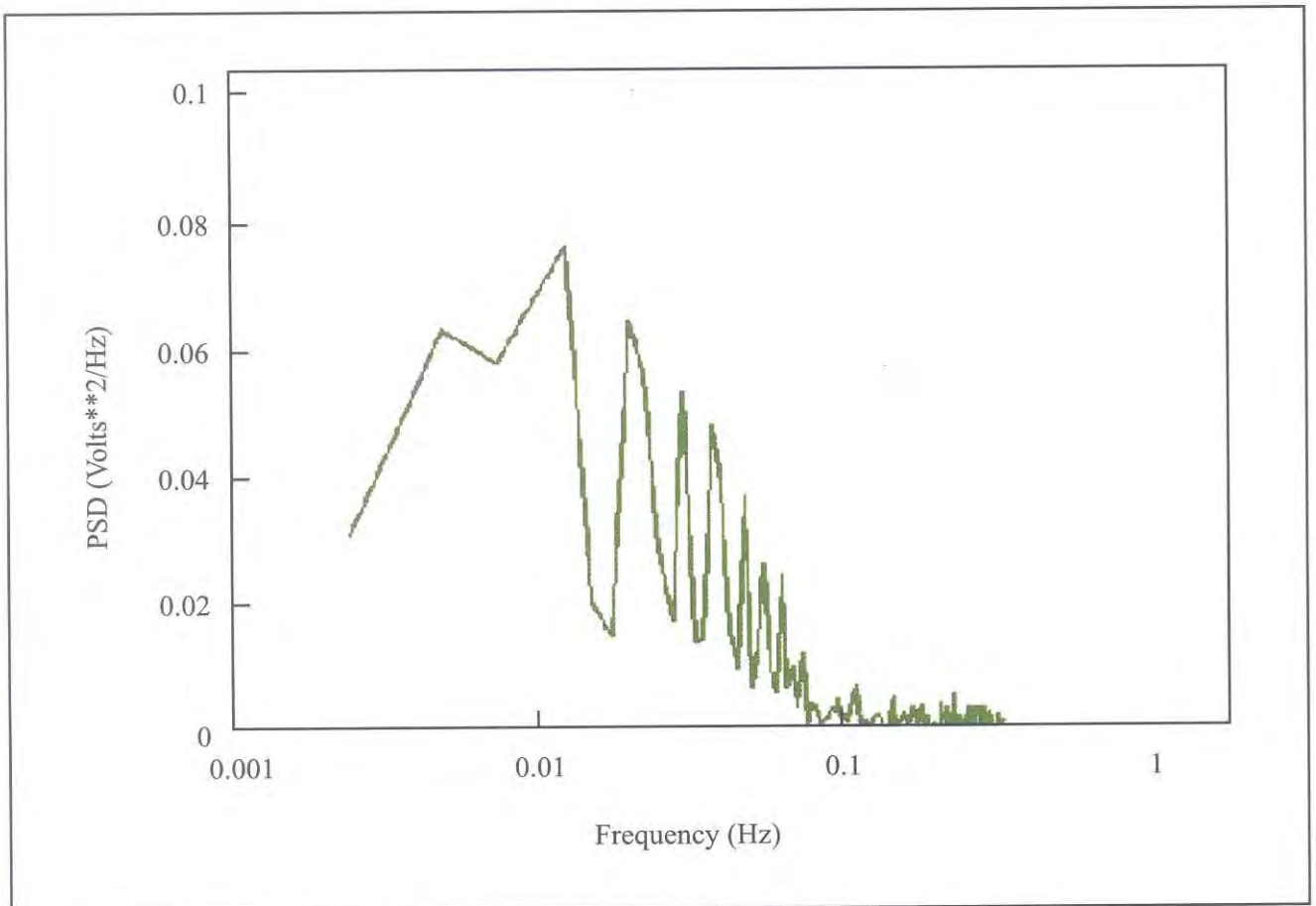


Fig. 7.14 : Power spectrum depicting typical Fresnel oscillations. Thin screen approximation is valid here. The frequency minima seen in this temporal spectrum are in the ratio of $v_1 : v_2 : v_3$. The actual frequency minima values are consistent with the drift value of $\sim 13\text{m/s}$. The numerical values of minima are 0.0189 G 0.0006 Hz, 0.02686 G 0.0006 Hz and 0.03287 G 0.0006 Hz.

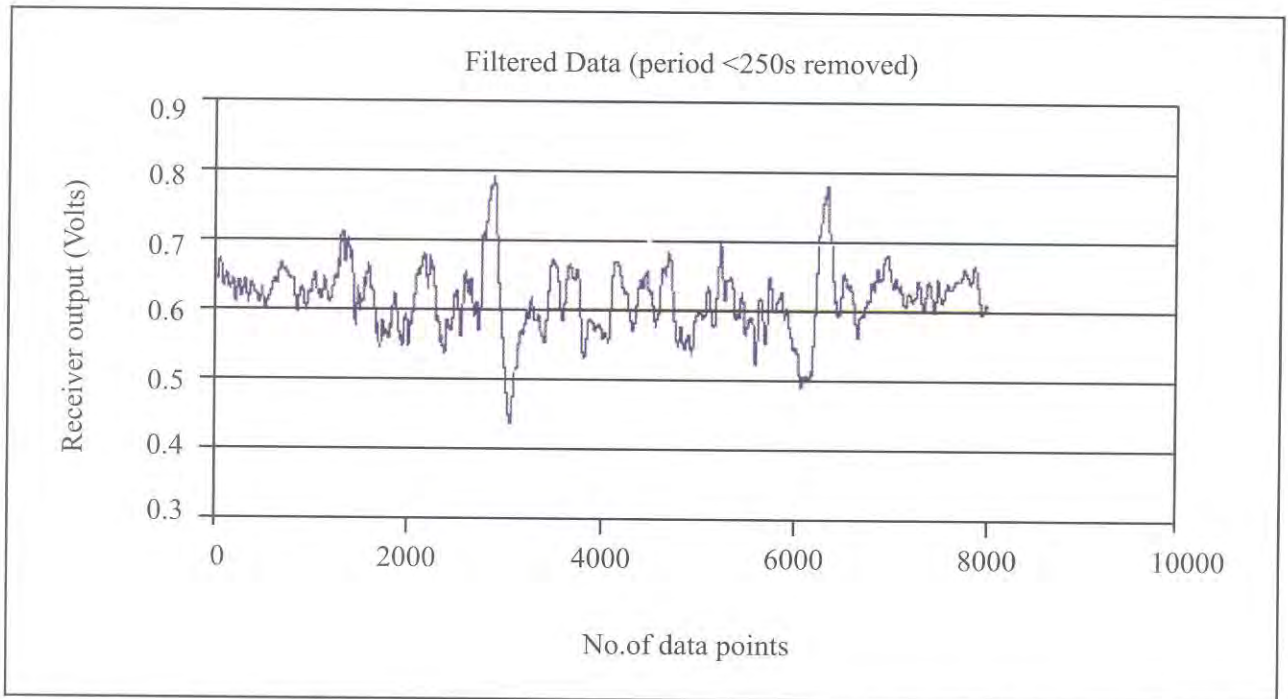


Fig.7.15: A plot of the filtered data with all periods < 250 s removed using the 8th order Butterworth filter. The edge signatures are clearly brought out by the filtration process. From the number of points (3413-points) separating these edge signatures \times sample period (1.6s) \times the drift speed (13m/s) gives the trail-width of the Leonid meteors ~ 71 km. Similarly the width of these edges are computed to be ~ 12 km.

abnormal conditions like magnetic storms. Major users include Indian Navy and Army, ISRO Tracking and Ranging Centre, Bangalore and INSAT Master Control Facility, Hassan.

Instrument Development

MID-FACE Facility for South Asian Region

Exponentially increasing levels of carbon dioxide (CO_2) in global atmosphere is a reality due to industrialization during past century. Present level of CO_2 concentration in earth's atmosphere is around 370 ppm and is increasing at present at the rate of 1.5 ppm per year. It is conjectured that by the middle of the 21st century the atmospheric CO_2 level might double its pre-industrial level of 280 ppm in the year 1880.

CO_2 being a green house gas affects directly our environment, carbon cycle and also the vegetation growth. The effects of elevated CO_2 on the environment, crops, forests, animals etc. are being studied in a few countries by simulating the elevated CO_2 conditions in the open fields of finite size using a technique called the Free Air CO_2 Enrichment (FACE)

facility. The level of CO_2 is maintained at a desired elevated value (around 570 ppm) in the FACE facility. For this CO_2 gas is mixed with air and then released in the field in a controlled manner using a number of gas injecting vent pipes in which gas flow is controlled by a set of on/off and proportional controlled valves under the control of a computer. PID algorithms have been developed for achieving the elevated CO_2 level at a predetermined value under varied winds and environmental conditions. Several FACE facilities, based on different designs, have been developed during past 15 years and are operational mostly in USA and Europe and one in Japan. But, no such facility exists in the whole of South Asia. The FACE facility first developed in US cost around Rs. 600 lakh.

Based on requests received from the agricultural community in India and neighboring countries through the South Asian Regional Research Network for Study of Global change, NPL undertook the task of developing first such experimental facility of a medium size called Mid-FACE, in South Asia in collaboration with IATA-CNR, Italy and IARI, New Delhi. To carryout this task, grant was provided by CSIR and by the Asian Pacific Network (APN) for

Global Change Research. NPL developed this facility at 1/10th of the cost required in US.

One Mid-FACE ring, based on this design, has been successfully installed and tested in the agricultural fields of IARI. This facility is planned to be the central facility for South Asian countries, namely, Bangladesh, India, Nepal, Pakistan and Sri Lanka for elevated CO₂ agricultural research.

The octagonal shaped Mid-FACE ring with 8 meter diameter designed and developed at NPL is shown in Fig. 7.16. The ring arms are made of 200mm dia rigid PVC pipes with suitable holes drilled on them for CO₂ release. All the eight sides of the octagon have independent supply of CO₂ gas controlled by on/off valves and a common computer controlled PID valve. Each pipe of the octagon is fitted with a centrifugal air

blower. The pure CO₂ gas is injected at the input of each air blower for pre-mixing with air before injection of the mixer in the fields from pipes. For each arm there are three calibrated nozzles for CO₂ injection. At a time the CO₂ gas is injected into the field from only 3 out of the 8 arms that are adjacent to each other and are in the downward wind direction. The central arm of these three gets pure CO₂ from the 100% nozzle and the adjacent two arms get supply from 70% nozzle to take care of tilt of adjacent arms with wind direction. The direction of the wind is sensed by a wind vane and wind speed by a sensitive anemometer. A bank of 50 cylinders is used for CO₂ storage & dissemination under constant pressure. The buffer tank installed after the cylinder bank takes care of the pressure variations in the supply line due to decreasing level of CO₂ level in cylinders. The CO₂ concentration is measured at the

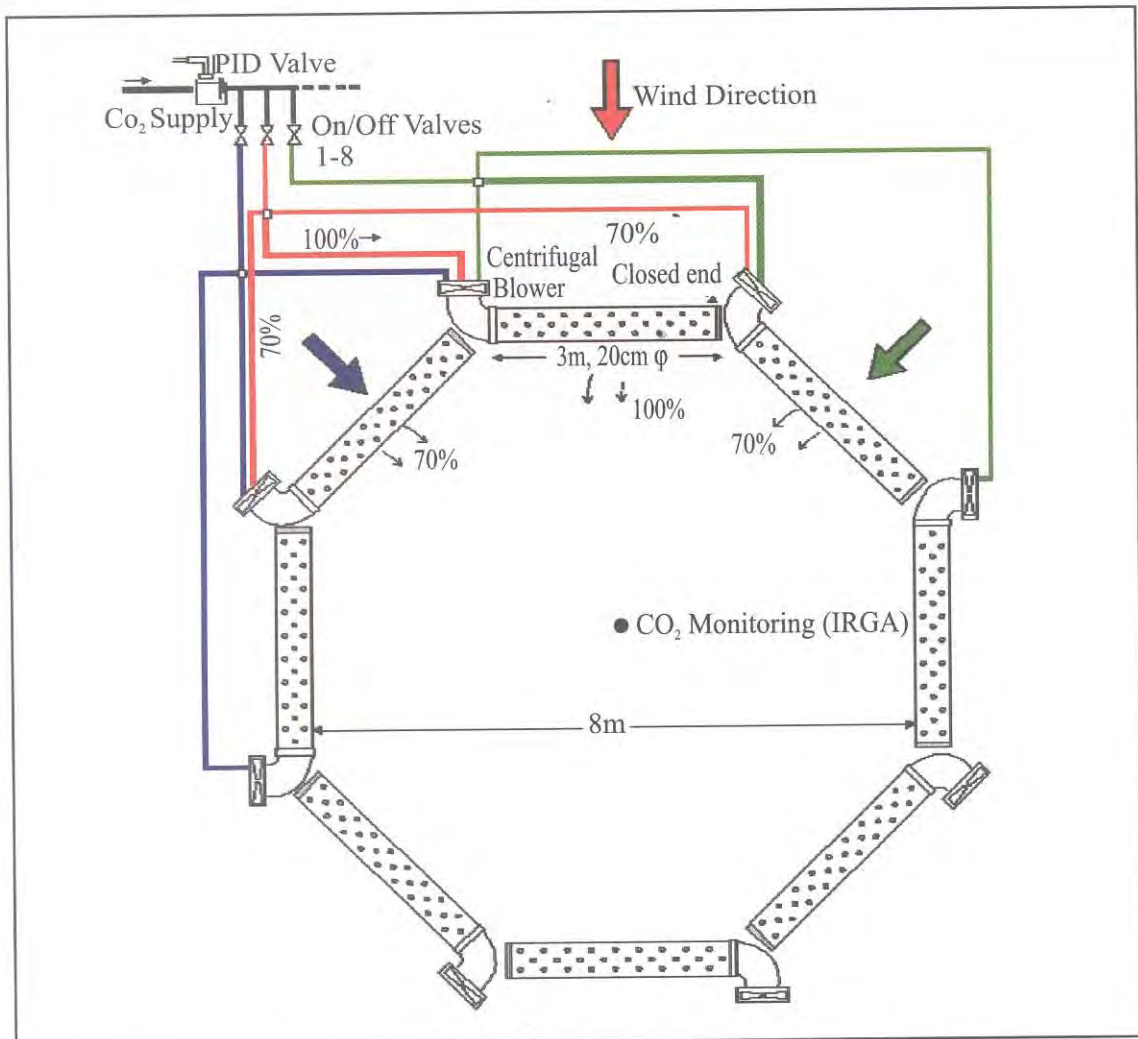


Fig. 7.16 : MID-FACE Ring for south Asia

center of the field with the help of an Infra Red Gas Analyzer 10 to 15 cm above the crop canopy level. A PC-based system-controller controls the operation of the FACE facility using a PID algorithm developed at NPL. Based on the input data, such as CO₂ concentration at the centre of ring, wind speed, wind direction, ambient temperature etc., computations are carried out by the PC and then command signals are issued to operate PID valve and appropriate On/Off valves for maintaining the required elevated CO₂ concentration in the field. During the trial run, the CO₂ was maintained well within the permissible $\pm 10\%$ limit of the target value of 560ppm as shown in Fig. 7.17. CO₂ fumigation is not required during night time.

Post Earthquake Rescue System

Following the severe earthquake in Maharashtra a few years ago, a project funded by DST was undertaken at NPL to develop an electromagnetic system in GHz

band for remote detection of victims trapped under the earthquake rubble. The system works on the principle of the Doppler phase shift of an irradiating electromagnetic wave due to movement of body parts (Fig. 7.18).

A human subject trapped under rubble is illuminated by a medium intensity microwave radio beam in GHz band from the top of the rubble. Movements of chest due to breathing/heartbeat or any other body movement produce a change in phase and amplitude of the back-scattered signal. The phase change detected in a microwave receiver is in perfect synchronism with breathing/heartbeats. Thus, these two vital life signs (or even any one of them) are the indicators of life in a human subject and, hence, can be used as a Remote Electromagnetic Life Detection System for victims trapped under rubble or for people hiding behind a barrier.

The system designed, presently, can detect

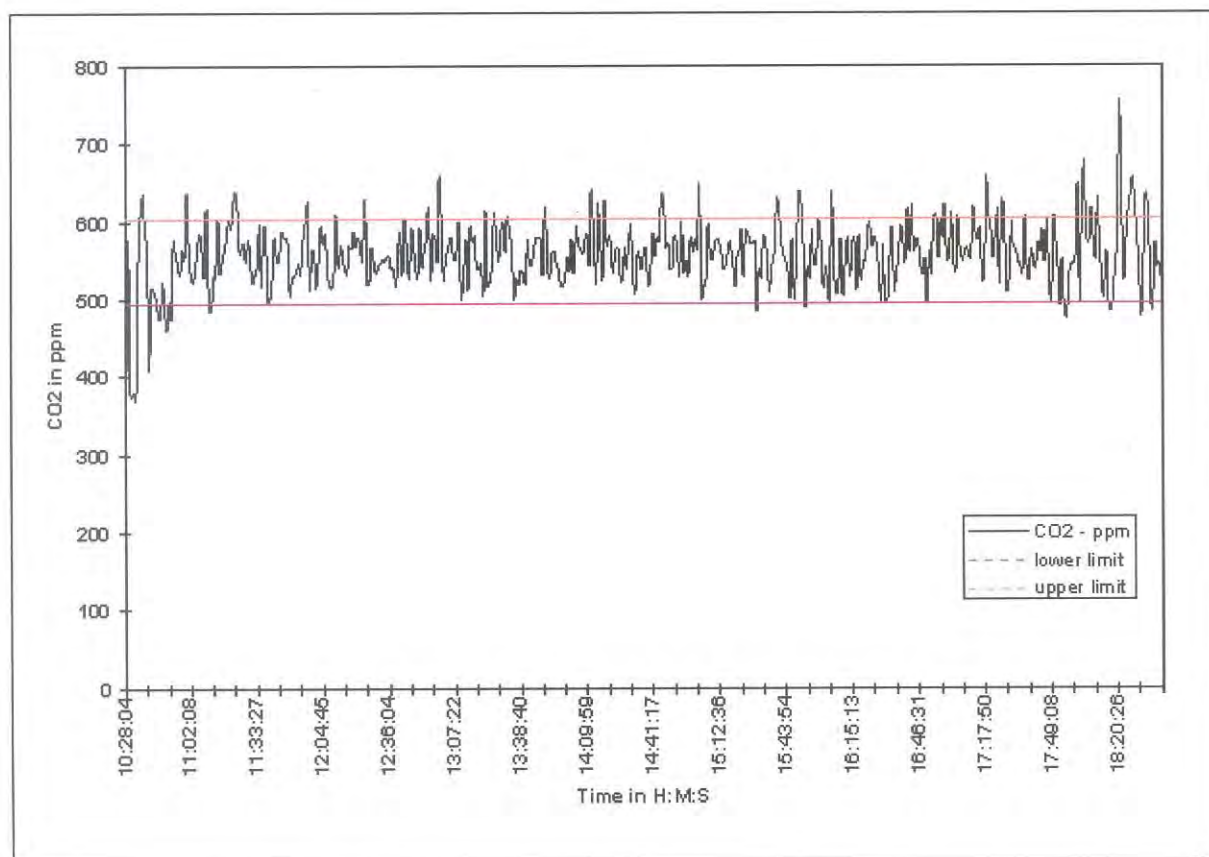


Fig. 7.17 : CO₂ concentration measurement during daytime

presence of life from a depth of a little over 2 meters of dry debris by either displaying breathing cycles or a signal jump resulting from a slight movement of the body trapped under rubble. Efforts are underway at present to improve the detection depth to 3 m. The same system can also be used to detect the presence of a person behind a wall in security operations. Fig. 7.19 shows the instrument developed at NPL.

Differential Absorption Lidar (DIAL)

A Differential Absorption Lidar (DIAL) system using a tunable CO₂ laser (9-11 micro meter) has been designed and developed at NPL to monitor various minor constituents in the atmosphere. The block diagram of the DIAL developed at NPL is depicted in Fig. 7.20. In this system a manually tunable CO₂ laser

which has a good spectral coincidence between laser emission lines and the absorption lines of a number of gases of interest is used. The system has been tried to monitor water vapour, surface ozone, ammonia and ethylene concentration in the medium. A pair of CO₂ laser wave lengths at 'ON' and [ABG2] 'OFF' the absorption line of the gas of interest, is transmitted in the atmosphere and reflected back by a reflector placed at a distance of 100 m to a receiver located near the transmitter. For example, the measurement of surface ozone is made by tuning the laser on "ON" resonance line P (14) at 1052.1956 cm⁻¹ and "OFF" resonance line P (24) at 1043.1633 cm⁻¹. A liquid nitrogen cooled HgCdTe detector has been used to detect the signal which in turn is fed to a PC through lock-in-amplifier for data acquisition and analysis. The system has been put for trial and results are being evaluated.

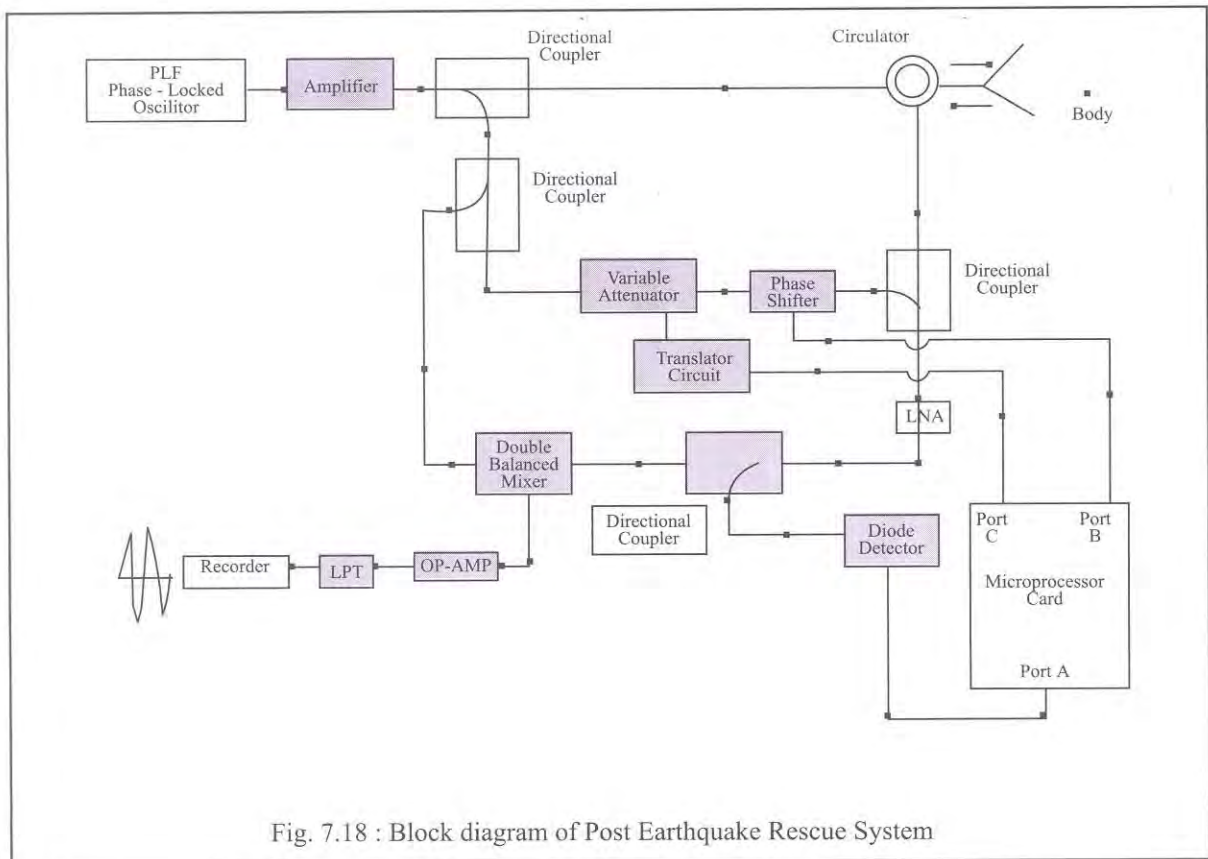


Fig. 7.18 : Block diagram of Post Earthquake Rescue System

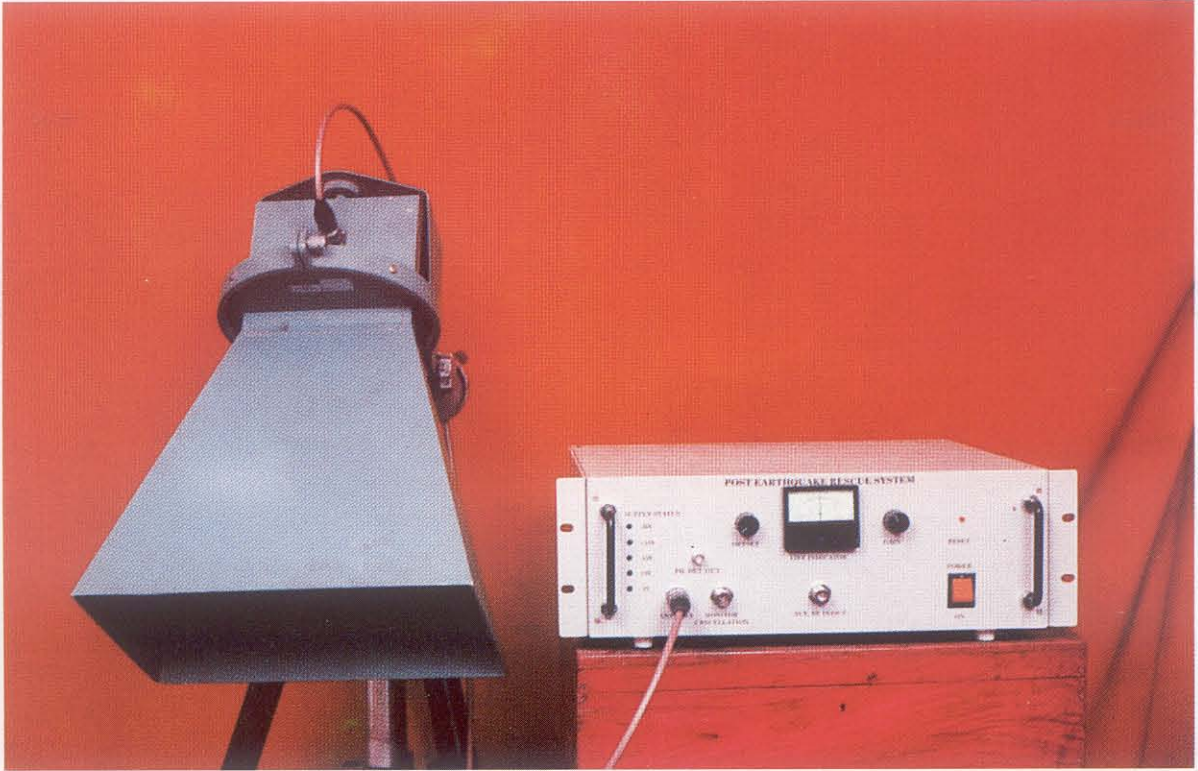


Fig. 7.19 : The instrument developed at NPL for the post earthquake Rescue operation

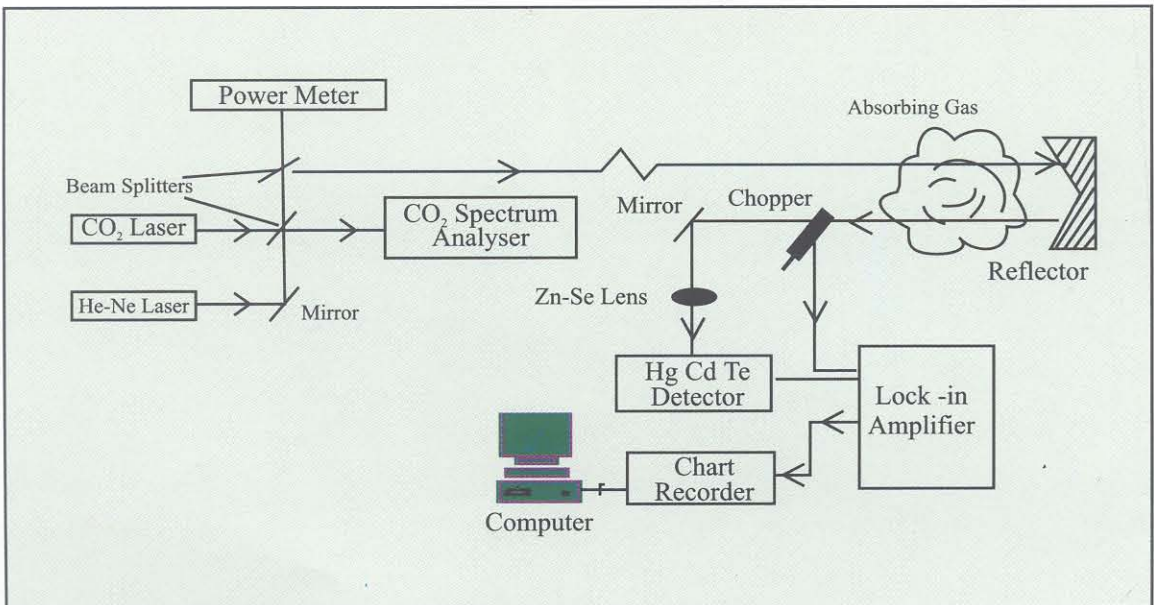


Fig. 7.20 : A Differential absorption Lidar system designed and developed at NPL

अतिचालकता तथा निम्नतापिकी
SUPERCONDUCTIVITY & CRYOGENICS

अतिचालकता तथा निम्नतापिकी

उच्च Tc अतिचालकों पर आधारभूत जांच-पड़ताल करने, विशिष्ट अतिचालकीय चुम्बकों का विकास करने, आर्द्रता मानकों को स्थापित करने तथा अंशांकन का कार्य करने तथा प्रयोगशाला के विभिन्न ग्रुपों को द्रव हीलियम और द्रव नाइट्रोजन उपलब्ध करवाने का कार्य निम्नतापिकी तथा अतिचालकता प्रभाग को सौंपा गया है। इस वर्ष के दौरान काफी अधिक संख्या में अतिचालकीय चुम्बकों का विकास किया गया है। छः-सात टेसला चुम्बकों का निर्माण किया गया जो प्रचालन(ऑपरेशन) के लिए तैयार हैं। दो Nb₃Sn इंसर्ट भी बनाए गए थे तथा 255 mm वर्किंग बोर वाले अभी तक के सबसे बड़े तैयार किए जा रहे चुम्बक के पूरा होने का कार्य प्रगति पर है।

उच्च Tc अतिचालकों के केटिऑनिक प्रतिस्थापनों के संबंध में किए गए मूल अध्ययन के क्षेत्र में इन नए द्रव्यों की उत्पत्ति पर गहन कार्य किया गया ताकि इनमें पाए जाने वाली खराबियों/गठनात्मक और इलेक्ट्रॉनिक परिवर्तनों के बारे में पर्याप्त ब्यौरे मिल सकें। जिन सम-संरचनात्मक द्रव्यों में अतिचालकता का अभाव है उनमें इन ब्यौरों के मिलने से अतिचालकता का बढ़िया तरीके से प्रसार और संचार हो सकेगा। इसके अतिरिक्त विशुद्ध और प्रतिस्थापित YBaCuO प्रकार के यौगिकों, कुछ नए द्रव्य जैसे क्वार्टरनरी बोरोकारबाइड्स, Cu-1234 तथा (CuTI)-1223 की भी जांच-पड़ताल यह देखने के लिए की गई ताकि दुर्बल सह-संबंध स्वरूप आवेश भण्डार माडुलन तथा SC एनीसोट्रोपी (Anisotropy) घटबढ़ चालकता और कमिक मानदंड, की दिशात्मकता आदि के बारे में इन द्रव्यों के भीतरी व्यवहार का पता चल सके। एकल और दोहरी परत क्यूपरेटस की चुम्बकीय गतिकी को समझने के लिए एक सैद्धांतिक अध्ययन किया गया है। विश्वविद्यालयों से प्राप्त सहयोग तथा प्रमुख अनुसंधान तथा विकास संस्थाओं से प्राप्त सहयोग परिणामदायक सिद्ध हुआ है।

SUPERCONDUCTIVITY & CRYOGENICS

The mandate of this division has been to carry out the basic investigations on high T_c superconductors, to develop specialized superconducting magnets, to maintain humidity standard and carry out calibrations and to make liquid helium and liquid nitrogen available to various groups of the laboratory. During this year a number of superconducting magnets were developed. Six 7 Tesla magnets were made ready for operation. Two Nb₃Sn inserts were also wound and the winding of a largest ever magnet with a 255 mm working bore is in progress.

In the area of basic studies on high T_c superconductors cationic substitutions, the genesis of these novel materials, have been intensely pursued to unveil the details about the induced disorder/structural and electronic changes. These might lead to the strategic revival of superconductivity in the non-superconducting isostructural materials. Besides pure and substituted YBaCuO type compounds, some new materials like quarternary borocarbides, Cu-1234 and (Cu,Tl)-1223 have also been investigated from the point of view of getting an insight about the weak-link behaviour, charge reservoir modulation and SC anisotropy, fluctuation conductivity and order parameter dimensionality. A theoretical study has also been undertaken to understand the magnetic dynamics of the single and double layer cuprates. Collaboration with universities and the premier R & D institutions has been quite fruitful.

Superconducting Magnet Technology

7 Tesla SC Magnet Systems

Development of six 7 Tesla SC magnets (50 mm bore dia.) with their suspension system and seven nos. of cryostats (for housing the above magnets) have been completed. The suspension system of the magnet consists of SS tubes / rods, radiation baffles, styrofoam spacers in the neck area (to reduce LHe evaporation rate), LHe level sensor and vapour cooled current leads (Fig.8.1). The dump resistors kept in vapour phase protects the magnet against quench. The cryostat is a double walled superinsulated bucket type vessel with a neck dia. of 164 mm and a volume of 25 litres. The cryostat assembly comprises an inner LHe vessel, copper radiation shield and an outer vessel. Superinsulation (multilayers of aluminized mylar and nylon net) is wrapped on inner LHe vessel and copper radiation shield. The cryostat is provided with He gas recovery port, pressure relief port and vacuum port. The cryostats have been leak tested at room temperature and LN₂ temperature.

A Large Bore 6 Tesla SC Magnet

A large bore (255 mm) 6 Tesla SC magnet is under fabrication in collaboration with Institute for Plasma Research, Gandhinagar. The magnet will be sixth order compensated using outside notch. The magnet consists of 42 layers in main coil and will have 25 layers in

compensation coil. Multifilamentary Cu/Nb-Ti wire of dia. 0.56 mm is being used for winding the magnet. The overall dimension of the magnet is $\phi 400$ mm X 680 mm. A wire-tensioner, to hold the heavy wire spool and to provide the requisite tension for coil winding, has also been designed and fabricated (Fig. 8.2).

An 11 Tesla SC Magnet

Development of two Nb₃Sn insert magnets (50 mm bore dia.) is under progress. The insert magnet is to be used for producing a field of 11 Tesla in hybrid form (Fig. 8.3). The background field will be provided by Nb-Ti magnet, which was developed in the previous year. The problem with Nb₃Sn is that it is an intermetallic compound, which is very brittle. It is difficult to handle or wind the magnet once the Nb₃Sn is formed. It is commercially available in the form of pure Nb filaments in a Cu-Sn (bronze) matrix. The magnet was wound with wire consisting of 6000 NbTa filaments in a Cu-Sn matrix covered with quartz sleeve. The magnet winding dia. is 56.6 mm and a winding length of 170 mm. The overall dia. of wire is 0.85 mm. Each magnet consists of 20 layers. The magnet after winding was chemically treated. One magnet was heat treated at 570°C for 120 hrs and 700°C for 80 hrs under inert atmosphere. The magnet is now ready for impregnation followed by testing.



Fig.8.1 : The six 7 Tesla SC Magnets (50 mm. bore dia.) with suspension system. LHe level meters and seven nos. of bucket type LHe cryostats.

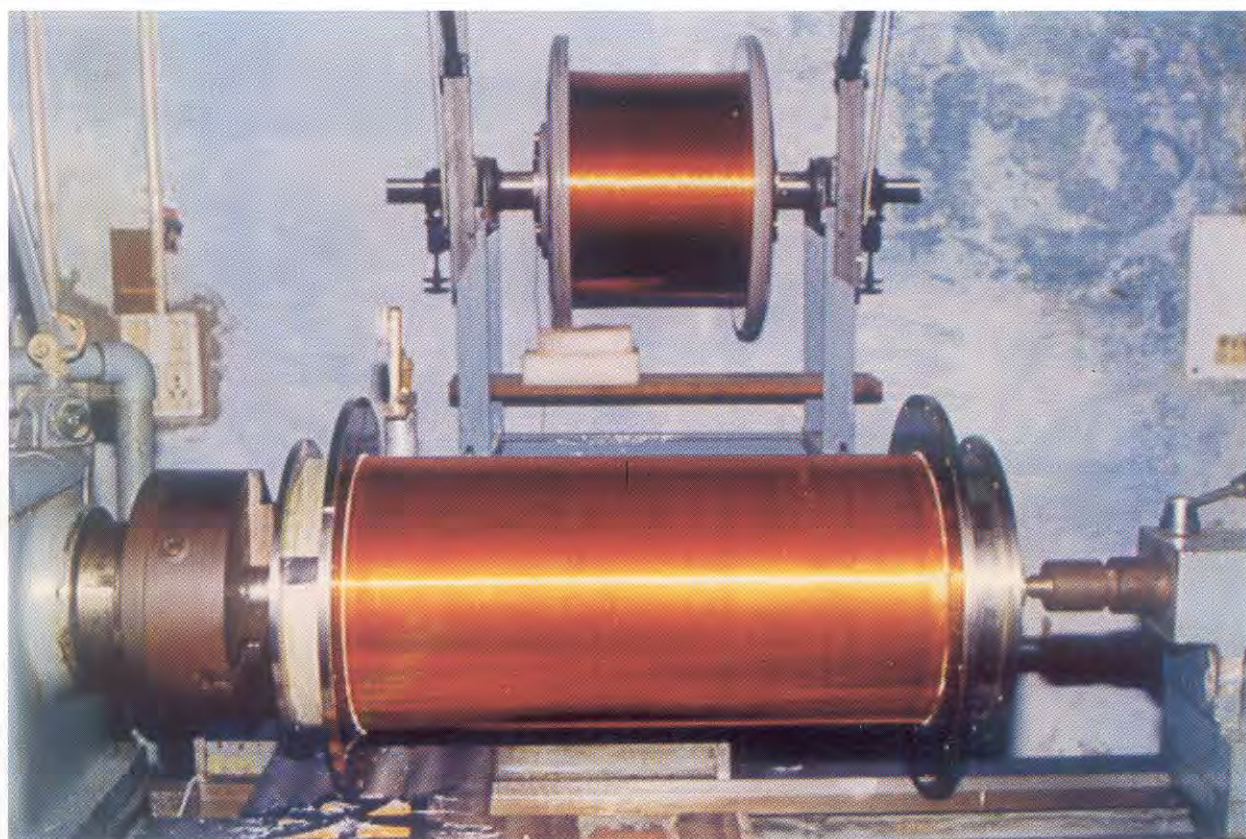


Fig.8.2 : A large bore (255 mm) SC magnet being wound using a Cu/Nb-Ti wire of dia. 0.56 mm. The overall dimension of the magnet is 400 mm X 680 mm.

Humidity Standards

The work on humidity standards was started in 1996 in the Laboratory with an objective to provide calibration services to various industries. The group has developed a reference humidity standard and offered calibration services to several industries from 1996 itself. Besides, the following techniques have also been developed:

Maintenance of secondary (reference) humidity standard (aspirated psychrometer) using two accurate, matched quartz thermometers in the range of 10 % to 95 % relative humidity (RH) with an uncertainty of ± 1 % RH.

Overhauling and maintenance of humidity oven for calibrating different RH sensors at various temperatures and RH.

Generation of different humidity using sodium hydroxide-water and saturated salt solutions.

Development of a portable and mini RH generators based upon two-pressure principle.

An application for a patent for the portable RH generator has been filed. The device is totally indigenous and the novelty is in the design of its expansion valve. Efforts are being pursued to develop a laboratory model of a two-pressure cum two-temperature humidity generator in order to achieve better accuracy. Such type of a device is known as practical humidity standard and is being used in almost all the standard laboratories of the world. The pre-saturator, an important part of this generator, has been designed, fabricated, assembled and tested. Figure 8.4 shows the assembly of pre-saturator. The PID temperature controller is used to maintain the desired temperature of the pre-saturator.



Fig. 8.3 : Two insert magnets wound with NbTa/Cu-Sn wire. (left - insert magnet after heat treatment at 570°C for 120 hrs. and 700°C for 80 hrs under inert atmosphere, right - insert magnet before heat treatment) The insert magnet is to be used with Nb-Ti magnet for producing a field of 11 tesla.



Fig. 8.4 : The assembled pre-saturator, a part of the RH generator under development

Superconductivity Studies

Basic Studies on High Temperature Superconductors

Magnetisation behaviour studied in bulk polycrystalline YBCO and BPSCCO superconductors show relaxation and inter-granular critical state at very low magnetic fields in the temperature range 20-77K. Inter-granular relaxation dominated by disordered Josephson junction (J-J) network is seen to be slower than the intra-granular relaxation yielding a higher pinning energy U_0 . With DT_c as the measure of disorder, critical current density J_c follows the relationship $J_c \sim \exp(-DT_c)$ while the pinning energy $U_0 \sim DT_c$. Such conclusions will be helpful in optimizing Ag-addition to achieve high J_c . Silver addition to these materials results in sharp drop in the flux pinning energy E_j across the J-J network. The degree of disorder is also reduced by silver addition, causing variation in the effective vortex mass m^* .

Annealing effects in reducing environment (flowing nitrogen) in the temperature range of 200-600C on high Tl content $(Cu_{1-x}Tl_x)Ba_2Ca_2Cu_3O_y$ system, synthesized under high temperature - high pressure (1000C, 4.5GPa), were studied. A considerable enhancement in T_c from 97K (as-synthesized) to 130K (annealed at 550C) together with an anomalous behaviour in resistivity with annealing, has been noticed (Fig. 8.5). Such results, observed for the first time in Tl-based system, have been analysed in the

context of the predominant role of hole depletion and addition by oxygen removal and Tl^{3+} (R) Tl^{4+} conversion of Tl-valence state in 550C sample with $T_c \sim 130K$. It is also suggested that there is a need to consider the Tl-valence change in the band structure proposed earlier to account for the annealing effects seen in (Cu,Tl)-1223 system.

Experiments for reviving superconductivity in the non-superconducting $PrBa_2Cu_3O_7$ are being conducted on single crystals from Electrotechnical Lab. Japan, as a part of the strategy planned. Indications of such a revival have been observed through ac susceptibility measurements. These experiments have great bearing on the existing understanding of these materials.

Recent studies in the 4- CuO_2 layer compound $Cu_1Ba_2Ca_3Cu_4O_y$ (Cu-1234) have revealed that the 5-fold outer CuO_2 -layers of the superconducting block has been found to be under-doped while the inner 4-fold layers are seen to be nearly optimally doped. In view of the different doping levels in Cu-1234 material, Ba-site substitutions have been proposed. Such materials containing Cs at Ba place have been synthesized and characterized through XRD and resistivity (in collaboration with ETL, Tsukuba and Science University of Tokyo, Japan). Further experiments are underway to investigate the different CuO_2 layers.

The similarity of the characteristic weak link behaviour in the polycrystalline high T_c

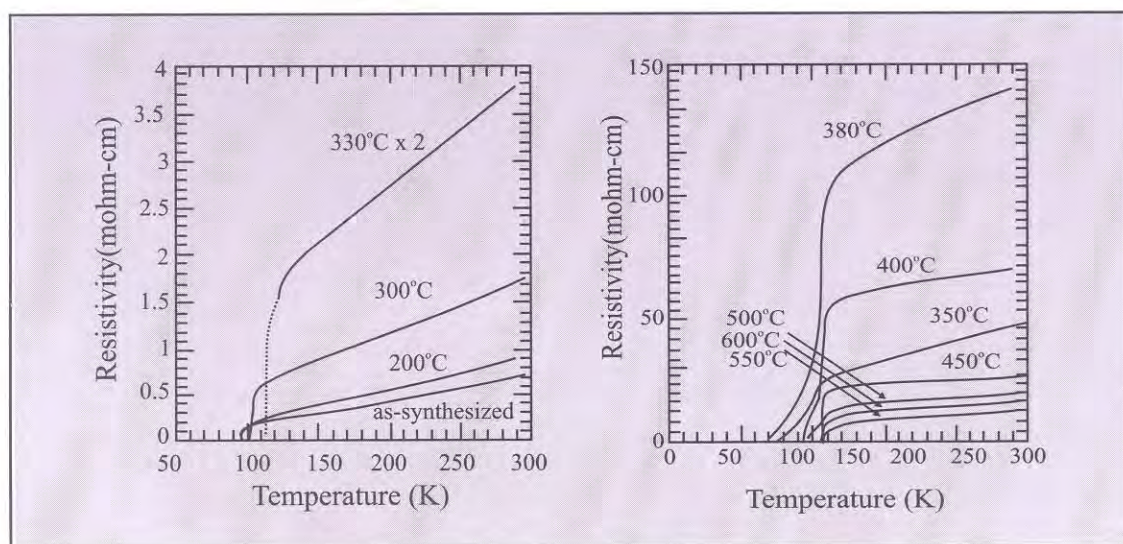


Fig.8.5 : Resistivity behaviour of (Cu,Tl)-1223 sample with annealing in N_2 at different temperatures.

superconductors and the low T_c quaternary borocarbides has been found to be quite unusual. To understand such unexpected behaviour the grain boundary (GB) structure has been examined using scanning tunneling microscopy/spectroscopy (STM/STS) techniques with atomic level resolution. For a comparative study, grain boundaries of pure metal like copper and of high T_c cuprate $\text{Bi}_2\text{CaSr}_2\text{Cu}_2\text{O}_8$ (BSCCO) have also been investigated. The results reveal that although the GB in $\text{YNi}_2\text{B}_2\text{C}$ as seen by STM is smaller than the range of coherence (Fig. 8.6), the spread of disorder detected by STS is significantly larger to justify the weak link effect. In case of the BSCCO sample, the GB which is significantly broad contains microbridges across the neighbouring grains, which are presumably responsible for the weak link effects.

STM /STS facilities were also extended to other divisions for investigations of a variety of samples like amino-propyl-diethoxy-silane, sol-gel films of WO_3 , synthesized poly propyl sodium nitrate composite films, high porosity porous silicon layers, DLC nanotubes deposited by microwave plasma enhanced CVD system insitu $\text{C}_2\text{H}_2+\text{Ar}$ mixture, high

strength high modulus Langmuir-Blodgett films of poly-3-hexyl thiophene, poly-3-dodecyle thiophene and poly-vinyl carbazole with and without enzyme (glucose oxide).

The influence of substitutions in inducing disorder/structural and electronic changes has been studied in various series like $\text{ErBa}_2\text{Cu}_{3-x}\text{M}_x\text{O}_{7-d}$ (M: Fe, Co, Ni and Ga), $\text{ErBa}_2\text{Cu}_{3-x-y}\text{Zn}_x\text{Fe}_y\text{O}_{7-d}$, $\text{REBaSrCu}_3\text{O}_{7-d}$ (RE : Y, Dy, Nd and La), and $\text{Er}_{1-x}\text{Ca}_x\text{Ba}_2\text{Cu}_3\text{O}_{7-d}$. Such changes play a dominant role in determining the superconductivity in these compounds. The structural and oxygen content changes by substitution of trivalent cations $M = \text{Fe}, \text{Co}$ and Ga at Cu(1) site in $\text{ErBa}_2\text{Cu}_{3-x}\text{M}_x\text{O}_{7-y}$ system suggests the formation of oxygen vacancies in CuO_2 planes. The $T^* (> T_c)$, where the $R(T)$ shows a change of slope, was seen to increase with Fe/Co/Ga content and decrease with Ni content. $\text{ErBa}_2\text{Cu}_{3-x}\text{Zn}_x\text{Fe}_y\text{O}_{7-d}$ system shows an interesting correlation of T_c with T_{\min} (where $r(T)$ goes through a minimum), residual resistivity and the slope dr/dT of linear $r(T)$ region. The former two parameters suppress the T_c , whereas the latter enhances T_c . The dependence of the structure and T_c on the ionic size of the chosen rare earth (RE) is

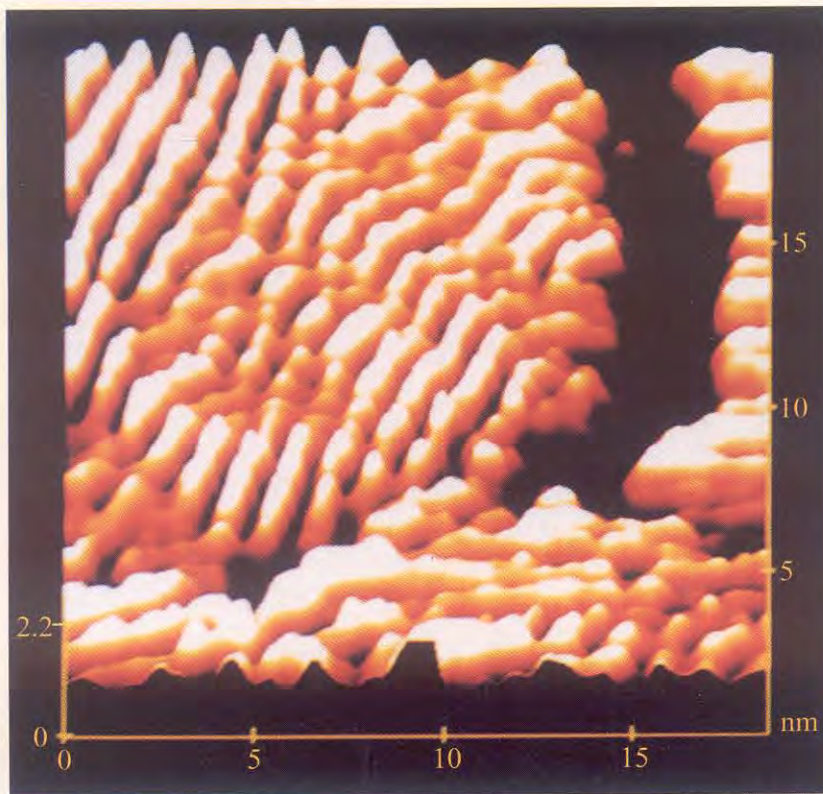


Fig. 8.6 : STM image of Grain Boundary 3 nm x 18 nm. Image in 3D mode at 60° pitch.

shown to be quite different in $\text{REBaSrCu}_3\text{O}_7$ and $\text{REBa}_2\text{Cu}_3\text{O}_7$ systems (Fig. 8.7). In the former case, the T_c is strongly dependent on the ionic size, whereas in the latter case T_c is nearly independent. In $\text{Er}_{1-x}\text{Ca}_x\text{Ba}_2\text{Cu}_3\text{O}_{7-y}$ with increasing x (between 0 to 0.3) it was shown that a sharp decrease in T_c is probably a consequence of loss of oxygen from CuO_2 planes. Neutron diffraction studies confirm this scenario.

The precise magneto-resistivity measurements were carried out on $\text{Tl}_2\text{Ba}_2\text{CuO}_6$ single crystals at high magnetic fields (up to 14T) at NRIM, Tsukuba, Japan and recent analysis of the data revealed the following features. A sharp drop, a dip and a peak together were observed in the flux flow resistivity $r(q)$ as the magnetic field angle q with c -axis approaches 90° . These features were observed for the first time and were ascribed to the vortex phase transitions of different types viz., pancake, tilted, combined and Josephson types. Such identification of the regimes of different types of vortices in turn led to the revelation of the first time q - t and q - H phase diagrams of vortices, where $t = T/T_c$ and H is the applied magnetic field. These features were observed above the irreversibility line for the magnetic field aligned along the c -axis and led to the verification of the failure of the applicability of the two- and three- dimensional models usually applied to identify the dimensionality of such a highly anisotropic superconductor.

Excess conductivity studies in $\text{ErBa}_2\text{Cu}_3\text{Fe}_x\text{O}_y$ showed reduced order parameter fluctuations and Cu-O network coupling deterioration. Order parameter dimensionality (OPD) shows invariance (marked variation) to low (increased) Fe concentration and shows oxygen content dependence. Higher Fe concentration promotes dimensionality reversal. Fe-doped Y-123 bulk samples show OPD increase by Fe and intrinsic disorder independence. The system anisotropy is invariant to (raised with) Zn (Fe) disorder. Low-disorder Cu-site occupancy of Fe(Zn) in YBCO shows OPD to be directly proportional to T_c^{mf} , with Ds having weak dependence on resistivity. Low Fe disorder shows suppression of OPD (or fluctuations). Dopant modified carrier scattering affects T_c and x behaviour and the interactions between r and x indicate strong interplay between impurity effects and carrier carrier scattering. The OPD in Zn-doped $\text{YBa}_2\text{Cu}_4\text{O}_8$ is invariant to Zn content, has oxygen content dependence and is independent of T_c . The excess conductivity fluctuations in Zn-doped Y-124 system are inferred to larger than the Y-123 system.

TGA/DTA facilities were utilised to decipher the thermal and structural characteristics under specific heat treatments, of a variety of materials like high T_c cuprates, sol-gel based WO_3 film casting precursor materials peroxypolytungstic acid (PTA) and acetylated peroxypolytungstic acid (APTA), the PAN family of polymers and bio-degradable polymer.

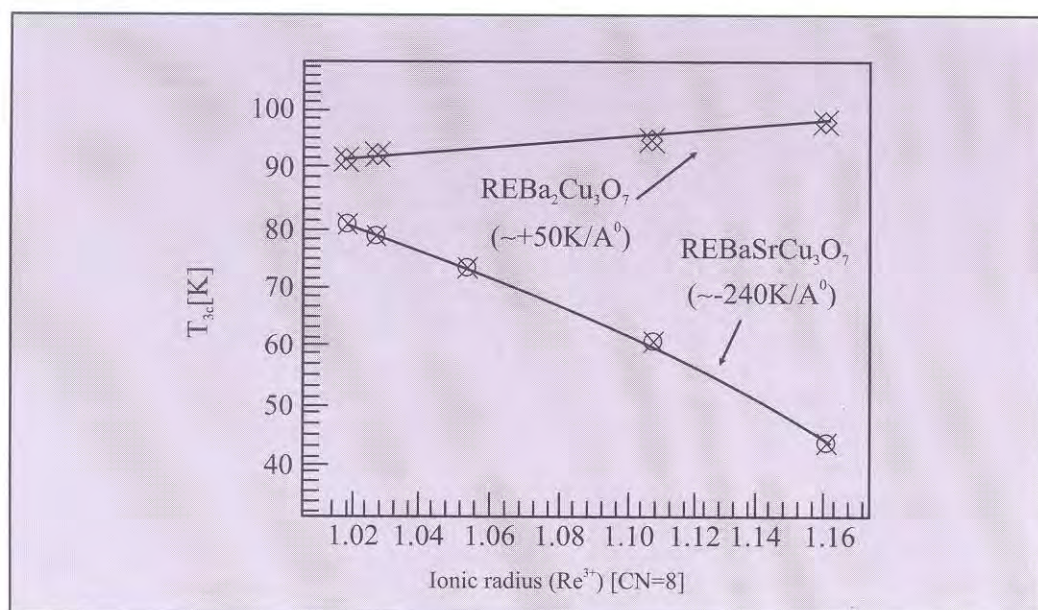


Fig.8.7 : Rare earth (RE) ionic size versus T_c plots for the $\text{REBa}_2\text{Cu}_3\text{O}_7$ and $\text{REBaSrCu}_3\text{O}_7$ systems

AC susceptibility of pure and Pr substituted Y-123 have been studied at various amplitudes and frequencies of the ac field in the temperature range 65-100K. The c'' -T curves exhibit well defined peaks, indicative of good inter-granular coupling. Results are being analysed to understand the effect of Pr doping on the inter-granular J_c and flux creep activation energy E_a . Low Pr concentration is seen to decrease J_c and E_a . Also the effect of rare-earth ion size (Yb, Nd and Sm) in Y-123 has been initiated. The normal state resistivity results indicate the disorder brought about by different rare-earth substitutional effect.

Studies of Pinning Centres

In the basic investigation programme a new project was initiated with the aim of examining the role of dopants as possible pinning centres in high T_c superconductors. Previous work on Bi-based high T_c series; both $(\text{BiPb})_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_y$ and $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_y$ had shown some interesting features when doped with f-level impurities. Some of these impurities, particularly those with half- or near half-level filling have shown tendency of formation of VBS near the Fermi level E_F . Since the effect was common to both the two-layer (2212) and the three-layer (2223) systems it was considered worth examining for the other high T_c superconductors also. For this purpose samples of $\text{YBa}_2\text{Cu}_3\text{O}_{7-y}$ were prepared in air and without the help of any oxidizing agent such as HgO etc. so that the role of the dopant could be seen as distinct from that of oxygen which is known to have a drastic effect on T_c and other superconducting properties of Y-123. Unlike the case of Bi-based superconductors here it was observed that doping affects not only the T_c but also phase-formation as seen from multiple superconducting transitions. There were indications of formation of the $\text{YBa}_2\text{Cu}_4\text{O}_8$ phase also (important from oxygen stability point of view) but the effect of f-level doping has not been so distinct as for the Bi-system. Further investigations are presently underway to clarify these effects in the Y-123 and Y-124 systems. Critical current studies at liquid helium temperature (4.2K) have also shown variations which can be tentatively correlated with the nature of the dopant. Extension of these studies to high magnetic fields and temperatures above 4.2 K are being done in order to understand the role of pinning centres and pinning mechanisms.

Theoretical Studies

Theoretical studies have been made of the magnetic

dynamics of single layer cuprate La_2CuO_4 and double layer cuprate $\text{YBa}_2\text{Cu}_3\text{O}_6$. Lattice magnetization and specific heat are calculated. Spectral function and self energy are calculated for the metallic state of bilayer cuprates for different values of doping, temperature and anisotropy parameters. Hole scattering rate has been calculated by considering the combined effect of the Coulomb interaction and the electron-phonon interaction.

The pJT problem of $(T_{1u} + T_{1g}) \cdot t_{1u}$ coupling in endohedral, $M@60$, system is put on a sound quantum mechanical basis by involving infinite coupling model. Using a canonical transformation the vibronic hamiltonian is transformed to a form which is a sum of two parts: (1) a zero phonon part, which is independent of the phonon operators, and second (2) the phonon dependent part. The analysis of the zero-phonon hamiltonian automatically provides the ground level vibronic eigen-value and eigen states. It is found that the ground level reflects a symmetry higher than the icosahedral symmetry I_h . Therefore higher order terms in pseudoelastic potential and vibronic coupling is essential to wrap this minimum energy surface to total minima.

This year only the contribution to pseudoelastic term could be considered. No wrapping is found to occur for harmonics of (Q_x, Q_y, Q_z) less the triquadratic. The analysis of this triquadratic term yields either twelve pentagonal type or twenty hexagonal type of minima, depending upon the sign of the involved parameter. The inverse splitting for both the pentagonal and hexagonal type of solutions is being investigated.

Liquid Nitrogen & Helium Facilities

The supply of liquid nitrogen to various divisions/groups of the laboratory was maintained. The installation and the commissioning of the 6000 litres capacity liquid nitrogen storage vessel has enabled us to maintain an uninterrupted supply. A total of approximately 14260 litres of liquid nitrogen was consumed during the year. The liquid nitrogen was procured both commercially as well as produced in our own plant.

Liquid helium was also procured from commercial sources and used for a variety of important experiments. Funds have been sanctioned for the purchase of a new helium liquefier.

सहायक सेवाएँ
SUPPORT SERVICES

सहायक सेवाएँ

SUPPORT SERVICES

Library and Technical Information Services

NPL library is a leading repository of publications in physics and related sciences in the country. During the year it expanded its collection by adding new books and journals on need basis. In this regard it spent Rs.85.16 lakh on journal subscriptions and Rs.1.96 lakh on book acquisition. It subscribed 116 journals and purchased 58 books. It also added 2 books in Hindi, and 77 bound volumes of journals. It also subscribed to four leading bibliographic databases: *Current Contents: Physical, Chemical & Earth Sciences* ; *Current Contents : Engineering, Technology & Applied Sciences* ; *Materials Science Citation Index and INSPEC*.

Named as KSK Library, in honour of the first director of the laboratory, late Sir K.S. Krishnan, the library is fast emerging as an electronic library. Its library and information services are accessible via NPL Intranet. The Intranet site offers access to information on current journals, new issues received during the week, and current contents of electronic journals, etc. It also offers Internet links to electronic journals, electronic libraries, publishing houses of leading journals, etc.

This year the library has started bar-coding its books and journals in-house. It is performing its house keeping functions on computer using a Library Management package developed in-house. It also continued to provide services like selective dissemination of information, in-house literature search, access to bibliographic databases, bibliography service, photocopying service, etc.

Publication and Reports

This cell is responsible for compiling, editing, printing, and distribution of Annual Reports and other documents on laboratory activities. This unit also compiles inputs for reporting the same to CSIR.

Scientific Support System

Planning, Monitoring & Evaluation

This group coordinates all the project-wise activities

of the laboratory, including in-house, collaborative, sponsored and grant-in-aid projects. It keeps track of current manpower deployment. On these activities it collects information, analyses it and places it to the top management for decision making. This year the group handled work relating to 23 new projects, 59 on-going projects, and 9 completed projects. This group also handles matters relating to Research Council.

Marketing Group

This cell is responsible for marketing and liasoning of technological know-how transfer of the laboratory. It has marketed one technology this year, and five more technologies are in the pipeline.

Intellectual Property Right

Realizing the strategic importance of intellectual property in the ever-changing global economic scenario, this completely independent cell was created with the exclusive purpose of managing IP portfolio of the laboratory. This cell provides help to the scientists in filing patents of the R&D outputs. It also scouts around and explores every possibility to protect any R&D output, which the scientists might have missed for taking protection.

During this year five patent applications have been filed in India and eight in foreign countries. Besides, the two patents were granted in USA.

Human Resource Development Group

This group arranges in-house training programmes for the benefit of NPL staff and also offers in-house training courses for the benefit of industries in various areas of calibration. It also supports the organization of various symposia, conferences, etc. at NPL. It also attends to various public relations activities and follows up various MoUs with educational institutions in respect of doctoral, post-graduate and summer training programmes on reciprocal basis. It processes induction of JRFs, SRFs, Research Associates in NPL. It also pursues other schemes of CSIR on EMR and HRD activities. A list of training programmes and other events organized by the group is given in the respective appendices.

International Science & Technology Affairs Group (ISTAG)

This group maintains and processes applications of scientists for deputation abroad. It also arranges K.S. Krishnan Memorial lecture, invited talks, and special lectures delivered by visitors. ISTAG has processed applications for deputation of NPL staff to various international seminars /conferences /visits /exchange programmes, etc. Special lecturers organised this year are listed in the respective appendices.

Technical Support System

Responsibility of general maintenance of infrastructure like electricity, pumping, air-conditioning, telephones, fax, photography service, auditorium, maintenance of campus and colony, etc. lies with this section.

Central Workshop

NPL Central Workshop undertakes design, development and maintenance of work related to scientific equipment of the laboratory and assists the industry by accepting outside assignments on payment basis.

The Workshop is equipped with general purpose machines, CNC machines and has precision measurement facilities. CNC machines aided by computerized modeling enable the machining of complicated parts such as die cavities, moulds and punches.

Glass Technology Unit

Glass Technology Unit undertakes jobs relating to the design, development, fabrication of scientific apparatus and equipments. The Unit offers its services to internal customers and to external customers from the industry, R&D organizations, medical and educational institutions. This year the unit processed 217 jobs for NPL and 39 external jobs and earned a sum of Rs.1.89 lakh as ECF.

Central Computer Facility

Parallel Computing: A parallel computing environment was set up based on PVM (Parallel Virtual Machine). A number of ordinary PCs were connected on a 100 MBPS LAN. Examples from image processing and Fast Fourier Transforms are being programmed to test the set up. Such a computing environment would be cost effective for data analysis where the amount of data is very large and the analysis is amenable to parallelization.

Web Based Calibration Report Generation Facility:

This facility is being tried out to further increase the efficiency and introduce uniformity (to the extent possible) in generating and printing calibration reports for various items calibrated at NPL. The user would need to just complete a form online in a web browser (like Netscape or Internet Explorer) with all the calibration details and results. As soon as the form is submitted to a central server by clicking a button, a formatted report is generated which is suitable for either viewing on screen or printing on a local printer on NPL Calibration Report Forms. The facility would be available on all nodes of the NPL-LAN.

Rajbhasha Unit

This Unit helps the scientists in the Hindi transcription of their papers, articles, reports etc. This year also this unit arranged various training programmes and organized events for encouraging use of Hindi in all official proceedings and in writing research papers in Hindi for the benefit of the society. As per Government of India directives the unit arranges selection of NPL employees who have contributed most to the propagation of Hindi in office work. Cash awards are given to the winners in various categories. Detailed report of the unit is given in Hindi in the following pages.

राजभाषा कार्यान्वयन

राष्ट्रीय भौतिक प्रयोगशाला सूचना तकनीक के दिनोंदिन बढ़ते प्रयोग के अनुरूप सरकारी अधिकारियों की हिन्दी में कार्य करने की दक्षता बढ़ाने के लिए निरन्तर प्रयास कर रही है। राजभाषा विभाग, गृह मंत्रालय भारत सरकार द्वारा राजभाषा नीति के कार्यान्वयन के लिए तैयार किए गए वर्ष 2000-2001 के वार्षिक कार्यक्रम में निहित लक्ष्यों को प्राप्त करने के लिए प्रयोगशाला हर सम्भव प्रयास कर रही है जिसमें हिन्दी कार्यशालाओं, हिन्दी पखवाड़ा, विशिष्ट व्यक्तियों द्वारा व्याख्यान दिया जाना, बैठकों में हिन्दी में चर्चा करना, प्रयोगशाला की राजभाषा यूनिट द्वारा वर्ष 2000 के आरम्भ में इंटरनल टेलिफोन डायरेक्टरी तथा एन. पी. एल. इनफो को द्विभाषी रूप में प्रकाशित किया जाना आदि सम्मिलित हैं।

राजभाषा स्वर्ण जयन्ती वर्ष के दौरान प्रयोगशाला में राजभाषा नीति के कार्यान्वयन हेतु दिनांक 11-7-2000 तथा 12-7-2000 को दो दिन के लिए प्रशासन के अधिकारियों/कर्मचारियों के लिए कार्यशाला का आयोजन किया गया जिसमें प्रशासन के 68 अधिकारियों/कर्मचारियों ने भाग लिया। कार्यशाला का उद्घाटन

डा० कृष्ण लाल, निदेशक एन.पी.एल. ने किया। अपने उद्घाटन भाषण में निदेशक महोदय ने आमन्त्रित वक्ताओं तथा प्रतिभागियों का स्वागत करते हुए कहा कि प्रयोगशाला में राजभाषा हिन्दी के प्रगामी प्रयोग के लिए अथक प्रयास किए जा रहे हैं जिसमें हिन्दी कार्यशालाओं, संगोष्ठियों, हिन्दी व्याख्यानों, हिन्दी दिवस आदि के आयोजनों से निश्चित रूप से हमें हिन्दी में कार्य करने में सफलता प्राप्त हुई है। उन्होंने राजभाषा यूनिट के अधिकारियों द्वारा किए गए सक्रिय प्रयासों की सराहना की और कार्यशाला के सफल आयोजन की कामना की।

इस कार्यशाला में चार सत्र रखे गए जिसमें प्रथम सत्र में केन्द्रीय हिन्दी प्रशिक्षण संस्थान के निदेशक श्री बिचार दास ने 'राजभाषा नीति तथा इसके प्रति सरकारी अधिकारियों/कर्मचारियों का दायित्व' से सम्बन्धित व्याख्यान प्रस्तुत किया। द्वितीय सत्र में हिन्दी अधिकारी डा० पूरन पाल ने हिन्दी में कार्य करने सम्बन्धी विभिन्न प्रोत्साहन योजनाओं से सम्बन्धी जानकारी से अवगत कराया। तृतीय सत्र में उपनिदेशक, श्री एम एस कठैत द्वारा 'राजभाषा प्रबन्धन' के बारे में जानकारी दी गयी। चौथे तथा अंतिम सत्र में डा० पूरन पाल, हिन्दी अधिकारी



उद्घाटन समारोह में उपस्थित एन.पी.एल. स्टाफ सदस्यों के समूह का एक दृश्य

द्वारा हिन्दी तिमाही प्रगति रिपोर्ट का सही-सही भरने सम्बन्धी जानकारी दी गयी। अंत में परस्पर विचार-विमर्श के साथ कार्यशाला का समापन हुआ।

हिन्दी पखवाड़ा

प्रयोगशाला में हिन्दी के व्यापक प्रचार-प्रसार तथा इसके प्रगामी प्रयोग के लिए विभिन्न कार्यक्रमों के साथ-साथ 1 सितम्बर से 14 सितम्बर, 2000 तक हिन्दी पखवाड़ा का आयोजन किया गया। हिन्दी पखवाड़े के दौरान टिप्पण एवं प्रारूप लेखन प्रतियोगिता, निबन्ध, डिक्टेशन, कविता तथा टाईपिंग आदि प्रतियोगिताओं का आयोजन किया गया जिसमें प्रयोगशाला के विभिन्न अधिकारियों/कर्मचारियों ने उत्साहपूर्वक भाग लिया।

14 सितम्बर, 2000 को प्रयोगशाला के सभा भवन में समापन समारोह आयोजित किया गया जिसका संचालन श्रीमती मंजु, अनुवादक ने किया। श्री हरि मोहन, प्रशासनिक अधिकारी ने कार्यक्रम के प्रारम्भ में कहा कि हिन्दी में काम करने में सी एस आई आर की सभी प्रयोगशालाओं में एन पी एल का विशेष स्थान है। यह बड़े हर्ष की बात है कि हमारे यहाँ प्रशासनिक वर्ग के साथ-साथ वैज्ञानिक/तकनीकी वर्ग के अधिकारी/कर्मचारी भी हिन्दी में काम करने में गहरी

रुचि ले रहे हैं। कार्यक्रम की अध्यक्षता डा० कृष्ण लाल, निदेशक, एन पी एल ने की। अपने अध्यक्षीय भाषण में निदेशक महोदय ने कहा कि जैसे तो प्रयोगशाला ने हिन्दी के क्षेत्र में काफी प्रगति की है, अब प्रशासन के साथ-साथ वैज्ञानिक/तकनीकी अनुभागों में भी हिन्दी में कार्य होने लगा है किन्तु हिन्दी का और अधिक प्रचार-प्रसार करने के लिए हमें ठोस कार्यक्रम तैयार करने होंगे और इस कार्य में प्रतिबद्धता दिखानी होगी। इस अवसर पर निदेशक ने हिन्दी के नए सॉफ्टवेयर की घोषणा की और उपस्थित सभी सदस्यों को हिन्दी में अधिकाधिक कार्य करने के लिए प्रेरित किया।

मुख्य अतिथि प्रो० एस० के० जोशी, पूर्व महानिदेशक, सी एस आई आर ने कहा कि प्रयोगशाला में हिन्दी को बढ़ावा देने के लिए निरन्तर प्रयास जारी हैं और लोगों में हिन्दी में कार्य करने की रुचि भी है। अतः वैज्ञानिकों को चाहिए कि अपने शोध कार्यों और क्रिया-कलापों को हिन्दी में लिखें जिससे कि अधिक से अधिक जनता इन शोध-कार्यों के महत्व को समझ सके। हिन्दी में लिखने से हमारी सोच और रचनात्मकता को बढ़ावा मिलेगा और इससे पूरा देश लाभान्वित हो सकेगा। विज्ञान में रुचि उत्पन्न करने के लिए हिन्दी में विज्ञान सम्बन्धी रोचक लेख व पुस्तकें लिखनी चाहिए।



समारोह के दौरान एन.पी.एल. स्टाफ सदस्यों को सम्बोधित करते हुए प्रो० एस. के. जोशी, पूर्व महानिदेशक, सी एस आई आर

प्रयोगशाला के अहिन्दी भाषी डा० भगवन्नारायण डा० एस बी सामन्ता ने हिन्दी भाषा के बारे में अपने लेखी अनुभव प्रस्तुत किए जो वास्तव में अत्यन्त रोचक व प्रेरणादायक थे। कविता प्रतियोगिता में प्रथम, द्वितीय आने वाले अधिकारियों ने पुनः अपनी कविताएं सुनाई। इसके उपरान्त प्रोफेसर एस.के. जोशी ने विभिन्न प्रतियोगिताओं के विजेताओं को पुरस्कार प्रदान किए तथा धन्यवाद प्रस्ताव के साथ समारोह का समापन किया गया।

व्याख्यान की श्रृंखला के अन्तर्गत विशिष्ट वैज्ञानिक व्याख्यान

हिन्दी के व्यापक प्रचार-प्रसार के लिए सितम्बर, 2000 में विशिष्ट व्यक्तियों द्वारा वैज्ञानिक व्याख्यान दिये जाने की श्रृंखला का आरम्भ किया गया। इस श्रृंखला का शुभारम्भ डा० ए० आर० वर्मा, पूर्व निदेशक, एन. पी. एल. द्वारा किया गया। डा० ए० आर० वर्मा ने 'क्या वैज्ञानिक और तकनीकी शिक्षा हिन्दी के माध्यम से संभव है?' नामक विषय पर व्याख्यान देकर उपस्थित सभी सदस्यों को यह दिखा दिया कि चाहे कोई कार्य वैज्ञानिक है अथवा तकनीकी या और प्रशासनिक-सभी क्षेत्रों में हिन्दी में कार्य बखूबी किया

जा सकता है। हर हिन्दुस्तानी हिन्दी में सोचता है, अपने विचारों को हिन्दी में व्यक्त करने में अधिक दक्षता रखता है, उसे सपने हिन्दी में ही आते हैं, हृदय से उद्गार हिन्दी में ही आते हैं, लड़ाई-झगड़ा भी हिन्दी में ही कर सकते हैं तो फिर कार्य हिन्दी में क्यों नहीं कर सकते।

दिनांक 15-12-2000 को डा० एच. एन. दत्ता, वैज्ञानिक एन. पी. एल. ने 'अंटार्कटिका में भारत का योगदान व व्यापारिक अवसर' नामक विषय पर व्याख्यान दिया।

मापन व्यवस्था व गुणवत्ता प्रबन्धन पर राष्ट्रीय कार्यशाला

राष्ट्रीय भौतिक प्रयोगशाला में 14-15 मार्च, 2001 को मापन व्यवस्था व गुणवत्ता प्रबंधन पर राष्ट्रीय कार्यशाला का आयोजन किया गया। जिसका उद्घाटन प्रयोगशाला के सभाभवन (आडिटोरियम) में हुआ। कार्यशाला के उद्घाटन अवसर पर डा० कृष्ण लाल, अध्यक्ष मापन कार्यशाला-2001 ने सबका स्वागत किया तथा कार्यशाला के उपाध्यक्ष डा० ए. के. गुप्ता ने कार्यशाला के आयोजन के सम्बन्ध में विस्तृत जानकारी दी। श्री सर्वेश्वर झा, अपर सचिव, प्रोग्राम इम्प्लीमेंटेशन मंत्रालय ने कार्यशाला का



मापन कार्यशाला मार्च, 2001 (दायें से बायें) डा० ए. के. गुप्ता, श्री सुधीर कुमार, श्री सर्वेश्वर झा, प्रो० ए आर वर्मा, डा० कृष्ण लाल

उद्घाटन किया। अपने उद्घाटन भाषण में श्री सर्वेश्वर झा ने प्रयोगशाला द्वारा किए गए इस प्रथम प्रयास की सराहना की तथा इसके सफल आयोजन की कामना की।

कार्यशाला के उद्घाटन अवसर पर उपस्थित श्री सुधीर कुमार, संयुक्त सचिव, सी एस आई आर द्वारा अध्यक्षीय भाषण दिया गया। अंत में डा०(श्रीमती) एस शर्मा, सचिव, मापन कार्यशाला-2001 द्वारा धन्यवाद ज्ञापन के साथ समारोह का समापन किया गया।

एन पी एल में मापन व्यवस्था व गुणवत्ता प्रबंधन तथा इससे सम्बन्धित विषयों पर कई वैज्ञानिक कार्यरत हैं जो इसे अन्तर्राष्ट्रीय स्तर पर रखने का प्रयास कर रहे हैं। इस कार्यशाला के विषय थे :-

1. SI मात्रक (यूनित)
2. मानक निदेशक द्रव्य (स्टैन्डर्ड रेफरेन्स मेटिरियल)
3. पर्यावरण मापन (एनवायरमेन्ट)
4. औद्योगिक मापन व गुणवत्ता आश्वासन (इंडस्ट्रियल मेजरमेंट एण्ड क्वालिटी एशयोरेंस)
5. WTO तथा SI मात्रक पद्धति
6. मापन की अनुमार्गणीयता (ट्रेसिबिलिटी)
7. राष्ट्रीय प्रत्यायन (एकेडिटेशन)
8. मापन में स्वचालन
9. मापन में अनिश्चितता (अनसर्टेनिटी)
10. उद्योगों में मापन मानक संबंधी समस्याएं और समाधान

इस कार्यशाला की भाषा राजभाषा हिन्दी थी। इसमें 43 वैज्ञानिकों ने अपने पेपर प्रस्तुत किए। इस कार्यशाला में एन. पी. एल. के ही नहीं अपितु बाह्य संस्थाओं के अनेक प्रतिभागियों ने सक्रिय रूप से भाग लिया। पूर्णतः वैज्ञानिक इस दो दिवसीय राष्ट्रीय कार्यशाला के समापन के दौरान निदेशक, एन पी एल ने कार्यशाला के सफल आयोजन के लिए सभी को बधाई दी।

उपर्युक्त कार्यों के अतिरिक्त प्रशासन विभाग द्वारा अपना अधिकांश कार्य हिन्दी में ही किया जाना, धारा 3 (3) का सम्यक, अनुपालन, राजभाषा कार्यान्वयन समिति की तिमाही बैठक समय पर बुलाना, प्रयोगशाला की तिमाही प्रगति रिपोर्ट समय पर सी एस आई आर मुख्यालय भेजना, प्रयोगशाला के वैज्ञानिकों द्वारा विभिन्न प्रोत्साहन योजनाओं में उत्साहपूर्वक भाग लेना आदि विशेष उल्लेखनीय हैं। राजभाषा विभाग, गृह मंत्रालय द्वारा तैयार किए गए वार्षिक कार्यक्रम में निहित लक्ष्यों को प्राप्त करने में प्रयोगशाला द्वारा सराहनीय कार्य किये गए जिसे सी एस आई आर मुख्यालय ने सराहनीय एवं प्रशंसनीय बताया गया है।

वर्ष के दौरान 1999-2000 के वार्षिक प्रतिवेदन का द्विभाषी रूप में प्रकाशित किया जाना एक बहुत बड़ी उपलब्धि थी।

APPENDIX : 1**PUBLICATIONS****PHYSICO - MECHANICAL STANDARDS****Papers Published in Journals**

1. Aggarwal, N.K., Mukesh Kumar & Singhal, R.P. Traceability in form and roundness measurement. MAPAN - *Journal of Metrology Society of India* 16 (1), Supplementary Issue No.1, 313-320 (2001).
2. Bandyopadhyay, A. K. Status report of APMP sponsored regional pneumatic pressure comparison [Phase A] : (1) 20 to 105 kPa and (2) 0.4 to 4.0 MPa (Gauge Mode). MAPAN-*Journal of Metrology Society of India* 16 (1), Supplementary Issue No. 1, 321-327 (2001).
3. Bhunia, S., Banerji, P., Choudhuri, T.K., Haldar A. R., Bose, D. N., Aparna, Y., Chettri, M. B. & Chakraborty, B. R. Optimization of growth of InGaAs/InP quantum wells using photoluminescence and secondary ion mass spectrometry. *Bull. Mater. Sci.* 23 (3), 207-209 (2000).
4. Bose, D.N., Banerji, P., Bhunia, S., Aparna, Y., Chhetri, M.B. & Chakraborty, B.R. Determination of well widths in a MOVPE grown InGaAs/InP multi-quantum well structures using SIMS & photoluminescence. *Applied Surface Science* 158 (1-2), 16-20 (2000).
5. Chakraborty, B. R., Pardeep Mohan., Shivaprasad, S. M., Sharma, D. R., Anandan, C., Gupta, A. C. & Raychaudhuri, A. K. Surface analytical facility at NPL, New Delhi. *Current Science* 78, 1523-1527 (2000).
6. Chaudhary, K.P. & Tanwar, L.S. Non contact dimensional measurement in relation to precise time interval measurement. MAPAN - *Journal of Metrology Society of India* 16 (1), Supplementary Issue No. 1, 11 - 18 (2001).
7. Chawla, S., Sengupta A., Pugla S., Roy B.K. & Kanjilal, A.K. & Ahmad, S.A. Cs saturated absorption spectrometer with diode laser at 852nm. MAPAN-*Journal of Metrology Society of India* 16 (1), Supplementary Issue No.2, 77-84 (2001).
8. Dilawar, N., Varandani, D., Chakraborty, B. R. & Bandyopadhyay, A. K. Raman and SIMS studies of rapid thermal annealing effect of silicon ion implanted GaAs. *J. Phys. Chem. Solids* 61, 1927-1933 (2000).
9. Garg, R K & Ram, R S. Measurement of 253.7 nm radiation from low pressure mercury lamps. MAPAN-*Journal of Metrology Society of India* 16(1), Supplementary Issue No. 1, 19-22 (2001)
10. Garg, R K & Kumar, Pardeep. Photothermal spectroscopy and its application in characterization of polycyclic aromatic hydrocarbons. *Asian Journal of Physics* 9, 15-30 (2000).
11. Garg, R K & Ram, R S. UV transmission measurement of eye protector/welding glass. MAPAN - *Journal of Metrology Society of India* 16(1), Supplementary Issue No. 1, 23 - 26 (2001)
12. Ghosh, A.B., Bose, S., Sharma, MC & Gera, B. S. Greenhouse gases, aerosols, solar flux, dynamics and their comparison with COSMIC. *Indian Journal of Radio and Space Physics* 29, 41-46 (Feb.2000).
13. Gupta, Alka., Mehrotra, Ranjana., Tewari, Jagdish. & Varma, S. P. Studies on dehydrophenylalanine containing models of b-Turn in thin solid films by FTIR spectroscopy. MAPAN- *Journal of Metrology Society of India* 16 (1), Supplementary Issue No. 1, 260 - 263, (2001).
14. Gupta, D. & Varma, S.P. Photometric accuracy: special feature of FTIR spectrophotometer at NPL. MAPAN - *Journal of Metrology Society of India* 16 (1), Supplementary Issue No. 1, 27 - 31 (2001).
15. Jain, Kamlesh., Yueqin Cen., Bowers, Walter J. & Schmidt, James W. A primary dead weight tester for pressures (35-175 kPa) in gauge mode. MAPAN - *Journal of Metrology Society of India* 16, Supplementary Issue No. 1, 50 -55, (2001).
16. Kandpal, H.C. & Vaishya, J.S. Experimental study of coherence properties of the light fields

- in the region of superposition in Young's interference experiment. *Opt. Commun.* 186, 15-20(2000).
17. Kandpal, H.C. & Vaishya, J.S. Simple method of measurement of surface roughness using spectral interferometry. *MAPAN - Journal of Metrology Society of India* 16(1), Supplementary Issue No. 1, 56-61 (2001).
 18. Kandpal, H.C. Mehta, D.S & Vaishya, J.S. Simple method for determination of surface roughness using spectral interferometry *Optics and Lasers in Engineering* 34, 139-148 (2000).
 19. Karfa, Mrityunjay. Determination of phase correction arising at the interface of base platen and slip gauge material in gauge interferometer. *Indian Journal of Research and Applied Physics* 38, 6-9 (Jan 2000).
 20. Kumar, Vinaya., Jain, Kamalesh K.& Kashyap, Subhash C. Use of ferroelectric relaxor as a pressure gauge. *MAPAN - Journal of Metrology Society of India* 16(1), Supplementary Issue No.1, 77-82 (2001).
 21. Luthra, Ram Krishan., Gupta, J.K. & Sharma, V.P. Realization of aluminium temperature standard at NPL and calibration of long stem standard platinum resistance thermometer in the Range 0 - 660°C as per ITS-90. *MAPAN - Journal of Metrology Society of India* 15(2), 65-71 (2000).
 22. M. Deepa., Sharma, N., Varshney, P., Varma, S. P. & Agnihotry, S. A.. FTIR investigation of solid pre-cursor materials for sol-gel deposition of WO₃ based electrochrome films. *Journal of Materials Science* 35, 5313 - 5318 (2000).
 23. Mohan, Pradeep & Kumar, Harish. Comparison of gravimetric and expansion method for volumetric measurement related to vacuum metrology / primary vacuum standard. *MAPAN - Journal of Metrology Society of India* 16(1), Supplementary Issue No.1, 97-99 (2001).
 24. Mohan, Pradeep. Generation of pressures at NPL, New Delhi for CCM key comparison CCM.P-K4 in absolute pressure (1 Pa to 1000 Pa). *MAPAN-Journal of Metrology Society of India* 16(1), Supplementary Issue No.1, 90-95(2001).
 25. Mohanan, V. & Sharma, Omkar. Acoustical design of a noise barrier for an elevated rail condor. *J. Acoust. Soc. of India* 28(1-4), 95-100(2000).
 26. Mohanan, V. Economic aspects of environmental noise pollution control. *J.Acoust. Soc. of India.*28(1-4), 61-66 (2000)
 27. Mohanan, V. Noise labelling of household electrical appliances. *MAPAN - Journal of Metrology Society of India* 16(1), Supplementary Issue No. 1, 100-105 (2001).
 28. Om Prakash. Measurement of refractive index of lens material. *MAPAN - Journal of Metrology Society of India*, 16(1), Supplementary Issue No. 1, 106-109 (2001).
 29. Sharma, D.R., Vijaykumar, D. Arun. & Gupta, A.C. Evaluation of measurement uncertainty of national primary standard in the barometric pressure region. *MAPAN -Journal of Metrology Society of India* 16(1), Supplementary Issue No. 1, 110-116 (2001).
 30. Sharma, D. R. & Gupta, A. C. Pressure metrology based on liquid column displacement. *MAPAN - Journal of Metrology Society of India* 15(2), 45-55 (2000).
 31. Sharma, Rina, Chaudhary, K. P, Kanjilal, A. K. & Kulkarni, V.G. Estimation of uncertainty in measurement: Application of ISO guidelines in case of measurement and calibration using laser interferometer. *MAPAN-Journal of Metrology Society of India* 16(1), Supplementary Issue No.1, 117- 123 (2001).
 32. Singh, D., Rajagopalan, M., Husain, M. & Bandyopadhyay, A. K. High pressure band structures and structural stability of EuS. *Solid State Communication* 115, 323 (2000).
 33. Singh, M., Pujara, K.K. & Mohanan, V. A general method for determining sound transmission loss through complicated structure by statistical energy analysis. *J. Acoust. Soc. of India* 28(1-4), 145-156 (2000).
 34. Singh, M., Pujara, K.K. & Mohanan, V. Effect of amount and location of absorptive material on airborne sound transmission of light weight double panels. *MAPAN-Journal of Metrology Society of India* 16(1), Supplementary Issue No. 1, 134-139 (2001).

35. Singh, M., Pujara, K.K. & Mohanan, V. A general method for determining sound pressure level through complicated structure by statistical energy analysis. *J. Acoust. Soc. of India* 28(1-4), 135-144 (2000).
36. Tewari, Jagdish., Mehrotra, Ranjana, Gupta, Alka., & Varma, S. P. Determination of sugar content in sugarcane juice using near infrared reflectance spectroscopy. *MAPAN - Journal of Metrology Society of India* 16(1), Supplementary Issue No. 1, 301-304 (2001).
37. Titus, S.S.K., Kumar, Anil & Jain, K. K. Development of hardness metrology at NPL, India. *MAPAN - Journal of Metrology Society of India* 16(1), Supplementary Issue No. 1, 150-155 (2001).
38. Tripurari Lal. The unit of mass - challenges in metrology. *Indian J. Phys.* 74B (5) 357-361 (2000).
39. Tripurari Lal. Uncertainty evaluation in mass measurements. *MAPAN - Journal of Metrology Society of India* 15(2), 57-64 (2000)
40. Varandani, Deepak., Dilawar, Nita., Chakraborty, B.R., Singh, D. & Bandyopadhyay, A.K. Raman studies on n-GaAs under high pressures. *J. Mat. Sci. Lett.* 20, 5-7 (2001).
41. Vinay Kumar., Jain, Kamlesh K. & Kashyap, Subhash C. Use of ferroelectric relaxor as a pressure gauge. *MAPAN - Journal of Metrology Society of India* 16(1), Supplementary Issue No. 1, 77-82 (2001).
42. Vijaykumar, D. Arun., Sharma, D.R., & Gupta, A.C. Software development in window environment for evaluation of measurement uncertainty of pressure / vacuum dial gauges. *MAPAN - Journal of Metrology Society of India* 16(1), Supplementary Issue No.1, 110-116 (2001).
43. Yadav, Sanjay., Bandyopadhyay, A. K., Dilawar, Nita & Gupta, A.C. Reestablishment of uncertainty in pressure measurement through in-house laboratory intercomparison of national hydraulic pressure standards upto 500 MPa. *MAPAN-Journal of Metrology Society of India* 16(1), Supplementary Issue No.1, 170-177 (2001)
44. Yadav, Sanjay, Gupta, V. K. & Gupta A. C. Comparative study of different approaches used for estimation of uncertainty in pressure measurements using dead weight testers through a case study. *MAPAN-Journal of Metrology Society of India* 16(1), Supplementary Issue No. 1, 178-185 (2001).
45. Yadav, Sanjay., Bandyopadhyay A. K., Gupta V. K. & Gupta A. C. A reliable quartz digital transfer pressure standard for high pressure measurements upto 275 MPa. *J. Instrument Soc. India* 30, 43 (2000).
46. Yadav, Sanjay., Vijyakumar, Arun., Bandyopadhyay A.K. & Gupta A.C. A proposal for the establishment of measurement uncertainty for pressure dial gauge and transducers. *Cal Lab - The International Journal of Metrology* 7, 32-43 (2000).

Chapter in Encyclopaedia

1. Mehrotra, R. Infrared spectroscopy, gas chromatography / infrared in food analysis. Chapter in *The Encyclopaedia of Analytical Chemistry: Instrumentation and Applications*. R.A. Meyers, Ed. 4007-4024 (2000).

Papers Published in Conference/Symposia/ Workshop Proceedings

1. Bandyopadhyay, A.K., Dilawar, Nita., Vijaykumar, Arun., Varandani, Deepak., Singh, Dharambir & Chakraborty, B.R. Raman spectrometer and its various applications including high pressure studies up to 20 GPa. *Proc. of the Vth National Conference on High Pressure Science and Technology*, Anna University, Chennai, March 1-3, 2000. Allied Publishers. pp.246- 251.
2. Chakraborty, B. C., Vinod, P. N., Singh, S. N. & Chakraborty, B. R. Design and simulation of antireflection coating for application to silicon solar cells. *International Workshop on Preparation and Characterisation of Technologically Important Single Crystal*, NPL, New Delhi, Feb. 26-28, 2001. pp. 650-654.
3. Chakraborty, B.R., Dilawar, Nita., Pal, S. & Bose, D.N. Characterization of GaAs MIS devices at the interface with N-rich PECVD silicon nitride dielectric using SIMS. *International Workshop on Preparation and Characterisation of Technologically Important*

- Single Crystal*, NPL, New Delhi, Feb. 26-28, 2001. pp. 478-482.
- Gupta, D. & Varma, S.P. FTIR studies of single crystals. *International Workshop on Preparation and Characterization of Technologically Important Single Crystals* (PCSC-2001), National Physical Laboratory, New Delhi, February 26-28, 2001. pp. 703-706.
 - Palafox, M Alcolea., Rastogi, V K., Jain, D K. & Garg, R K. Vibrational spectral study of 6-amino-1-3-dimethyluracil. *Proceedings of 70th Annual Session of the National Academy of Sciences*, India, IIT, Allahabad, India, Nov. 3-6, 2000. pp. 42
 - Pant, R.P., Sandarnarayana, V.K., Vijay Kumar., Singh, D.P., Kandpal, H.C., Haldar, S.K. & Suri, D.K. Growth and characterisation of ferrofluid thin films. *International Workshop on Preparation and Characterisation of Technologically Important Single Crystal*, NPL, New Delhi, Feb. 26-28, 2001. pp. 601-605.
 - Shivaprasad, S.M. & Paliwal, V.K. Epitaxial growth of Sb on 7x7 reconstructed single crystal Si(111) surface. *International Workshop on Preparation and Characterisation of Technologically Important Single Crystal*, NPL, New Delhi, Feb. 26-28, 2001. pp. 573-576.
 - Shivaprasad, S.M., Shingaya, Y. & Behm, R. J. STM study of novel pathway to strain relaxation by misfit dislocation in the Ni/Ru (0001) heteroepitaxial system. *International Workshop on Preparation and Characterisation of Technologically Important Single Crystal*, NPL, New Delhi, Feb. 26-28, 2001. pp. 694-697.
 - Tewari, Jagdish., Mehrotra, Ranjana., Gupta, Alka., & Varma, S.P. Determination of sugar content in sugar cane juice using near infrared reflectance spectroscopy. *3rd International Conference on Metrology in New Millennium and Global Trade* (MMGT 2001), National Physical Laboratory, New Delhi, Feb. 8-10, 2001. pp. 301-304.
 - Uncertainty Evolution in Pressure Measurement: A Worked Example National Symposium on Standards, Inc., July 16-20, INMS, Toronto, Canada. (2000).
 - Chakraborty, B.R., Pal, S. & Bose, D.N. Detection of arsenic oxide at the interface of Gd₂Ga₃O₁₃/GaAs using Secondary ion mass spectrometry (SIMS). *National Symposium of Instrumentation* (NSI-25), Bangalore, 8-11 Nov. 2000.
 - Chandra, Mukesh., Chandra, Subhash., Lamba, G.S. & Singh, Janardan. Measurement and test facilities for calibration of underwater acoustic projectors and hydrophones at NPL. Tenth National Symposium on Ultrasonics (X-NSU), Department of Physics, Osmania University, Hyderabad, March 15-16, 2001.
 - Choubey, A., Bhagvannarayana, G., Chakraborty, B.R., Shubin, Yu. V. & Lal, Krishan. High resolution X-ray diffraction study of very low angle boundaries observed in bismuth germanate single crystals grown by low thermal gradient Czochralski method. National Seminar on Crystallography (XXX), S.V. University, Tirupati, 27-29 June, 2000.
 - Dilawar, Nita., Varandani, Deepak., Bandyopadhyay, A.K. & Gupta, A.C.. Establishment of traceability of transfer pneumatic pressure standard. National Seminar on Advanced Instrumentation (NSAI-2001), CSIO, Chandigarh, Jan. 29-31, 2001.
 - Gera, B.S., Singh, G., Ojha, V.K., Saxena, N., Gupta, P.K. & Dutta, H.N. Studies of boundary layer parameters and air pollution concentration at different traffic junctions. Proc. Int. Symposium in Acoustic Remote Sensing of Atmosphere and Oceans (ISARS -2000), Auckland, New Zealand., 26NW, 1 Dec, 2000.
 - Jain, S.C., Tanwar, V.K., Dixit, V., Varma, S. P. & Samanta, S. B. Surface order and structural studies of polymer solid interface. International Workshop on Nanomaterials, Saha Institute of Nuclear Physics, Kolkata, India, Feb. 5-8, 2001
 - Kandpal, H.C., Bharat Kumar. & Vaishya, J. S. Characterisation of random rough surfaces using gonireflectometric measurements in visible range. *3rd International Conference on Metrology in New Millennium and Global Trade* (MMGT-2001), Feb. 8-10, 2001.
- Papers Presented in Symposia/ Conferences/ Seminars/Workshops**
- Aggarwal, Anil. & Vijay Kumar, D. Arun.

9. Kumar, Ashok. & Kumar, Yudhisther. Design and calibration of the ultrasonic reference standards. 3rd International Conference on Metrology in New Millennium and Global Trade, New Delhi, February 8-10, 2001
10. Kumar, Ashok., Kumar, Yudhisther. & Paik, B. A new technique for the calibration of ultrasonic flaw detector. 3rd International Conference on Metrology in New Millennium and Global Trade, New Delhi, February 8-10, 2001.
11. Mehrotra, Ranjana, Gupta, Alka, Tewari, Jagdish & Varma, S.P Identification of synthetic milk using infrared spectroscopy. 3rd International Conference on Metrology in New Millennium and Global Trade (MMGT 2001), National Physical Laboratory, New Delhi, Feb. 8-10, 2001.
12. Mehrotra, Ranjana., Gupta, Alka., Varma, S. P., Tangri, Rajeev. & Verma, R. N. Determination of different stages of infiltrating ductal carcinoma of breast using FTIR spectroscopy - Case study. National Symposium on Instrumentation (NSI-25), Indian Institute of Science, Bangalore, Nov. 8-11, 2000.
13. Mohan, P. & Gupta, A.C. Modern Trends in medium and high vacuum measurements. National Symposium on Advanced Instrumentation (NSAI 2001) at CSIO, Chandigarh, 29-31 Jan. 2001.
14. Paliwal, V.K., Vedeshwar, A.G. & Shivaprasad, S.M.. Surface Phase transition and band bending in the Sb/Si(111) interface as observed by X-ray Photoelectron Spectroscopy. 12th AGM of Materials Research Society of India, Science City, Kolkata, Feb. 2001.
15. Prakash, Om. Reference materials of refractive index and optical activity. National Workshop on Measurement System and Quality Management, National Physical Laboratory, New Delhi, India, March 14-15, 2001. (in Hindi)
16. Rastogi, V K., Garg, R K. & Mittal, H P. Spectroscopic study of some gallstones. 8th International Conference on Laser Applications in Life Sciences (LAL 2000), Waseda University, Tokyo, Japan, Aug. 13-18, 2000.
17. Sharma, D.R., Vijay Kumar, D. Arun. & Gupta, A.C. Upgradation of National Primary Standard in the barometric region at NPL-India. 1st APMP Pressure/Vacuum Workshop Meeting & Symposium 2001, NRLM, Japan, 13-16 March 2001.
18. Sharma, D.R., Vijay Kumar, D. Arun. & Gupta, A.C. Characterization of gauges below 1000 Pa using ultrasonic interferometer manometer. National Symposium on Instrumentation (NSI-25), Nov. 8-11, IISc., Bangalore (2000).
19. Sharma, Seema, Radheshyam., Singh, Janardan. & Soni, N.C. Investigation on electromechanical and relaxor properties of lead zirconate titanate ceramics added with lanthanum and iron oxides. Tenth National Symposium on Ultrasonics (X-NSU), Department of Physics, Osmania University, Hyderabad, March 15-16, 2001.
20. Shivaprasad, S.M., Shingaya, & Behm, R.J. CO surfactant induced heteroepitaxial growth of Ni on Ru(0001). 12th AGM of Materials Research Society of India, Science City, Calcutta, Feb. 2001.
21. Singh, Janardan., Soni, N.C. & Lamba, G.S. Effect of electric field on the dielectric properties of chromium doped lead zirconate titanate piezoelectric ceramics. Tenth National Symposium on Ultrasonics (X-NSU), Department of Physics, Osmania University, Hyderabad, March 15-16, 2001.
22. Singh, Y. P., Nijhawan, S. K. & Sibal, R. B. Development of silver point standard for the calibration of type - S & R thermocouples on ITS-90. 3rd International Conference on Metrology in New Millennium and Global Trade (MMGT-2001), February 8 - 10, 2001.
23. Singhal R.P. ISO: 9000 and certification. Conference on Modern Trends in Metrology & Testing, Regional Engineering College, Surathkal, Karnatka, 9th April, 2000.
24. Som, J.N., Virendra Babu, Raj Singh & Taak, I.S. Study on the error analysis and uncertainty parameters involved on the flowrate measurement with the NPL Primary Water Flow Measurement facility. 3rd International Conference on Metrology in New Millennium

- and Global Trade (MMGT-2001), NPL, New Delhi, February 8-10, 2001.
25. Tewari, Jagdish., Mehrotra, Ranjana., Gupta, Alka & Varma, S.P. Measurement of particle size of sugar by near infrared diffuse reflectance spectroscopy. National Symposium on Instrumentation (NSI-25), Indian Institute of Science, Bangalore, Nov. 8-11, 2000.
 26. Singhal R.P., Aggarwal, N.E. & Kumar, Mukesh. Traceability in Form and Roundness Measurement 3rd International Conference on Metrology in New Millennium and Global Trade (MMGT-2001) NPL, New Delhi, 8-10 February, 2001.
 27. Virendra Babu, Raj Singh & Som, J.N. Fluid flow measurement and intercomparison. National Workshop on Measurement System and Quality Management, NPL, New Delhi March 14-15, 2001. (in Hindi)
 28. Yadav, Sanjay. & Sharma, D.R. Role of pressure balances in pressure measurements. National Workshop on Measurement System and Quality Management. March 14-15, 2001. (In Hindi).
 29. Yadav, Sanjay., Bandyopadhyay, A.K., Gupta, V.K. & Gupta, A.C. National hydraulic standards for pressure measurements and their traceability. National Workshop on Measurement System and Quality Management. March 14-15, 2001. (in Hindi).
 30. Yadav, Sanjay, Bandyopadhyay, A.K., Gupta, V.K. & Gupta, A.C. On the traceability and stability of a hydraulic transfer pressure standard up to 140 MPa. National Seminar on Advanced Instrumentation (NSAI -2001), Jan. 29-31, 2001.
 - and relationship between compressive strength and microstructure of gall bladder stones. *European J. Ultrasound* 11, 143-146 (2000).
 3. Banerjee, P., Bose, Anindya. & Mathur, B.S. Improvement of accuracy of GPS time - A new approach. *MAPAN-Journal of Metrology Society of India* 16(1), Supplementary Issue No.2, 326-331 (2001).
 4. Chawla, Santa., Sen Gupta, A., Pugla, Sarika., Roy, B.K., Kanjilal, A.K. & Ahmad, S.A. Cs saturated absorption spectrometer with diode laser at 852 nm. *MAPAN-Journal of Metrology Society of India* 16(1), Supplementary Issue No. 2, 77-84 (2001).
 5. Guha, A., Khare, N., Raychaudhuri, A.K., & Rao, C.N.R. Magnetic field resulting from non-linear electrical transport in single crystals of charge-ordered $\text{Pr}_{0.63}\text{Ca}_{0.37}\text{MnO}_3$. *Physical Review B* 62, R11941 (2000).
 6. Kataria, N.D. & Daya, K.S. Development of HTS based shielded dielectric resonator for frequency standard. *MAPAN - Journal of Metrology Society of India* 16(1), Supplementary Issue No.2, 89-93 (2001).
 7. Khare, N., Gupta, A.K., Hossain, Z., Nagarajan, R. & Gupta, L.C. Studies on rf-SQUID effect in quaternary borocarbide superconductors. *J. of Superconductivity* 13, 1019 (2000)
 8. Khare, N., Gupta, A.K., Moharil, U.P., Hossain, Z., Nagarajan, R. & Gupta, L.C. Generation of higher harmonics in superconducting $\text{YNi}_2\text{B}_2\text{C}$. *Supercond. Sci. & Technol.* 13, 1306-1308 (2000)
 9. Khare, N., Moharil, U.P., Gupta, A.K., Singh, H.K. & Srivastava, O.N. Reduction in conduction noise of La-Ca-Mn-O polycrystalline films due to Ag addition. *J. Appl. Phys.* 89, 3552-3555 (2001).
 10. Khare, N., Singh, H.K., Siwach, P.K., Moharil, U.P., Gupta, A.K., & Srivastava, O. N. Improvement in properties of $\text{La}_{0.67}\text{Ca}_{0.33}\text{MnO}_3$ polycrystalline film due to silver addition. *J. Phys. D: Appl. Phys.* 34, 673-677 (2001)
 11. Kotnala, R.K. & Kothari, P.C. Bilateral comparison of AC magnetic properties of electrical steel sheet using standard Epstein frame. *MAPAN - Journal of Metrology Society of India* 16(1) Supplementary Issue No.1, 347-350 (2001).

ELECTRICAL AND ELECTRONIC STANDARDS

Papers Published in Journals

1. Agarwal, Ashish., Saxena, G.M., Chatterjee, A. & Mathur, B.S. Cesium fountain clock with laser cooling in squeezed vacuum. *MAPAN-Journal of Metrology Society of India* 16(1), Supplementary Issue No.2, 70-76 (2001).
2. Agarwal, R. & Singh, V.R. Ultrasonic parameters

12. Kotnala, R.K. & Kothari, P.C. Magnetic measurements on electrical steel strips using standard Epstein frame. *Indian Journal of Pure and Applied Physics* 38, 797-800 (2000).
 13. Kramer, G., Banerjee, P. & Klische, W. A new PLL for disciplining a frequency standard. *MAPAN - Journal of Metrology Society of India* 16(1), Supplementary Issue No.2, 249-260 (2001).
 14. Kumar, N., Singh, V.R., Kumar, P. & Singh, B. Performance optimization of ultrasonic flowmeter. *MAPAN - Journal of Metrology Society of India* 16(1), Supplementary Issue No.1, 71-76 (2001).
 15. Misra, Mukul., Kataria, N.D., & Srivastava, G.P. Laterally resolved microwave surface resistance measurement of high-Tc superconducting samples by cavity substitution technique. *IEEE Transactions on Microwave Theory and Techniques* 48, 791 (2000).
 16. Mittal, M.K., Biswas, J.C., Yadav, A.S. & Gupta, A.K. Influence of abnormal magnetic induction on energy meters and their probable solutions. *MAPAN - Journal of Metrology Society of India* 16(1), Supplementary Issue No.1, 355-357 (2001).
 17. Rastogi, A., Kalra, N., Aggarwal, P.K., Sharma, S.K., Harit, R.C., Navalgund, R. R. & Dadhwal, V.K. Estimation of wheat leaf area index from IRS LISS-III data using price model. *Int. J. Remote Sensing*. 21 (15), 2943-2949 (2000).
 18. Sen Gupta, A. Popovic, Darko & Walls, F.L. Cs frequency synthesis: A new approach. *IEEE Transactions on Ultrasonics Ferroelectrics and Frequency Control* 47, 475 (2000).
 19. Sen Gupta, A., Hanjura, A.K., Mathur, B.S., Koul, R., Kaul, S.K., Kaul, I.K., Kothari, M., Goel, H.C., Bhat, C.L. & Das, S. Results of differential mode of operation of the standard time & frequency signal (STFS) broadcast via INSAT. *MAPAN - Journal of Metrology Society of India* 16(1) Supplementary Issue No.2, 145-156 (2001).
 20. Sen Gupta, A., Walls, F. L., Nava, J. F. Garcia., & Nelson, C. Microwave synthesizers for atomic frequency standards. *MAPAN - Journal of Metrology Society of India* 16 (1) Supplementary Issue No. 2, 59-69 (2001)
 21. Singh, A., Sharma, S.K. & Ojha, V.N. Calibration and evaluation of uncertainty of national standard of dc voltage. *MAPAN - Journal of Metrology Society of India* 16 (1) Supplementary Issue No. 1, 127-133 (2001)
 22. Singh, H.K., Khare, N., Siwach, P.K. & Srivastava, O.N. Low field magnetoresistance of spray pyrolysis deposited $\text{La}_{0.67}\text{Ca}_{0.33}\text{MnO}_3$ films. *J. Phy. D: Appl. Phys.* 33, 921 (2000).
 23. Singh, V.R. A piezoelectric bone sensor for biomedical applications. *J. Acoust Soc Ind.* 28, 207-209 (2000).
 24. Singh, V.R. Safety standards for lithotripters. *MAPAN - Journal of Metrology Society of India* 16(1) Supplementary Issue No.1, 226-231 (2001).
 25. Singh, V.R., Lafaut, J.P., Wevers, M., Vincent, C. & Baert, L. Transient cavitation and associated mechanisms of stone disintegration. *Innovation and Technology in Biology and Medicine* 21, 14-22 (2000).
 26. Singh, V.R., Singh, S. & Dhawan, U. Detection of cholesterol constituents in human gall bladder stones by using X-Ray diffraction technique. *Innovation and Technology in Biology and Medicine* 20(5), 297-301 (2000).
 27. Singh, V.R.. Telesurgery. *Bitcom India* 1(3), 30-31 (2000).
 28. Swarup, R., Anand, J.R. & Negi, P.S. On 30 MHz Te_{011} mode piston attenuator. *Rev. Sci. Instrum.* TE_{011} 72, 1858-1861 (2001)
- Papers Published in Conference/Symposia/Workshop Proceedings**
1. Agarwal, R. & Singh, V.R.. Smart sensors in biomedical measurements. *Proc. National Conf. on Biomedical Engg.*, Roorkee, 21-22 April 2000. pp. 224-228.
 2. Banerjee. P. Status report of Time & Frequency activities of NPL, New Delhi, *Proc. Asia Pacific Time and Frequency Workshop (ATF 2000)*, Tokyo, Japan, 31 October-2 Nov. 2000. pp. 69-72.
 3. Banerjee. P., Kramer, G., & Klische, W. A study on the performance of the PLL for

- disciplining crystal oscillator to be used as a standard frequency source. *Proc. Asia Pacific Time and Frequency Workshop (ATF2000)* Tokyo, Japan, 31 October - 2 Nov. 2000.
4. Bhalla, Seema T., Singh, V.R. & Singh, M.P. Ultrasonic velocity of the teeth. *Proc. National Conf on Biomedical Engg*, Roorkee, 21-22, April 2000. pp. 311-314.
 5. Kaur, P., Singh, V.R., Mehra, N.C. & Prakash, V.R. SEM analysis of gallbladder stones. *Proc. National Conf. on Biomedical Engg.*, Roorkee, 21-22 April 2000. pp. 459-473.
 6. Kedar, Ashutosh., Kataria, N.D., Gupta, A.K. & Srivastava, G.P. Efficient evaluation of 2D reaction integrals in microstrip patch antenna structures. *Proc. Asia-Pacific Microwave Conference*, Sydney, Australia, 6 Dec. 2000.
 7. Kumar, N., Singh, V.R. Kumar, P. & Singh, B. Design and testing of ultrasonic transit time flowmeter. *Proc. National Conference on Trends in Ind. Elect, Transducers, Controls and Communications (TIET. COM-2000)*, Patiala, Nov. 14-15, 2000. pp. 44-47.
 8. Kumar, N., Singh, V.R. Kumar, P. & Singh, B. Signal analysis of ultrasonic Doppler flow measurement. *Proc. National Conf. on Biomedical Engg.*, Roorkee, 21-22 April 2000. pp. 53 -59.
 9. Kumar, N., Singh, V.R., Kumar, V & Singh, B. Improved sensitivity of ultrasonic transit time flowmeter. *Proc. 10th National Symposium on Ultrasonics*, Hyderabad, 15-16 March 2000. pp. 263-266.
 10. Kumar, Sandeep., Kumar, Sareen. & Bansal, V. Scanning electron microscopic study of in vitro tooth structures. *Proc. National Conf. on Biomedical Engg.*, Roorkee, 21-22 April 2000, pp. 303-310.
 11. Kumar, Sanjeev., Momeen., Khan, M.Y. & Rai, R. Electrical and optical characterization of Kdp doped CDI_2 . *Proceedings of the International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, NPL, 26-28 Feb. 2001. pp 354-357.
 12. Kumar, Sareen., Kumar, Sandeep., Bansal, V.& Singh, V.R. XRD analysis of teeth. *Proc. National Conf. on Biomedical Engg.* Roorkee, 21-22 April 2000, pp. 293-302.
 13. Lochab, Jyoti., Kulshrestha, Gunjan., Singh, V.R. & Bansal, M.C. Ultrasonic velocity and elasticity of biomedical plastics. *Proc. National Conf. on Biomedical Engg.*, Roorkee, 21-22 April 2000. pp. 452-458.
 14. Malik, Rita., Singh, V.R. & Bhatnagar, V.P. Bio-heat transfer study of ultrasonically induced temperature elevation in brain tumour. *Proc. National Conf. on Biomedical Engg.*, Roorkee, 21-22 April 2000. pp. 60-64.
 15. Saxena, G.M., Agrawal, Ashish., Chatterjee, A. & Mathur, B.S. Squeezed light pumped Cesium Beam Atomic Clock. *Proc. of Vith International Conference on Squeezed States and Uncertainty Relations*, Eds. D. Han, Y S Kim and S. Solimeno. NASA Publication Series (CP-2000-209899), July 2000. pp. 263-272.
 16. Sen Gupta, A & Walls, F. L. Effect of aliasing on spurs and PM noise in frequency dividers. *Proceedings of the 2000 IEEE/ELA International Frequency Control Symposium*, Kansas City, USA, 7-9 June 2000.
 17. Singh, V.R. Smart sensors in automation. *Proc. National Seminar on Convergence of Technologies by 2010*, Arunai Engg College, Tiruvannamalai, Tamil Nadu, 20-22 Jan. 2001. pp. 58-65.
 18. Singh, V.R. Smart sensors: evolution, technology and applications. *Proc. National Conference on Trends in Ind. Elect, Transducers, Controls and Communications (TIET.COM-2000)*, Patiala, 14-15 Nov. 2000. pp. 11-14.
 19. Singh, V.R. Ultrasonic surgery of deep-seated tumours. *Proc. Int. Conf. Biomedical Engg*, Anna Univ, Chennai, 24-26 Jan.. 2001. pp. 8-11
 20. Singh, V.R.. Bone fracture imaging study with an acoustic technique. *Proc IEE International Conf on Advances in Medical Signal and Information Processing*, Bristol (UK), 4-6 Sept. 2000.
 21. Singh, V.R.. Ultrasonic study of bone tumours. *Proc. IEEE-EMBS Asia-Pacific Conf*

on *Biomed Engg, Hangzhou (China)*, 26-28 Sept. 2000. pp.471-472.

22. Singh, V.R. Mobile ultrasonic lithotripters: evolution in lithotripters. *Proc. National Conf.on Biomedical Engg.*, Roorkee, 21-22 April 2000. pp. 387-398.
23. Singh, V.R. Portable ultrasonic lithotripters. *Proc. IEEE-EMBS Asia-Pacific Conf on Biomedical Engg*, Hangzhou, China, 26-28 Sept 2000. pp.883.
24. Singh, V.R. Recent advances in smart sensors. *Proc. Nat Conf on Materials and Semiconductor Technologies in Electronic Research*, Pantnagar, 8-10 Nov. 2000. pp.9-15

Papers Presented in Symposia / Conferences/ Seminars/ Workshops

1. Bhatia, K. & Singh, V.R. Analysis of malignant ovarian tumors with ultrasound. Tenth National Symposium on Ultrasonics, Hyderabad, 15-16 March 2001.
2. Bhatia, Kirti., Singh, V.R. & Bansal, M.C. Acoustic cavitation in biological tissues. National. Conf. on Biomedical Engg., Roorkee, 21-22 April 2000.
3. Biswas, Jogesh Chand., Mittal, Mukesh Kumar., Yadav, P., Anoop Singh. & Gupta, Ashok Kumar. Pratyavarty dhara shakti avam urja ke kshetra mein gunvatta ki rashtriya tulna. Mapan Vyavastha aur Gunvatta Prabandhan par Rashtriya Karyashala, NPL, New Delhi, 14-15 March 2001. (in Hindi).
4. Gupta, A.K. Quantum standard. National Workshop on Measurement System and Quality Management. NPL, New Delhi 14-15 March 2001. (in Hindi).
5. Khare, N & Gupta, A.K. Measurement of very small magnetic field using high Tc SQUID. National Workshop on Measurement System and Quality Management. NPL, New Delhi, 14-15 March 2001. (in Hindi).
6. Mittal, K., Singh, V.R., Deori, K.L & Bhatnagar, V.P. Smart biomedical temperature sensor. 88th Indian Science Congress, New Delhi, 3-7 Jan. 2001.
7. Mittal, Mukesh Kumar., Biswas, Jogesh Chand., Yadav, Anoop Singh. & Gupta, Ashok Kumar. Asamanya chumbakiya shakti ka vidyut meteron ke mapan par prabhav tatha inka upchar. Mapan Vyavastha aur Gunvatta Prabandhan par Rashtriya Karyashala, NPL, New Delhi, 14-15 March 2001. (in Hindi)
8. Ojha, V.N. Evaluation and expression of uncertainty in DC measurements. Workshop on ISO/IEC 17025 and Uncertainty Measurement, Cochin University of Science & Technology, Kochin, 23-24 Feb. 2001.
9. Ojha, V.N. Evaluation and expression of uncertainty in measurement : A general introduction. Workshop on ISO/IEC 17025 and Uncertainty Measurement, Cochin University of Science & Technology, Kochin, 23-24 Feb. 2001.
10. Ojha, V.N. Evaluation of uncertainty by ANOVA method: a case study. 3rd International Conference MMGT 2001, NPL, New Delhi.
11. Ojha, V.N., Sharma, S.K. & Gupta, A.K. Josephson volt manak dwara zener volt manak ka anshakan. National Workshop on Measurement System and Quality Management, NPL, New Delhi. (in Hindi)
12. Ojha, V.N., Sharma, S.K. & Singh, A. E_n - Criterion for correlated measurement: a case study. 3rd International Conference MMGT 2001, NPL, New Delhi.
13. Sharma, R. & Ojha, V.N. Role of calibration and intercomparison in traceability. 3rd International Conference MMGT 2001, NPL, New Delhi.
14. Sharma, R., Ojha, V.N. & Kothari, P.C. Prayogashala pratyapan me nirishako ke bhumika National Workshop on Measurement System and Quality Management, NPL, New Delhi. (in Hindi).
15. Singh, A., Sharma, S.K. & Ojha, V.N. Swachalan ka prayog parishudh calibrator ke. mapan me. National Workshop on Measurement System and Quality Management, NPL, New Delhi. (in Hindi).
16. Singh, V.R. & Mittal, K. Modelling of smart pressure sensors. National Symposium on Instrumentation (NSI-25), Bangalore, 8-11 Nov. 2000.

17. Singh, V.R. & Mittal, K. Sensors for food quality and productivity. National Conference on Swadeshi Vigyan, New Delhi, 26-28 Dec 2000.
18. Singh, V.R. A bone piezoelectric sensor for biomedical application. 25th Int. Acoust. Imaging Symposium, Bristol (UK), 19-22 March 2000.
19. Singh, V.R. A bone piezoelectric sensor for biomedical application. 25th Int. Acoustic Imaging Symposium, Bristol (UK), 19-22 March 2000.
20. Singh, V.R. A piezoelectric bone sensor for biomedical applications. National Symp on Acoustics, Tiruchirapalli, 22-23 Nov. 2000.
21. Singh, V.R. Recent advances in smart sensors. National Symposium on Instrumentation (NSI-25), Bangalore, 8-11 Nov. 2000.
22. Singh, V.R. Smart sensors in environmental control. 88th Indian Science Congress, New Delhi, 3-7 Jan. 2001.
23. Singh, V.R., Singh, J.M. & Kumar, A. A low cost portable ultrasonic biometry instrument. National Symposium on Instrumentation (NSI-25), Bangalore, 8-11 Nov. 2000.
24. Yadav, Anoop Singh., Biswas, Jogesh Chand., Mittal, Mukesh Kumar & Gupta, Ashok Kumar. Single phase and three phase vidyut meteron mein vibhinna prakar ki tampering se bijli ki chori tatha unka mapan par dushprabhav. Mapan Vyavastha aur Gunvatta Prabandhan par Rashtriya Karyashala, NPL, New Delhi, 14-15 March 2001.

Monographs

1. *SI Units*. Compiled by Rina Sharma, V.N. Ojha, A.K. Saxena & P.C. Kothari
2. *Advances in Metrology and Global Trade: Proceeding on 3rd International Conference on Metrology in New Millennium and Global Trade*. A.K. Agrawal, A.K. Saxena, A. Sen Gupta, Guest Editor: P.C. Jain, P.C. Kothari, Eds. New Delhi: Metrology Society of India. 2001. x, 402p
3. *Current Trends in time and Frequency: Proceedings of International Conference on time and Frequency (ICTF)*. P.C. Jain, P.C. Kothari, Eds. and A. Sen Gupta, Guest

Editor. (2001) New Delhi: Metrology Society of India (2001). xi, 374p.

ENGINEERING MATERIALS

Papers Published in Journals

1. Aggarwal, R. K., Bhatia, G., Bahl O. P. & Punjabi, N. Effect of calcination conditions of self-sintering mesocarbon microbeads on the characteristics of resulting graphite. *J. Mat. Sci.* 35, 5437-5442 (Nov. 2000).
2. Bahl, O.P., Bhatia, G., Mathur, R.B., Aggarwal, R. K., Dhami, T. L. & Lal, C. Development of advanced carbon products at National Physical Laboratory, New Delhi, India. *J. Sci. & Ind. Res.* 59, 877-892 (Nov. 2000).
3. Dhakate, S.R., Parashar, V.K., Bahl, O.P. & Sahare, P.D. Oxidation behaviour of PAN based carbon fibre reinforced phenolic resin matrix composites. *J. Mat. Sci. Letts.* 19(21), 1959-1964 (Nov. 2000).
4. Dhakate, S.R., Parashar, V. K., Raman, V., Bahl, O. P. & Sahare, P. D. Influence of ceramic interphase on the mechanical properties of T-300 carbon fibre composites. *J. Mat. Sci. Letts.* 19(17), 1575-1577 (September 2000).
5. Mathur, R B., Bahl, O P., Gupta, V., Tressaud, A. & Flandrois, S. Structure and mechanical properties of fluorinated Polyacrylonitrile (PAN) based carbon fibres. *Molecular Crystals and Engineering Crystals* 114, 197-200 (July 2000)
6. Raman, V., Dhakate, S.R., & Bahl, O. P. Synthesis of silicon carbide incorporated carbon-carbon composites. *J. Mat. Sci. Letts.* 20(4), 315-317 (Feb. 2001).
7. Raman, V., Dhakate, S.R., & Sahare, P. D. Synthesis of titanium carbide whiskers (TiCw) through sol-gel process from rayon fibres. *J. Mat. Sci. Letts.* 19 (21), 1897-1898 (Nov. 2000).
8. Singh, Sadhana, Singh, R K, Singh, B.P., Singhal, S. K. & Chopra, R. Structural properties of KBr: Elastic behaviour and pressure effects. *Physica Stat. Solidi (A)* 180, 459-466 (Aug. 2000).
9. Singhal, S. K., Singh, B. P., Chopra, Rajeev &

Sharda, K.D. On catalytic action of nickel - copper alloy in graphite-diamond phase transformation. *Indian J.Pure & Appl. Phys.* 39, 163-169 (March 2001).

Papers Published in Conference/Symposia/ Workshop Proceedings

1. Dwivedi, H., Mathur, R. B., Dhama, T. L., Bahl, O. P. & Sharma, S. K. Role of different type of carbon fibres in the development of hybrid carbon /carbon composites. *Proceedings of Indo- German Workshop on High Temperature Fibre Composite Materials*, BHU, Varanasi, India, Sep. 11-15, (2000) pp.97-104.
2. Gupta, Anil K., Schubert, Thomas & Stephani, G. Aluminium metal matrix composite with low density and high stiffness. *Proceedings of 3rd International conference on Advances in Composites (ADCOMP - 2000)*, Bangalore, August 24-26, (2000). pp 724-727.

Papers Presented in Symposia/ Conferences/ Seminars/ Workshops

1. Bahl, O. P. & Dhakate, S. R. Applications of sol-gel techniques properties of carbon-carbon composites. National Seminar on Sol-gel Science & Technology, Calcutta, (CGCRI, Calcutta), Aug. 17-18 (2000)
2. Dwivedi, H., Mathur, R.B., Dhama, T.L., Bahl, O P. & Sharma, S K. Structure-property relationship in PANEX based carbon fibres. International Conference on Advanced Materials, Meerut University, Meerut, Dec. 26-28, (2000).
3. Gupta, Anil K. Significance of R&D Institute-Industry Interaction in Precision Forging. Seminar on Forging - Challenges Ahead, Automotive Component Manufacturing Association of India (ACMA), New Delhi, March 17, (2001).
4. Mathur, R B. Application of Carbon nanotubes in super strong composites. Workshop on Nanophase Materials, NPL, New Delhi, India, Dec. 8, (2000).
5. Raman, V., Bhatia, G., Aggarwal, R. K., Sengupta, P. R. & Mahur, J. S. Development of carbon-ceramic composites through sol-gel process. National Seminar on Sol-gel

Science & Technology, CGCRI, Calcutta, Aug. 17-18 (2000).

6. Singhal, S K., Singh, B P., Chopra, Rajeev. & Sharda, K D. International Workshop on preparation and characterisation of technologically important single crystals, NPL, New Delhi, India, Feb. 26-28 (2001)

ELECTRONIC MATERIALS

Papers Published in Journals

1. Agnihotry, S.A., Nidhi, Pradeep. & Sekhon, S.S. Li⁺ conducting gel electrolyte for electrochromic windows. *Solid State Ionics* 136-137, 573-576 (2000).
2. Basu, A., Sarkar, S.K., & Bhattacharyya, R. Propagation losses in silica-on-silicon optical waveguides - theoretical analysis and comparison with experimental results. *Ind. J. Pure & Appl. Phys.* 39, 137-148 (2001).
3. Deepa, M., Sharma, Nidhi., Varshney, P., Agnihotry, S.A. & Chandra, R. An insight into the interactions between LiN(CF₃SO₂)₂-(α BL/DMF-PMMA) by FTIR spectroscopy. *Ionics* 6, 448-454 (2000).
4. Deepa, M., Sharma, Nidhi., Varshney, P., Varma, S.P. & Agnihotry, S.A. FTIR investigations of solid precursor materials for sol-gel deposition of WO₃ based electrochromic films. *J. of Mater. Sci.* 35, 5313-5318 (2000).
5. Kumar, Sudheer., Kumar, S., Dixit, P.N., Rauthan, C.M.S., Sharma, Rajnish., Khan, M.Y., & Bhattacharyya, R. Composition of glass substrate, an important consideration for depositing adherent diamond like carbon films. *J. of Mater. Sci. Lett.*, 19, 2055-2057 (2000).
6. Luthra, V., Singh, R., & Mansingh, A. Effect of protonic acids on the dielectric spectroscopy of polyaniline. *Synth. Metals* 119, 291-292 (2001).
7. Narula, A.K., Singh R. & Chandra, S. Low frequency ac conductivity and dielectric relaxation in poly (N-methyl pyrrole). *Bull. Mater. Sci.* 23, 227-232 (2000).
8. Rastogi, A.C., Sharma, S.N. & Kohli, S. Structure and optical properties of rf magnetron sputtered CdTe nanocrystals: TiO₂ composite

- thin films. *Semicond. Sci. Technol.* 15, 1011-1018 (2000).
9. Sarangi, D., Panwar, O.S., Kumar, S. & Bhattacharyya, R. Characterisation studies of diamond like carbon films grown using a saddle field fast atom beam source. *J Vac. Sci. Tech. A* 18, 2302-2311 (2000).
 10. Sarangi, D., Panwar, O.S., Kumar, S., & Bhattacharyya R. Characterization of saddle field fast atom beam source and its application to the growth of the Diamond Like Carbon Film *Vacuum* 58, 609-627 (2000).
 11. Sekhon, S.S., Deepa, M. & Agnihotry, S.A. Solvent effect on gel electrolytes containing lithium salts. *Solid State Ionics* 136-137, 1189-1192 (2000).
 12. Sekhon, S.S., Arora, N. & Agnihotry, S.A., PAN based gel electrolyte with lithium salts. *Solid State Ionics* 136-137, 1201-1204 (2000).
 13. Senguttuvan, T.D., Kalsi, H.S., Sharda, S.K., & Das, B.K. Sintering behaviour of alumina rich cordierite porous ceramics. *Mater. Chem. and Phys.* 8875, 1-5 (2000).
 14. Sharma, Nidhi., Deepa, M., Varshney, P. & Agnihotry, S.A. Influence of organic additive on the morphological, electrical and electrochromic properties of sol-gel derived WO₃ coatings. *J. of Sol - Gel Sci. and Technol.* 18, 169-175 (2000).
- Papers Published in Conference/Symposia/ Workshop Proceedings**
1. Chakravarty, B.C., Vinod, P.N., Singh, S.N. & Chakraborty, B.R. Design and simulation of antireflection coating for application to Si Solar Cell. *Crystal Growth and Characterization: Proceedings of International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, National Physical Laboratory, New Delhi, India, Eds. S.K.Gupta, S.K.Halder and G. Bhagavanarayan. 26-28 Feb. 2001. pp.650-654
 2. Chander, Harish., Shanker, V., Haranath, D., Dudeja, Suman. & Ghosh, P.K. New synthesis route for ZnS:Cu electroluminescent phosphor. *Proc. National Seminar on Luminescence and its Applications* (NSLA-2001), Osmania University, Hyderabad, 17-18 Jan 2001. pp. 272-275.
 3. Haranath, D., Shanker, V., Chander, Harish., Dudeja, Suman. & Ghosh, P. K. Effect of halides on luminescence characteristics of Gd₂O₂S: Tb phosphors. *Proc. of National Seminar on Luminescence and its Applications* (NSLA-2001), Osmania University, Hyderabad, 17-18 Jan.2001. pp 241-245.
 4. Kumar, Sushil., Dixit, P. N., Panwar, O. S. & Bhattacharyya, R. Disorder in diamond-like carbon films. *Crystal growth and characterization- Proceedings of International Workshop on Preparation and Characterization of Technologically Important Single Crystals*. National Physical Laboratory, New Delhi, India. S.K.Gupta, S.K.Halder and G.Bhagavanarayan, Eds. 26-28 Feb. 2001. pp.473-477.
 5. Lal, M., Warta, W., & Wettling, W. Detection and characterization of sleeping defects in silicon by LBIC Scan Maps at 80K. *Crystal growth and characterization- Proceedings of International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, National Physical Laboratory, New Delhi, India, S.K.Gupta, S.K. Halder and G. Bhagavanarayan. Eds. 26-28 Feb. 2001. pp. 333-336.
 6. Prakash, Om., Sankaranarayanan, V.K., Pant, R.P. & Islam, M. Synthesis and characterization of Li-ferrite nanoparticles for ferrofluid applications. *Proceedings of 12th ISME Conference*, Chennai, Jan.(2001). pp. 190-193.
 7. Rajput, S. S. & Jamuar, S. S. A high performance current mirror for low voltage designs. *Proc. APCCAS*, Tianjin, China, Dec.2000.
 8. Sankaranarayanan, V.K., Hoa, L.M., Prakash, Om. & Rastogi, A.C. Magnetic and structural investigations of Co/Ag multilayers. *Crystal growth and characterization-proceedings of International Workshop on Preparation and Characterization of Technologically Important Single Crystals*,

- National Physical Laboratory, New Delhi, India, S.K.Gupta, S.K.Halder and G .Bhagavanarayan. Eds.26-28 Feb.2001. pp.459-463.
9. Shanker, V. Different luminescence phenomenon in Gadolinium oxysulfide phosphors. *Proc. National Seminar on Luminescence and its Applications* (NSLA-2001), Osmania University, Hyderabad, 17-18 Jan. 2001. pp. 51-55.
 10. Sharma, S.N., Kohli, Sandeep. & Rastogi, A.C. Synthesis and properties of titanium oxide thin films embedded with high density CdTe Nanocrystals. *Crystal Growth and Characterization- Proceedings of International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, National Physical Laboratory, New Delhi, India. S.K.Gupta, S.K.Halder and G. Bhagavanarayan. Eds.26-28 Feb.2001. pp.446-450.
 11. Sharma, S.N., Kohli, Sandeep. & Rastogi, A.C. Synthesis and characterization of nanocrystalline CdTe:TiO₂ thin films by rf magnetron sputtering. *Proc. of International Workshop on Nanomaterials*, Saha Institute of Nuclear Physics, Kolkata, India, 5-8 Feb. 2001. pp.91.
 12. Singh, Ramadhar. Water pollution by microbiological species: An overview. *Proc. National Conference on Swadeshi Vigyan: Traditional and Modern, Focus: Health, Agriculture, Water*, NIST, Delhi, India , 26-28 December 2000. pp. 340.
 13. Singh, Santosh., Jain, Kiran., Sharma, R.K., & Rastogi, A.C. Electrodeposition of ternary Cd_{1-x}Ph_x^{Tc} thin films. *Crystal Growth and Characterization-Proceedings of International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, National Physical Laboratory, New Delhi, India, S. K. Gupta, S. K. Halder and G. Bhagavanarayan., Eds. 26-28 Feb. 2001. pp. 537-541.
 14. Vinod, P.N., Chakravarty, B.C., Lal, M. & Singh, S.N. Effectiveness of oxidised porous Si layers as antireflection coating for silicon solar cells. *Proc. 24th National Renewable Energy Convention*, Bombay, 2000. pp.173-177.
- Papers Presented in Symposia/ Conferences/ Seminars/Workshops**
1. Agnihotry, S.A., Sharma, Nidhi., Deepa,M. & Varshney, P. A novel process for preparing a precursor material for depositing tungsten oxide(WO₃)based electrochromic films. National Seminar on Sol -Gel Science and Technology at CGCRI, Calcutta, 17-18 August,2000.
 2. Kumar, Sudheer., Dixit,P.N., Srivastava, K.M.K., Rauthan, C.M.S., & Bhattacharyya R., Photoluminescence studies in DLC films deposited by Remote microwave P E C V D system. Indian Science Congress, IARI, Delhi, 3-7 Jan. 2001.
 3. Kumar, Sudheer., Dixit,P.N., Srivatsa, K.M.K., Rauthan, C.M.S. & Bhattacharyya, R. Cathodoluminescence studies in diamond like carbon films using indigenously developed remote microwave PECVD system Electro-System. 2001, BHU, Varanasi, 4-6 Jan. 2001.
 4. Kumar, Sudheer., Rauthan, C.M.S., Srivastava, K.M.K., Dixit, P.N. & Bhattacharyya R. Realisation of different carbon nanostructures by a microwave plasma enhanced chemical vapour deposition technique. International Workshop on Nanomaterials, Saha Institute of Nuclear Physics, Calcutta, 5-8 Feb.2001.
 5. Kumar, Sushil. Stress relieved diamond like carbon films as an engineering material for various applications. Indian Science Congress, IARI, Delhi, 3-7 Jan. 2001. (Paper presented under ISCA Young Scientist Award Programme in Materials Science section at the 88th session)
 6. Rajput, S. S. & Jamuar, S. S. Low voltage low power high performance current conveyors. ISCAS-2001 Sydney, Australia.
 7. Rauthan, C.M.S., Basu, A., Dixit, P.N., Srivatsa, K.M.K., Sodhi, R. K. & Bhattacharyya, R. Silica-on-silicon films deposited by flame hydrolysis for integrated optical circuits. Indian Science Congress, IARI, Delhi, 3-7 Jan. 2001.
 8. Singh, Ramadhar., Yadav, K.L., Kaur, Amarjeet., Bhattacharyya, R., Hussain, Ejaz. & Ali Sher. synthesis, characterization and charge transport in polypyrrole/sodium nitrate composite. 12th Annual General Meeting of Materials Research Society of India

(MRSI-2001), Science City, Calcutta, 31 January -2nd February 2001.

Chapters in Books/Monographs

1. Deepa, M., Sharma, Nidhi., Varshney, Pradeep., Chandra, R. & Agnihotry, S.A. Pronounced Influence of Solvent Characteristics on RT of Electrolytes for ECDs. *Ion Conducting Materials: Theory and Applications* A.R. Kulkarni. P. Gopalan, Eds. Narosa Publishing House, (2001). pp 74-81.
2. Sharma, Nidhi., Deepa, M., Varshney, Pradeep., Upreti, U.C., Ramachandran, R. & Agnihotry S.A. A Comparative study of precursor materials for casting Sol-gel based Tungsten Oxide Films. *on Conducting Materials: Theory and Applications*. A.R. Kulkarni. P. Gopalan, Eds. Narosa Publishing House (2001). pp 67-73
3. Varshney, Pradeep., Deepa, M., Sharma, Nidhi., Gupta, S.R., Sharma B.B. & Agnihotry S.A. Sol-gel derived tin oxide film as a passive counter electrode for electrochromic devices (ECDs). *Ion Conducting Materials : Theory and Applications*. A.R. Kulkarni. & P. Gopalan, Eds. Narosa Publishing House (2001). pp 82-87

POLYMERIC & SOFT MATERIALS

Papers Published in Journals

1. Arun Kumar., Rajesh., Malhotra, B.D. & Grover, S.K.. Co-immobilization of cholesterol oxidase and horse radish peroxidase in a sol-gel film. *Analytica Chimica Acta* 414, 53-50 (2000)
2. Biradar, A.M., Bawa, S.S., Saini, K.K., & Haase, W. A correlation between surface effect and pitch value of FLC material by dielectric method. *Ferroelectrics* 245, 119-130 (2000).
3. Chaubey, Asha ., Pande, K.K., Singh, R. V. S. & Malhotra, B.D. Co-immobilization of lactate oxidase and lactate dehydrogenase on conducting polyaniline films. *Analytica Chimica Acta* 407, 97-103 (2000).
4. Chaubey, Asha., Gerard, M., Singhal, R., Singh, V.S., & Malhotra, B.D. Immobilization of lactate dehydrogenase on electro-chemically prepared polypyrrole-polyvinylsulphate composite films for application to lactate biosensors. *Electrochimica Acta* 46, 723-729 (2000).

5. Koul, S., Chandra, R., & Dhawan, S.K. Conducting polyaniline composites for ESD and EMI at 101 GHz. *Polymer* 41, 9305-9310 (2000).
6. Koul, S., Chandra, R., & Dhawan, S.K. Conducting polyaniline composites: A reusable sensor material for aqueous ammonia. *Sensors and Actuators B* 75, 151-159 (2001).
7. Misra, S C K., Suri, A., Chandra, Subhas. & Bhattacharyya, R. Semiconducting polymer thin films sensors for detection of toxic gases. *Indian J. Pure & Appl.Phys.* 38, 545-551 (Aug.2000).
8. Ramanathan, K., Pandey, S.S., Kumar, R., Gulati, A., Murthy, A.S.N. & Malhotra, B.D. Covalent immobilization of glucose oxidase to poly(o-amino benzoic acid) for application to glucose biosensor. *Journal of Applied Polymer Science* 178, 662-667 (2000).
9. Sharma, S.K., Sharma, V.K., Kapoor, A., Tripathi, K.N. & Misra., S.C.K. Fabrication and characterization of thin film polyacrylate waveguides. *Ind. J. Chem.* 39B, 236-238 (2000)

Papers Published in Conference/Symposia/Workshop Proceedings

1. Misra, S.C.K , Suri, A., Pant, R P, Suri, D K. & Bhattacharya, R. Preparation and characterization of vacuum deposited polyaniline crystalline thin films. *Proc.Intl. Workshop on Preparation and Characterization of Technologically Important Single Crystals*. NPL, New Delhi (2001) pp. 583-586.
2. Misra, S.C.K, Sharma, Indu., Suri, A. & Bhattacharya, R. Advancements in environment metrology systems for safety and health care. *Proc. International Conference on Time and Frequency* ICTF, Feb.2001. pp. 222 -225.

Papers Presented in Symposia/ Conferences/ Seminars/Workshops

1. Dhawan, S.K., N. Singh & Bhattacharyya, R. Novel antistatic materials based on conducting polyaniline composites. Macro 2000, DMSRDE, Kanpur, 1-2 Dec. 2000.
2. Jain, S. C., Dixit, Vivechana., Tanwar, V. K. &

- Kamalasanan, M. N.. Formation and structure of alkyl amine - silane monolayers on solid surfaces. 8th National Conference on Liquid Crystals, Mumbai, 28-30 December 2000.
3. Jain, S. C., Tanwar, V. K. & Dixit, Vivechana. Self-assembled bilayer molecular assembly for aligning liquid crystals. International Workshop on Preparation and Characterization of Technologically Important Single Crystals, NPL, New Delhi, 26-28 February 2001.
 4. Jain, S. C., Tanwar, V. K., Dixit, Vivechana., Verma, S. P. & Samanta, S.B.. Surface order and structure studies of polymer-solid interface. International Workshop on Nano Materials, Saha Institute of Nuclear Physics, Kolkata, 5-8 February 2001.
 5. Misra, S.C.K & Sharma, T P. ZnSe and ZnTe sintered films for use in photovoltaic applications. International Conference on Advanced Materials, Meerut University, Dec. 2000.
 6. Misra, S.C.K, Sherwood, J.N., Cruickshank, F.R., Bailey, R.T., Pugh, D. & Pethrick, R.A.. Aminobenzophenone thin film electro-optic devices. Indo Japanese Workshop on Micromechanical Systems Technology, Nov. 2000.
 7. Misra, S.C.K, Suri, A., Qureshi, G.J. & Tripathi, K.N. Vacuum deposited poly (3-methylthiophene) thin film solar photovoltaic generators. International Conference on Advanced Materials, Meerut University, Dec.2000.
 8. Misra, S.C.K, Bhattacharyya, R., Subhas Chandra, Angelucci, R., Maccagnani, P., Corticelli, F., & Tamarri, F. Polymeric thin film-silicon microsensors for detection of microorganisms. MRS, San Fransisco USA, Meeting 24-26 April 2000. Session S6/50
 9. Misra, S.C.K, Cruickshank, F R. & Sherwood, J N. Polymeric thin film non-linear electrooptic devices. International Conference on Advanced Materials, Meerut University, Dec. 2000.
 10. Misra, S.C.K, Cruickshank, F. R. & Sherwood, J. N. Polymeric thin film optoelectronic devices. International Workshop on Physics of Semiconductor Devices, 2001.
 11. Misra, S.C.K, Khare, Geeta. & Pandey, Jyoti Lata. Emerging trends in preparation. International Workshop on Physics of Semiconductor Devices, 2001.
 12. Misra, S.C.K, Mathur, Prafull. & Tripathi, P. Semiconducting polyaniline nanocrystalline. International Workshop on Physics of Semiconductor Devices, 2001.
 13. Misra, S.C.K, Sharma, Sachin K., Gaur, Ansul., Sharma, S.K. & Sharma, T.P. II-VI Alloy Thin films for solid state device applications. International Conference on Advanced Materials, Meerut University, Dec. 2000.
 14. Misra, S.C.K., Suri, A., Sharma, Vinod. & Subhas Chandra. Physics and technology of semiconducting polymer thin film sensors. National Seminar on Physics and Technology of Sensors, Pune, Jan. 2000.
 15. Misra, S.C.K, Bhattacharya, V & Angelucci, R.. Integrated polymer thin film macoporous silicon microsystems. Indo Japanese Workshop on Micromechanical Systems Technology, Nov. 2000.
 16. Singh, N & Dhawan, S.K. Novel concept on the designing of conducting polymers for antistatic applications. Polymeric thin film silicon microsensors for detection of microorganisms. 24th Australian Polymer Symposium, Beechworth, Australia, 4-8 Feb 2001.
 17. Koul, S. & Dhawan, S.K. Conducting blends of polyaniline with acrylonitrile-butadiene-styrene. Macro 2000, DMSRDE, Kanpur, 1-2 Dec. 2000.
 18. Dhawan, S.K., Rodrigues, David. & Singh, Navjot. Conducting polymer composites for dissipation of electrostatic static charge. World Polymer Congress, IUPAC, Macro 2000, Warsaw, Poland, 9-14 July 2000.
 19. Dhawan, S.K., Koul, S. & Bhattacharyya, R.. Modification of growth rate and properties of chemically synthesized polyaniline using ferric-p-toluene-sulphonate. World Polymer Congress, IUPAC, Macro 2000, Warsaw, Poland, 9-14 July 2000.
 20. Sharma, R.P., Misra, S.C.K. & Dori, L. Optical

- characteristics of evaporated polyaniline ultra thin films for electronic & gas sensor technology. International Conference on Advanced Materials, Meerut University, Dec. 2000.
21. Sharma, S.K., Gaur, Ansul., Sharma, T.P. & Misra, S.C.K. Structural properties of composite Se.As-Se.Te alloy films. International Conference on Advanced Materials, Meerut University, Dec. 2000.
 22. Sharma, Sudhir Kumar., Qureshi, G.J., Gupta, Virender., Kapoor, A., Tripathi, K.N. & Misra, S.C.K. Metal doped polyaniline waveguides for integrated optics. Indo Japanese Workshop on Micromechanical Systems Technology, Nov. 2000.

MATERIALS CHARACTERIZATION

Papers Published in Journals

1. Agrawal, A.K. & Lal, Krishan. Preparation and dissemination of Certified Reference Materials: Indiae experience. MAPAN - *J. Metrology Society of India* 16(1), Supplementary Issue No. 1, 393-400 (2001).
2. Agrawal, Rachna., Anand, Sneh., Sen, M.K. & Gupta, Prabhat K. Study of urban atmospheric pollutants impacts as human health using spirometry technique. MAPAN - *J. Metrology Society of India* 16(1), Supplementary Issue No. 1, 209-216 (2001).
3. Arora, Manju. & Gupta, S.K. Infrared spectroscopy for precise estimation of interstitial oxygen concentration in Cz-Si. MAPAN - *J. Metrology Society of India* 16(1), Supplementary Issue No. 1, 235-240 (2001).
4. Balaram, V., Chandrasekhar, K. Agarwal, A.K., Sharma, P.N., Ganju, Sunita., Nageswara Rao, T., Anjaiah, K.V., Hussain, Sajid. & Lal, Krishan. Analysis of sub-boil distilled water, hydrochloric and nitric acid for trace element impurities by ICP-MS. *Indian Journal of Chemistry* 39 A, 567- 570 (2000)
5. Gupta, A., Singh, R., Singh, D.P. & Narlikar, A.V. Substituted $\text{ErBa}_2\text{Cu}_{3-x}(\text{M}=\text{Fe, Co, Ni and Ga})$: possibility and impact of local structural disorder in CuO_2 planes. *J. Phys. Condens. Matter* 12, 7381 - 7393 (2000).
6. Gupta, Prabhat K., Sarkar, A.K., Sharma, C., Sharma, R.C., Agarwal, Rachna., Prasad., V. Krishna., Kant., Yogesh., Koul, S. & Badrinath, K.V.S. Greenhouse gas emission from biomass burning in India. MAPAN - *J. Metrology Society of India* 16(1), Supplementary Issue No. 1, 264-272 (2001).
7. Gupta, S.K. & Arora, Manju. EPR spectroscopy - a technique for quantitative measurements of spins concentration in materials. MAPAN - *J. Metrology Society of India* 16(1), Supplementary Issue No. 1, 32-37 (2001).
8. Gupta, S.K. Techniques and applications of electron paramagnetic resonance spectroscopy. *Asian Journal of Physics* 9, 31-44 (2000).
9. Jain, Monika., Kulshrestha, U.C., Sarkar, A.K. & Parashar, D.C. Influence of crystal aerosols on wet deposition at urban and rural sites in India. *Atmospheric Environment* 34, 5729 - 5737 (2000).
10. Kant, Yogesh., Ghosh, A.B., Sharma, M.C., Gupta, Prabhat K., Prasad, V. Krishna, Badrinath, K.V.S. & Mitra, A.P. Impact of aerosol optical depth of UV-B radiation - A case study over Eastern Ghats. *Indian J. of Radio & Space Physics* 29, 71 - 80 (2000).
11. Kishore, R., Hotz, Chris., Naseem, H.A. & Brown, W.D. Aluminium induced crystallization of amorphous silicon (a-Si:H) at 150°C. *Electrochemical and Solid State Letters* 4, G14 (2001).
12. Kishore, R., Hotz, Chris, Brown, W.D. & Naseem, H.A. TEM investigation of aluminium assisted crystallization of amorphous silicon (a-Si:H) *Microscopy and Microanalysis* 6, 452 - 453 (2000).
13. Kishore, R., Korapati, V., Naseem, H.A. & Brown, W.D. Scanning electron microscopy studies of vacuum evaporated CdCl_2 doped cadmium sulphide films. *Microscopy and Microanalysis* 6, 454 - 455 (2000).
14. Krishna Prasad, V., Gupta, Prabhat K., Kant, Yogesh., Sharma, C., Sarkar, A.K., Rajagopal, T., Badrinath, K.V.S. & Mitra, A.P. NO_x emission from biomass burning of shifting cultivation areas from tropical deciduous forests

- of India-estimates from ground based measurements. *Atmospheric Environment* 34, 3271-3280 (2000).
15. Kumar, K., Saxena, R.K. & Sarkar, A.K. Effect of heating rate on the char yield and pore structure of chars prepared from viscose rayon cloth. *Ind. Journal Chem. Tech.* 8, 149-152 (2001).
 16. Lal, Krishan., Hartnagal, H.L., Goswami, N. & Thoma, P. Experimental evaluation of on-chip measurement of charge transfer by X-rays. *Electronics Letters* 36, 1204-1205 (2000).
 17. Prasad, V. Krishna., Gupta, Prabhat K., Sharma, C., Kant, Yogesh. & Badrinath, K.V.S. Studies on biomass burning and related trace gas emissions using IRS-P3 satellite data. *ISRO-GBP Newsletter* 7, 10 -15 (2001).
 18. Sankaranarayanan, V.K., Pant, R.P. & Rastogi, A.C. Spray pyrolytic deposition of barium hexaferrite thin films for magnetic recording application. *J. Magn. Mater.* 220, 72-78 (2000).
 19. Sarkar, A.K., Singh, N. & Trehan, J.C. Determination of lead pollution in environment and blood by Atomic Absorption spectrophotometer. *MAPAN - J. Metrology Society of India* 16(1), Supplementary Issue No.1, 294-326 (2001).
 20. Sarkar, Ajit K., Singh, N. & Dasgupta, M.K. Typical characteristics of poly aluminium chloride- New generation liquid coagulant for water purification. *MAPAN - J. Metrology Society of India* 16(1), Supplementary Issue No.1, 290-293 (2001).
 21. Sharma, S.K., Tomokiyo, Y. & Singh, Sukhvir. Evolution of Moire Fringes in Indium antimonide films. *Annual Report of HVEM Lab, Kyushu University, Japan* 25, 3-4(2001).
 22. Singh, D.P. & Khan, M.Y. X-ray diffraction studies of Ga₂Te, *Indian J. Engg. & Mater. Sci.* 8, 46-49 (2001).
- Papers Published in Conference/Symposia/Workshop Proceedings**
1. Arora, Manju., Pradhan, M.M. & Gupta, S.K. FTIR spectroscopy of lithium niobate single crystals in the region 4000-400 cm⁻¹ *Proc. International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, -2001, NPL, New Delhi, Feb. 26-28, 2001. pp. 323.
 2. Bhagavannarayana, G., Shubin, Yu.V., Choubey, A. & Lal, Krishan. Study of point defects and their clusters in bismuth germanate crystals. *Crystal Growth and Characterization; Proceedings of International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, Feb. 26-28, 2001. pp. 264.
 3. Bhagavannarayana, G., Halder, S.K. & Lippert, G. Accurate determination of Ge depth profile in Si_{1-x}Ge_x/Si epilayers of advanced HBT structures by high resolution X-ray diffractometry. *Crystal Growth and Characterization; Proceedings of International Workshop on PCSC*, Feb. 26-28, 2001. pp. 655.
 4. Bhagavannarayana, G., Halder, S.K., Lal, Krishan., Srivastava, Meenakshi., Garg, A.K., Sethi, G.L., Singh Arminder. & Bagai, R.K. Study of real structure of cadmium zinc telluride crystals grown by Asymmetric Bridgman method. *Crystal Growth and Characterization; Proceedings of International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, Feb. 26-28, 2001. pp. 252.
 5. Choubey, A., Shubin, Yu. V., Bhagavannarayana, G., Chakravarthi, B.R. & Lal, Krishan. Study of effect of thermal annealing on crystalline perfection of bismuth germanate single crystals. *Crystal Growth and Characterization; proceedings of International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, Feb. 26-28, 2001. pp.269.
 6. Gadi, Ranu., Sarkar, A.K. & Parashar, D.C. Studies of emission from bio-fuels used in India. *IGAC Symposium on "Atmospheric Chemistry in the Tropics"* from Local to Global, from air pollution to climate change held in Bangkok, Thailand, Jan. 22-23, 2001. pp. 181
 7. Gupta, S.K., Viridi, G.S., Arora, Manju., Pathak, B.C. & Lal, Krishan. EPR study of ion-implanted silicon wafers for p+ -n junctions

- fabrication. *Proc. International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, 2001, Feb. 26-28, 2001. pp. 299.
8. Khasa, S., Seth, V.P. & Gupta, S.K. Electron paramagnetic resonance study of microstructure of $MCl.M_2O_3.B_2O_3$ (M = Li, Na or K) glasses. *Proc. DAE SSP Symposium*, Guru Ghasidas University, Bilaspur, Dec.27-31, 2000. pp.238
 9. Kishore, R., Al-Dhafi, A.M., Hussain, E.J., Naseem, H.A. & Brown, W.D. Aluminium induced Crystallization of PECVD grown amorphous silicon and its application to silicon solar cells. *Proc. National Renewable Energy Convention*, IIT Bombay, Nov. 30-Dec.2, 2000. pp. 161.
 10. Kishore, R., Naseem, H.A. & Brow, D.R. Growth and low temperature crystallization of sputtered amorphous silicon films. *Crystal growth and characterization, Proc. of the International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, Feb. 26-28, 2001. pp. 596.
 11. Kishore, R., Sood, K.N. & Naseem, H.A. SEM& EDS Analysis of Crystallized a-Si/Al thin film structure grown on Crystalline silicon substrate. *Crystal Growth and Characterization. Proc. Of the Int. Workshop on Workshop on Preparation and Characterization of Technologically Important Single Crystals*, Feb. 26-28, 2001. pp. 410.
 12. Kumar, V., Gupta, A.K., Pant R.P., & Suri D.K. Morphology and orientation studies of YBCO thin films. *Crystal growth and Characterization. Proceedings of International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, Feb.26-28, 2001. pp. 508
 13. Lal, Kasturi., Srivastava, A.K., Sood, K.N., Kishore R. & Sharma, S.K. Studies on Hillock formation during annealing of tin thin Films. *XXIV Annual Conference of EMSI on Electron Microscopy and Allied Fields*, Feb. 9-11, 2001. pp. 166.
 14. Lal, Kasturi., Singh, S., Srivastava, A.K., Kishore, R., Sharma, T.P. & Sharma, S.K. Synthesis and characterization of AlSb thin films. *Crystal Growth and Characterization, Proc. of the International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, Feb. 26-28, 2001. pp. 488.
 15. Lal, Krishan. Growth and characterization of single crystals at NPL: Reminiscences. *Crystal Growth and Characterization; Proceedings of International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, Feb. 26-28, 2001 pp.3.
 16. Maurya, K.K., Ramanan, R.R., Halder, S.K., Lal, Krishan. & Sherwood, J.N. Study of forward diffracted X-ray beam in a molecular single crystal (-) 2-(α) (Methylbenzylamino) -5-Nitropyropyridine. *Crystal Growth and Characterization. Proceedings of International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, Feb. 26-28, 2001. pp.247
 17. Mishra, S.C.K., Suri, A., Pant, R.P., Suri, D.K. & Bhattacharyya, R. Preparation and characterization of vacuum deposited polyaniline crystalline thin films. *Crystal Growth and Characterization. Proceedings of International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, Feb.26-28, 2001. pp.583
 18. Om Prakash., Sankaranarayanan, V.K., Pant, R.P. & Islam, Mohammad. Synthesis and characterization of lithium ferrite nanoparticles for ferrofluid applications. *XII ISME Conference*, Chennai, Jan.10-12, 2001. pp. 190
 19. Pant, R.P., Sankaranarayanan, V.K., Kumar, V., Singh, D.P., Kandpal, H.C., Halder, S.K. & Suri D.K. Growth and characterization of ferrofluid thin films. *Crystal Growth and Characterization. Proceedings of International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, Feb. 26-28, 2001. pp 601
 20. Prasad, V. Krishna., Gupta, Prabhat K., Kant, Yogesh., Sharma, C., Rajagopal, T., Badrinath, K.V.S. & Mitra, A.P. GHG Emission from biomass burning in India-Estimates from satellite and ground based measurements. *Proceedings of the IGES/NIES Workshop on CHG Inventories for the Asia Pacific Region*, March 9-10, 2000, Japan, Ed. Damasa, B. Macandog, IGES, Japan, 2000. pp. 205.

21. Sarkar, A.K., Sharma, R.C. & Singh, Niranjan. Study of physicochemical parameters of natural and adulterated milk. *XXX Dairy Conference, Souvenir Book*, Calcutta, Dec. 8-9, 2000. pp. 21
22. Singh, D.P. & Suri, D.K. Preparation and X-ray characterization of the single crystals in GaTe System. *Crystal Growth and Characterization. Proceedings of International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, Feb. 26-28, 2001. pp. 274
23. Singh, S., Sharma, S.K. & Zaidi, Z.H. Microstructural Features associated with Thermally evaporated InSb thin films Crystal growth and characterization. *Proceeding of International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, Feb. 26-28, 2001. pp. 527.
24. Singh, Sukhvir., Tomokiyo, Y., Srivastava, A.K., Zaidi, Z.H. & Sharma, S.K. Electron microscopy of InSb thin films deposited at 373K. *XXIV Annual Conference of EMSI on Electron microscopy & Allied fields* Feb. 9-11, 2001. pp. 167.
25. Srivastava, A.K., Singh, S., Sood, K.N., Kishore, R.Sharma, S.K., Xu, C. & Wej, B. *XXIV Annual Conference of EMSI on Electron Microscopy and Allied Fields* Feb. 9-11, 2001. pp. 126.
26. Viridi, G.S., Pathak, B.C., Kumar, Satish., Wadhawan, O.P., Gupta, S.K., Bhagavannarayana, G., Arora, Manju. & Lal, Krishan. Study and fabrication of ultra shallow junctions on Si crystals of microelectronic devices. *Crystal Growth and Characterization; Proceedings of International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, Feb. 26-28, 2001. pp. 358

Papers Presented in Symposia/ Conferences/ Seminars/ Workshops

1. Agrawal, A.K, & Lal, Krishan. An inter-laboratory programme on preparation and dissemination of Certified Reference Materials in India. *Eighth International Symposium on Biological and Environmental Reference Materials* (BERM 8), Bethesda, USA, September 17-22, 2000.
2. Agrawal, A.K, Bhatnagar, Abha., Ganju, Sunita. & Lal, Krishan. Certified Reference Materials of elemental solutions: Status in India. *Symposium on Reference Materials for Technologies in the New Millenium*, Berlin, Germany, May 22-23, 2000.
3. Agrawal, A.K. & Lal, Krishan. Certified Reference Materials and their status in India. *National Workshop on Measurement System and Quality Management*, New Delhi, March 14-15, 2001.
4. Agrawal, A.K. & Lal, Krishan. Certified Reference Materials: An Essential Requirement for Inter-laboratory Proficiency Testing. *National Workshop on Inter-laboratory Proficiency Testing*, New Delhi, March 12-13, 2001
5. Agrawal, A.K. Certified Reference Materials: Essential for traceable measurements. *37th Annual Convention of Chemists 2000*, Hardwar, November 15-18, 2000.
6. Agrawal, A.K. Ganju, Sunita. & Lal, Krishan. Preparation of multi-element certified reference material consisting of zinc, iron and copper in high purity water. *Eighth International Symposium on Biological and Environmental Reference Materials* (BERM 8), Bethesda, USA, September 17-22, 2000.
7. Agrawal, A.K., Bhatnagar, Abha. & Lal, Krishan. Bhartiya Nirdeshak Dravyas of Mercury: Its preparation and characterization. *National Workshop on Measurement System and Quality Management*, New Delhi, March 14-15, 2001.
8. Ananthamurthy, R.V., Assmus, W. & Luther, Klaus Dieter. Growth of olivine single crystals by Skull melting technique. *XXX National Seminar on Crystallography*, S.V. University, Tirupati, June 28-30, 2000.
9. Ananthamurthy, R.V., Ravikumara, M., Bhagavannarayana, G., Kharachenko, Lyudmila, Shleguel, V., Guerasimov, V., Shubin, Yu.V. & Lal, Krishan. Growth of nearly perfect bismuth germanate single crystals by low thermal gradient Czochralski method and their characterization by high resolution X-ray diffraction techniques. *Souvenir of Vision 2000*, Jawaharlal Nehru University, New Delhi, 8 April 2000.

10. Choubey, A., Bhagvannarayana, G., Chakraborty, B.R., Shubin, Yu.V., & Lal, Krishan. High resolution X-ray diffraction study of very low angle boundaries observed in bismuth germanate single crystals grown by low thermal gradient Czochralski method. *XXX National Seminar on Crystallography*, S.V. University, Tirupati, June 28-30, 2000.
 11. Gadi, Ranu., Sarkar, A.K. & Parashar, D.C. Mass size distribution and chemical composition of aerosol. *Proceedings of Ninth National Symposium on Environment (NSE-9)* Bangalore University, Jnambharath, June 5-7, 2000.
 12. Goswami, Niranjana., Lal, Krishan., Vogt, A. & Hartnagel, H.L. Quantitative determination of lattice-and orientational mis-matches, evaluation of crystalline perfection and composition of highly strained GaSb films on GaAs substrates by high resolution X-ray diffraction techniques. *XXX National Seminar on Crystallography*, S.V. University, Tirupati, June 28-30, 2000.
 13. Kulshrestha, U.C., Jain, Monika., Sarkar, A.K. & Parashar, D.C. Evidence of buffering of acidity of rain water due to crystal sources in Indian sub-Continent. Book of Abstract, *6th International Conference on Acid Deposition (Acid Rain 2000)*, Japan, Dec. 2000.
 14. Lal, Krishan., Ramanan, R.R. & Bhagavannarayana, G. Role of oxygen concentration on crystalline perfection of high purity FZ-grown silicon single crystals. *XXX National Seminar on Crystallography*, S.V. University, Tirupati June 28-30, 2000.
 15. Maurya, K.K., Ramanan, R.R., Halder, S.K., Sherwood, J.N. & Lal, Krishan. Direct observation of a forward diffracted X-ray beam in imperfect 2- α -(methylbenzylamino)-5-nitropyridine single crystals. *XXX National Seminar on Crystallography*, S.V. University, Tirupati, June 28-30, 2000.
 16. Ramachandra, R. & Rashmi. Suitability of a transition metal oxide (prepared for professional grade ferrite) as a reference material in analytical chemistry. *Eighth Int. Symposium on Biological and Environmental Reference Materials (BERM-8)*, Bethesda, Maryland, USA, Sept. 17-22, 2000.
 17. Ramachandran, R. & Rashmi. Chemical analysis of minor elements in steel using matrix matched certified reference material. *Eighth Int. Symposium on Biological and Environmental Reference Materials (BERM-8)*, Bethesda, Maryland, USA, Sept. 17-22, 2000.
 18. Saxena, R.K., Bohra, J.N., Bahl, O.P. & Dhama, T.L. Development of an Important activated porous carbon material and its technology transfer. *National Workshop on Measurement System and Quality Management*, New Delhi, March 14-15, 2001
 19. Saxena, R.K., Kothari, Ranjan. & Bohra, J.N. Preparation of activated carbon cloth and its adsorption characteristics for organic vapours. *12th Annual General Meeting of materials Research Society*, Calcutta, Jan. 31- Feb. 2, 2001.
 20. Suri, D.K., Pant, R.P., Agrawal, A.K & Lal, Krishan. Preparation of Certified Reference Materials of Silicon Powder for X-ray Diffraction Studies. *Eighth International Symposium on Biological and Environmental Reference Materials (BERM 8)*, Bethesda, USA, Sept. 17-22, 2000.
 21. Suri, D.K., Pant, R.P., Agrawal, A.K. & Lal, Krishan. Silicon powder diffraction Certified Reference Material BND 1505. *XXX National Seminar on Crystallography*, S.V. University, Tirupati, June 28-30, 2000.
- Conference Proceedings**
1. **Crystal Growth and Characterization: Proc. of Intl. Workshop on Preparation and Characterization of Technologically Important Single Crystals**, NPL, New Delhi, Feb. 26-28, 2001. Eds : S.K. Gupta, S.K. Halder, & G. Bhagavannarayana, NPL, New Delhi. 2001. pp. 727+xxiv
 2. **Advances in Metrology and Global Trade: Proc. 3rd Intl. Conference on Metrology in New Millennium and Global Trade**, NPL, New Delhi, Feb. 8-10, 2001. A.K. Agrawal, A.K. Saxena, A. Sengupta, *Guest Editors*. P.C. Kothari and P.C. Jain, *Eds*. New Delhi, Metrology Society of India. 2001. pp.402+xi
- Scientific Reports, Chapters in Monographs**
1. Badrinath, K.V.S. & Gupta, Prabhat K. Eds. Trace Gas emission from Shifting - Cultivation areas of Rampa forests - (Eastern

- Ghats) Andhra Pradesh, India: Result from Ground based measurements and Satellite derived estimates: A joint study conducted by NRSA - NPL, Feb. 17th to 25th, 1999. NRSA (DOS) Hyderabad and NPL, New Delhi, June 2000.
2. Gupta, Prabhat K. Report on Experimental Study on Polycyclic Hydrocarbons (PAHs) and Particles Matter Emission from Combustion of Fuel Wood in the improved Indian cookstove. Submitted to AIT, Thailand, under the ARRPEEC-II project of SIDA, December 2000.
 3. Mitra, A.P., Mahajan, K.K., Parashar, D.C., Tiwari, M.K., Ghosh, A.B., Zalpuri, K.S., Sharma, M.C., Ram, R.S., Gupta, Prabhat K., Beig, G. Sharma, C., Bhattacharya, S.B., Bose, S., Kulshrestha, U.C. & Mandal, T.K. Greenhouse gas inventory, modelling and global change Paper 3 (Atmospheric Science Section) in DST special volume, "Research Highlights in Earth Sciences". Indian Geological Congress, (2000). pp 265-289.
 4. Prasad, V., Krishna, Kant., Yogesh., Badrinath, K.V.S., Gupta, Prabhat K., Sharma, C. & Mitra, A.P. Studies on biomass burning using satellite data and ground observations GBP in India 2000: A status Report on projects. INSA, New Delhi (2000). pp. 215 - 222.
 5. Sharma, Nidhi, Deepa, M., Varshney, Pradeep, Upreti, U.C., Ramachandran, R. Agnihotry, S.A. A comparative study of precursor materials for casting sol-gel based tungsten oxide films. *Ion Conducting Materials: Theory and Applications* (Eds.), A.R. Kulkarni and P. Gopalan, 2001, Narosa Publishing House, New Delhi. pp.67.
 3. Dabas, R. S., Reddy, B. M., Lakshmi, D. R. & Oyama, K. I. Study of anomalous electron variation in the topside ionosphere using HINOTORI satellite data. *J. Atmos. Solar and Terr. Phys.* 62, 1351-1359 (2000).
 4. Gulyaeva, T. L. & Mahajan, K. K. Dynamic boundaries of the ionosphere variability. *Advances in Space Research.* 27, 91-94 (2001).
 5. Gupta, J. K. & Singh, L. Long term ionospheric electron content variations over Delhi. *Ann. Geophysicae.* 18, 1635-1644 (2001).
 6. Jain, Meena. & Kundu, Namita. Late summer maximum in ozone over Delhi. *Indian J. Radio Space Phys.* 29, 298-303 (2001).
 7. Jain, S. L. Laser probing of the atmosphere. *Asian J. of Phys.* 9, 159-167 (2001).
 8. Jain, S. L. & Arya, B.C. Surface ozone measurements over New Delhi. *J. Mar. and Atoms. Res.* 2, 22-25 (2001)
 9. Kant, Yogesh., Ghosh, A. B., Sharma, M. C., Gupta, P. K., Prasad, V Krishna., Badrinath, K. V.S. & Mitra, A.P. Studies of aerosol optical depth in biomass burning areas using satellite and ground based observations. *Infrared Phys. & Tech.* 41, 21-28 (2000).
 10. Kant, Yogesh., Sharma, M. C., Ghosh, A. B., Gupta, P. K., Prasad, V Krishna., Badrinath, K. V.S. & Mitra, A.P. Impact of aerosol optical depth on UV-B radiation - A case study over Eastern Ghats; *Indian J. Radio & Space Phys.* 29, 71-80 (2000).
 11. Mahajan, K. K. & Oyama, K. I. The ionosphere and upper atmosphere of Venus: A review. *Proceedings of Indian National Science Academy (PINS A)*, 66A, 483-498 (2000).
 12. Mahajan, K. K. & Sethi, N.K. Empirical models of parameters B0, B1 from Arecibo Radar Observatory. *Advances in Space Research* 27, 17-20 (2001).
 13. Mali P., Sarkar, S. K. & Bhattacharaya, A. B. Temperature effects on attenuation due to rain at millimeter and centimeter waves. *International J. Infrared and Millimeter Waves.* 22, 153 - 171 (2001).
 14. Mondal, N. C., Sarkar, S. K., Bhattacharya, A. B. & Mali, P. Rain height in relation to 0° C

RADIO & ATMOSPHERIC SCIENCES

Papers Published in Journals

1. Arya, B. C., Jain, S. L. & Arun Kumar. Measurements of water vapour and ethylene (C₂H₄) by Differential Absorption Lidar. *J. Mar. and Atoms. Res.* 2, 12-15 (2001).
2. Arya, B. C., Jain, S. L., Tripathi, O. P. & Arun Kumar. Measurements of surface ozone, total ozone and water vapour in biomass burning areas of Rampa Agency (Eastern Ghats) Andhra Pradesh. *MAPAN - J. Metrology Society of India* 16(1), Supplement 1, 241-244 (2001).

- isotherm height over some tropical locations and rain attenuation for an Indian south station for micro wave and millimeter wave communication system. *International J. Infrared and Millimeter Waves* 22, 495-504 (2001).
15. Pandey, V. K, Sethi, N. K. & Mahajan, K. K. Equivalent slab thickness and its variability. *Advances in Space Research* 27, 61-64 (2001).
 16. Raju, Mega K., Punyaseshudu, D., Sarkar, S. K., Gupta, M. M., & Prasad, M. V. S. N. Deterioration in performance of a line of sight link at 7.3 GHz located in Indian dry southern region. *Indian J., Physics* 74, 139 - 142 (2000).
 17. Rao, T. R., Rao, S. V. B., Prasad, M. V. S. N., Sain, M., Ahmed, I. & Lakshmi D. R. Mobile radio propagation path loss studies at VHF/UHF bands in Southern India. *IEEE Transactions on Broadcasting* 46(2), 158-164 (2000).
 18. Sarkar, S. K. & Mondel, N. C. Attenuation by rain and associated radio propagation at microwave and millimeter wave frequency bands for communication. *Indian J. Physics* 74B, 101-115 (2000).
 19. Sethi, N. K. & Pandey, V. K. Comparative study of electron density from incoherent scatter measurements at Arecibo with IRI-95 model during solar maximum. *Ann Geophyscae*, 18, 1630-1634 (2000).
 20. Sethi, N. K., Pandey, V. K. & Mahajan, K. K. Comparative study of TEC with IRI model for solar maximum period at low latitude. *Advances in Space Research* 27, 45-48 (2001).
 21. Sharma, M. C., Singh, R., Tanwar, R. S., Shambu Nath. & Tiwari, M. K. UV-B radiation, aerosol and erythema dose measurements during field campaign of December 1999 at Delhi. *MAPAN - J. Metrology Society of India* 16(1), Supplement No. 1, 297-300 (2001).
 22. Tripathi, O.P. & Jain, S. L. Measure of ozone at Maitri, Antarctica. *J. Mar. and Atoms. Res.* 2, 37-39(2001).
 23. Uprety, D. C., Garg, S. C., Tiwari, M. K. & Mitra, A. P. Crop responses to elevated CO₂: Technology and research (Indian Studies). *Global Environ. Res.* 3(2), 155 - 167(2000).
 24. Zachariasse, M., Van Velthoven, P. F. J., Smit, H. G. J., Lelieveld, L., Mandal, T. K. & Kelder, H. Influence of stratospheric-tropospheric ozone over the tropical Indian ocean during the winter monsoon. *J. Geophys. Res.* D12, 15403 -15416(2000).
- Papers Published in Conference/Symposia/ Workshop Proceedings**
1. Arya, B.C., Jain, S.L. and Arun Kumar; Kshobhamandliya ozone gas ka aik vishleshnatmak adhyayan. *Proc. Mapan Vyavastha va Gunvata Prabandhan par Rashtriya Karyashala*, NPL, New Delhi, 14-15 March 2001. pp 24. (in Hindi).
 2. Jain, S.L. & Arya, B.C. Measurement Of Surface Ozone at NPL, New Delhi. *Proc. Quadrennial Ozone Symposium - Sapporo 2000*, Hokkaido University, Sapporo, Hokkaido, Japan, 3-8 July 2000.
 3. Jain, S.L. & Arya, B.C. Measurement of surface ozone, total ozone and water vapour at a high altitude observatory, Hanle. *Proc. Quadrennial Ozone Symposium - Sapporo 2000*, Hokkaido University, Sapporo, Hokkaido, Japan, 3-8 July 2000.
 4. Jain, S.L. & Tripathi, O.P. Monitoring of total ozone. water vapour etc at Maitri, Antarctica. *Proc. Quadrennial Ozone Symposium - Sapporo 2000*, Hokkaido University, Sapporo, Hokkaido, Japan, 3-8 July 2000.
 5. Jain, S.L., Ghosh, A.B., Sharma, M.C., Arya, B.C., Vohra, V.K & Tanwar, R.S. Measurement of various atmospheric parameters during Solar Eclipse on 11th August 1999. *Quadrennial Ozone Symposium - Sapporo 2000*, Hokkaido University, Sapporo, Hokkaido, Japan, 3-8 July 2000.
 6. Shastri, S. Global disturbance climatology for F-region - Long term changes. *Long term Changes and Trends in the Atmosphere - Proceedings of an Intl. Conference.* G. Beig, Ed. New International, India, (2001). pp. 149.
- Papers Presented in Conference/Symposia/ Workshops**
1. Goel, M. K. Reduction of transition heights from SROSS - C2 data. ISRO Workshop on RPA data from SROSS - C2, National Physical Laboratory, New Delhi, Nov. 16, 2000.

2. Goel, M.K. & Bhatia S.K. Studies on ion composition variations during magnetic storms using AE series of data, presented at the International Conference. AGU Conference on Storm-Substorms Relationship, Lonavala (Near Mumbai), March 12-16, 2001.
3. Jain, S.L. Laser based activities for atmospheric environmental monitoring at NPL 2nd International Workshop on Radar and Lidar Remote Sensing Technology in Asia, Communications Research Laboratory, Tokyo, Japan. 13 October 2000.
4. Jain, S.L., Arya B.C. & Arun Kumar. Measurements of water vapour, surface ozone and ethylene using Differential Absorption Lidar. Conference on Lidar Remote Sensing for Industry and Environmental Monitoring II (AE04), SPIE's Second International Asia-Pacific Symposium on Remote Sensing of the Atmosphere, Environment, and Space, Sendai International Ctr., Sendai, Japan, October 9 - 12, 2000.
5. Jain, S.L. Laser and environmental monitoring, Indian Science Congress Association (ISCA), 88th Session, IARI, New Delhi, 3-7 January 2001.
6. Jain, S.L., Arya, B.C & Arun Kumar. Measurements of various minor constituents in the atmosphere using Differential Absorption Lidar. 20th Internl. Laser Radar Conference, Vichy, France, July 10-14, 2000.
7. Jain, S.L., Arya, B.C & Tripathi, O.P. Measurement of ozone, water vapour and aerosol optical depth at Maitri, Antarctica and high altitude station. 10th International Symposium of Acoustic Remote Sensing and Associated Techniques of the Atmosphere and Ocean, Auckland, New Zealand, 27 Nov.- 1 Dec. 2000.
8. Jain, S.L., Arya, B.C. & Arun Kumar. Measurement of atmospheric ammonia using Differential Absorption Lidar. 10th International Symposium of Acoustic Remote Sensing and Associated Techniques of the Atmosphere and Ocean, Auckland, New Zealand, 27 Nov. 1 Dec. 2000.
9. Lakshmi, D.R. Low latitude ionospheric response to May 1-5, 1998 Magnetic storm period using SROSS C2 data. ISRO Workshop on RPA data from SROSS- C2, National Physical Laboratory, New Delhi, November 16, 2000.
10. Lakshmi, D.R., Veenadhari, B. & Reddy, B.M. On the night time response of equatorial ionosphere to magnetic storms. AGU Conference on Storm - Substorms Relationship, Lonavala (Near Mumbai), India, March 12 - 16, 2001.
11. Lal, M., Dutta, H.N. & Kim, V.P. Influence of variations of cosmic rays on meteorological parameters. AGU Conference on Storm - Substorms Relationship, Lonavala (Near Mumbai), March 12 - 16, 2001.
12. Lokanadham, B., Lakshmi, D.R. & Geetha, M. Effects of large magnetic storms observed on the plasmasphere at low latitudes by SROSS-C2 satellite. AGU Conference on Storm - Substorms Relationship, Lonavala (Near Mumbai), March 12 - 16, 2001.
13. Mahajan, K.K. & Oyama, K.I. The central night side Venus ionosphere: Dependence of ion concentration and plasma holes on Solar Wind dynamic pressure. 3rd COSPAR Assembly, Warsaw, Holland, 16-23 July, 2000.
14. Marwha, R. Variability of thunderstorm activity (tsa) as atmospheric radio noise (arn) generators affect the e.m. environment & deforestation. National Workshop on Recent Developments in Atmospheric and Space Sciences, Department of Physics, Univ. of Roorkee, Roorkee, March 19-21, 2001.
15. Maini, H. K., Chopra, P., John, T., Singh, D., Tiwari, M. K., Anand, J. R., Gera, S. C., Garg, S. C., Uprety, D. C., Mohan, R., Dwivedi, N., Saxena, D. C., Miglietta, M & Zaldei, A. Design of Mid-FACE facility for South Asian Region,. FACE2000 Int. conference, Tsukuba, Japan, 24th June - 1st July 2000.
16. Subrahmanyam, P. Observations of the leonid meteor showers of November, 1998 by comparing campaign data obtained from Mauritius, Bangalore and Lucknow passes. ISRO Workshop on RPA data from SROSS - C2, National Physical Laboratory, New Delhi, November 16, 2000.

17. Veenadhari, B., Lakshmi, D.R. & Tim, Yeoman. Comparison of low and high latitude sporadic E occurrences during magnetic storms and substorms. AGU Conference on Storm - Substorms Relationship, Lonavala (Near Mumbai), March 12-16, 2001.
18. Vijaykumar, P.N. A novel method of tracking the trails of leonoid meteors using the VHF signals from a geostationary satellite. National Workshop on Recent Developments in Atmospheric and Space Sciences, Department of Physics, Univ. of Roorkee, Roorkee, March 19-21, 2001.
2. Awana, V.P.S., Cardoso, Claudio A., de Lima, O.F., Malik, S.K., Yelon, W.B., Ram Prasad., Gupta, A., Sedky, A., & Narlikar, A.V. Rare earth ionic size dependant Tc in $\text{RBaSrCu}_3\text{O}_7$ (R = Y, Dy, Nd and La). *Physica C* 341-348, 627-628 (2000).
3. Awana, V.P.S., Malik, S.K., Yelon, W.B., Cardoso, Claudio A., de Lima, O.F., Gupta, A., Sedky, A., & Narlikar, A.V. Neutron diffraction on $\text{Er}_{1-x}\text{Ca}_x\text{Ba}_2\text{Cu}_3\text{O}_7$ system: Possible oxygen vacancies in Cu-O2 planes. *Physica C* 338, 197-204 (2000).
4. Awana, V.P.S., Malik, S.K., Cardoso, Claudio A., de Lima, O.F., Gupta, Anurag., Sedky, A., Yelon, W.B., Ram Prasad. & Narlikar, A.V. Strong dependence of superconducting transition temperature (Tc) on the rare earth ionic size in $\text{REBaSrCu}_3\text{O}_7$ (RE = Y, Dy, Nd and La) series. *Mod. Phys. Lett. B* 14, 361-372 (2000).
5. Awana, V.P.S., Schmidt, E., Gmelin, E., Gupta, A., Sedky, A., Narlikar, A.V., Cardoso, Claudio A., de Lima, O.F., Malik, S.K. & Yelon, W.B. Effect of Zn substitution on para- to ferromagnetic transition temperature in $\text{La}_{0.67}\text{Ca}_{0.33}\text{Mn}_{1-x}\text{Zn}_x\text{O}_3$ colossal magnetoresistance materials. *J. Appl. Phys.* 87 (9), 5034-5036 (2000).
6. Bhattacharya, D., Pandey, A. & Sharma, R.G. Flux pinning in an array of Josephson Junction with Columnar Defects. *Physica C* 341-348, 1205 - 1206 (2000).
7. Gupta, Anurag., Singh, Rajvir., Singh, D. P. & Narlikar, A. V. Substituted $\text{Er Ba}_2\text{C}_{u_{3-x}}\text{M}_x\text{O}_{7-y}$ (M = Fe, Co, Ni, and Ga): Possibility and impact of local structural disorder in CuO2 planes. *J. Phys.:Cond. Matter* ,12, 7381-7393 (2000).
8. Gupta, Anurag., Ratan Lal., Sedky, A., Narlikar, A.V. & Awana. V.P.S. Correlation between superconducting critical temperature and normal state resistivity parameters from the co-doped $\text{ErBa}_2\text{Cu}_{3-x-y}\text{Zn}_x\text{FeyO}_7$ -d system. *Phys. Rev. B* 61, 11752 - 11761, (2000).
9. Kishan, Hari. & Singh, Bhikham. Humidity generation using glycerine -water and sodium hydroxide water mixtures. *MAPAN -Journal of Metrology Society of India* 16(1), Supplementary Issue No 1, 66-70, (2001).

Published Research Reports

1. Jain, S. L. & Tripathi, O. P. Measurement of water vapour at Maitri, Antarctica. Technical Publication No. 14. Scientific Report on 16th Indian Expedition to Antarctica. Dept. of Ocean Development, Govt. of India. 113-116 (2000).
2. Jain, S. L. Monitoring of Ozone water vapour etc during the voyage to Antarctica, Technical Publication No. 14. Scientific Report on 16th Indian Expedition to Antarctica. Dept. of Ocean Development, Govt. of India. 103-112 (2000).
3. Mitra, A. P., Mahajan, K. K., Parashar, D. C., Tiwari, M. K., Ghosh, A. B., Zalpuri, K. S., Sharma, M. C., Ram, R.S., Gupta, P. K., Beig G., Sharma, C., Bhattacharya, S., Bose, S., Kulshreshtha, U. C. & Mondal, T. K. Greenhouse gases, modeling and Global Change ; In 'Research highlights in Earth System Sciences, DST Special Report Vol. 1' Publ. Indian Geological Congress 265 (2000).
4. Tripathi, O. P. & Jain S. L. Measurement of ozone at Maitri, Antarctica.; In 'Technical Publication No. 14., Scientific Report on 16th Indian Expedition to Antarctica' Dept. of Ocean Development, Govt. of India. (2000). pp. 117-124.

SUPERCONDUCTIVITY & CRYOGENICS

Papers Published in Journals

1. Awana, V.P.S., Cardoso, Claudio A., de Lima, O.F., Yelon, W.B., Gupta, A., Sedky, A., & Narlikar, A.V. Structural details of $\text{Er}_{1-x}\text{Ca}_x\text{Ba}_2\text{Cu}_3\text{O}_7$: Oxygen vacancies in Cu-O₂ planes. *Physica C* 341-348, 557-558 (2000).

10. Kishan, Hari. The NPL (India) Humidity standard. *MAPAN-Journal of Metrology Society of India* 16(1), Supplementary Issue No.1, 62-65, (2001).
 11. Mishra, D.R., Sharma, S.V. & Sharma, R.G. Role of vanadium in Bi-2223. *Pramana* 54, 317-330 (2000).
 12. Mishra, D.R., Zadeh, H.S., Bhattacharya, D., Dheer, P.N. & Sharma, V. Studies on percolation models in YBaCuO system, *Physica C* 341-348, 1931-1932 (2000).
 13. Okram, G. S., Terakura, C., Uji, S., Aoki, S., Xu, S. & Hinks, S. S. Irreversibility line and lock-in transition in $Tl_2Ba_2CuO_6$ single crystals. *Physica C* 356, 115 - 121 (2001).
 14. Okram, G. S., Aoki, H., Xu, M. & Hinks, D. G. Vortex lock-in transition in $Tl_2Ba_2CuO_6$ superconductor and vortex phase diagram. *Physica C* 355, 65 - 76 (2001).
 15. Okram, G. S., Aoki, H., Xu, Ming., Hinks, D. G. & Li, T.W. Vortex types and their phase diagram in $Tl_2Ba_2CuO_6$ Single Crystals. *Solid State Communications* 118, 47-51 (2001).
 16. Pandey, A. Arun Partap, Bhattacharya, D. & Sharma, R.G. Stability of oxygen in HgO added bulk YBaCuO superconductor. *Physica C* 341-348, 2449-2450 (2000).
 17. Pandey, A., Bhattacharya, D. & Sharma, R. G. Role of intergranular silver in modulating the aperiodicity in disordered Josephson junction arrays : Impact on relaxation of intergranular critical state. *Physica C* 340, 211-224 (2000).
 18. Rai, R. Study of Jahn-Teller and vibronic mixing interaction in T_{1u} and T_{1g} levels of C_{60} in icosahedral symmetry. *Indian J. Physics* 75A, 419-421 (2001).
 19. Rajendra Singh., Samanta, S.B., Narlikar, A.V. & Trigunayat, G.C. A combined optical, SEM and STM study of growth spirals on the polytypic cadmium iodide crystals. *J. Crystal Growth* 213, 70-74 (2000).
 - 20.. Ratan Lal. Study of hole scattering rate in cuprate superconductors by a novel approach. *Solid State Commun.* 115, 359-363 (2000).
 21. Ratan Lal. Study of scattering rate in cuprate superconductors. *Physica C* 340, 71-78 (2000).
 22. Tanaka, K., Iyo, A., Terada, N., Tokiwa, K., Miyashita, S., Tanaka, Y., Tsukamoto, T., Agarwal, S.K., Watanabe, T. & Ihara, H. Tl-valence change and T_c enhancement ($>130K$) in $(Cu,Tl)Ba_2Ca_2Cu_3O_y$ due to nitrogen annealing. *Phys. Rev. B* 63, 64508 - 64513 (2001).
- Papers Published in Conference /Symposia /Workshop Proceedings**
1. Kumar, Sanjeev., Momeen., Khan, M.Y. & Rai, R. Electrical and optical characterization of Kdp doped CDI_2 . *Proceedings of the International Workshop on Preparation and Characterization of Technologically Important Single Crystals*, NPL, 26-28 Feb. 2001. S.K. Gupta, S.K. Haldar, and G. Bhagwannarayana. (2001). pp.354-357.
 2. Sharma, R.G. A review of superconducting magnets developed at National Physical Laboratory. *Proc. Eighteenth International Cryo. Engg. Conf.*, (ICEC-18), 2000. pp 63-66.
 3. Sharma, R.G., Saxena, R.B., & Ansari, M.A. A multi-purpose 7 tesla superconducting magnet. *Proc. Eighteenth International Cryo. Engg. Conf.*, (ICEC-18), 2000. pp 71-74.
 4. Tokiwa, K., Agarwal, S.K., Watanabe, T., Iyo, A., Tanaka, Y. & Ihara, H. Evaluation of carrier concentration and superconductivity properties under normal and high pressure in Cu-Tl system superconductors. *1st CREST Symposium JST*, Tokyo, Japan, 2000. pp 36-37.
 5. Upadhyay, P.L. & Sharma, R.G. Critical current and microstructural investigations of PIT processed Bi-2223/Ag tapes. *Proc. Eighteenth International Cryo. Engg. Conf.*, (ICEC-18), 2000. pp 239-242.
- Papers Presented at Conferences / Symposia / Seminars / Workshops**
1. Agarwal, S.K & Okram, G.S. Superconductivity in Pr substituted $REBa_2Cu_3O_7$ cuprates : Some novel features. 6th Asian Thermophysical Properties Conf. (ATPC), Gauhati (8-11 Oct. 2001).
 2. Rai, R. The study of $(T_{1u} + T_{1g}) \times t_{1u}$ vibronic interaction in endohedral fulleride. 12th Annual General Meeting of MRSI, SINP, Kolkatta, 31 Jan-2 Feb. 2000.

Technical Report

1. Tanaka, K., Iyo, A., Terada, N., Tokiwa, K., Miyashita, S., Tanaka, Y., Tsukamoto, T., Agarwal, S.K., Watanabe, T. & Ihara, H. TI

valence change and T_c enhancement ($>130K$) in $(CuTi)Ba_2Ca_2Cu_3O_y$ due to Nitrogen annealing. Electrotechnical Laboratory, Tsukuba, Japan, Report No. TR-2000-04.

APPENDIX : 2

PATENTS

Patents Filed in India

S.No.	Title	NF-NO.	Application No.	Filing Date
1.	An improved constant temperature bath.	193NF 2000	0610 DEI-2000	23-06-2000
2.	An improved cold discharge ion atom beam source useful for micro-milling & material modification.	336NF2000	0908 DEI-2000	06-10-2000
3.	A device for monitoring ion beam etching process.	106NF 2001	0208 DEI-2001	27-02-2001
4.	A novel apparatus useful for slip gauge calibration and a technique for slip gauge calibration therefrom.	148NF2001	402 DEI-2001	29-03-2001
5.	Method for making reusable heat pack	168NF2001		29-03-2001

Patents Filed Abroad

S.No.	Title	NF-NO	OC	Filing Date
1.	A simulation circuit layout design for low voltage, low power & high performance Type-II current conveyor for analog signal processing applications	159NF2001	US	25-03-2001
2.	Method for making reusable heat pack	168 NF 2001	US	20-03-2001
3.	A simulation circuit layout design for low voltage, low power & high performance Type-II current conveyor for analog signal processing applications	159 NF 2001	JP	28-03-2001

S.No.	Title	NF-NO	OC	Filing Date
4.	A simulation circuit layout design for low voltage, low power & high performance Type-II current conveyor for analog signal processing applications.	159 NF 2001	SP	28-03-2001
5.	A simulation circuit layout design for low voltage, low power & high performance Type-II current conveyor for analog signal processing applications	159 NF 2001	TA	28-03-2001
6.	A simulation circuit layout design for low voltage, low power & high performance Type-II current conveyor for analog signal processing applications	159 NF 2001	KO	30-03-2001
7.	Method for making reusable heat pack	168 NF 2001	EP	30-03-2001
8.	Method for making reusable heat pack	168 NF 2001	WO	30-03-2001

Patents Granted Abroad

S.No	Title	Patent No.	Country	Grant Date
1.	Conducting polymer membranes and a process for preparation of the same membrane	US Patent No. 6,156,202	USA	05-12-2000
2.	A device useful as master/slave clock for transmitting standard time over a telephone network and a telephone network incorporating the device for transmitting and receiving standard time	US Patent No 6,091,804	USA	July 18, 2000

APPENDIX : 3

TECHNOLOGIES MARKETED / IN PIPELINE

Technologies Marketed	In Pipeline for Marketing
Miniature Teleclock (Marketed to M/s Bihar Communications, Patna)	Front surface coated rear view mirror Fog coating Anti-glare coating on spectacle lenses for night driving applications Heat pack Basic Sodar operating in the monostatic/doppler mode Accelerometer Long decay phosphor materials Constant temperature bath Multi channel particle analyzer Piston gauge transfer pressure standard up to 80 Mpa

APPENDIX : 4

R & D COLLABORATIONS

Collaborating Agency	Title of the Project
Electrical Standards	
Overseas	
NML (South Africa)	Development of 10 pF ULE capacitor
NABL	Proficiency testing of standards
Indian	
University of Delhi	Microwave superconductivity
Jamia Millia Islamia, Jamia Nagar, New Delhi	High power piezoelectric transducers
All India Institute of Medical Sciences, New Delhi	Biometry and tumour therapy studies
National Institute of Museology, New Delhi	Materials study of ancient monuments
Engineering Materials	
Overseas	
Indo-US	Application of carbon nanotubes in composites-alignment and adhesion problems
Indo-UK	Role of matrix precursor in the development of high thermal conductivity carbon-carbon composites
Indo-Japan Mechanical Engineering Laboratory, Agency of Industrial Science & Technology, Ministry of Industrial Trade & Industry, Japan.	Precision forming for net shaped parts
Indian	
Hindustan Aeronautics Limited, Bangalore.	Development of oval shaped tubes, as skid landing gear, for advanced light helicopter (Phase-I)
Hindustan Aeronautics Limited, Bangalore.	Development of oval shaped tubes, as skid landing gear, for advanced light helicopter (Phase II)
Hindustan Aeronautical Limited Bangalore.	Development of titanium fasteners using warm forging

Collaborating Agency	Title of the Project
AR&DB, New Delhi	Development of carbon monofilament suitable for CVD-based SiC fibres
Department of Science & Technology New Delhi	Asbestos free brake material for automobile-tailoring, characterization and evaluation
Institute for Plasma Research Gandhinagar, Gujarat.	Development of high thermal conductivity graphite
Indian Oil Corporation, R & D Centre Faridabad.	Feasibility studies of various petroleum refinery streams as precursor for high performance carbon fibres
Graphite India Ltd., Bangalore.	Consultancy relating to up scaling of high density graphite development
Naval Materials Research Laboratory Ambarnath.	Development of porous conducting carbon paper

Electronic Materials

Indian

Bhabha Atomic Research Centre, Mumbai.	Development of silicon photodiodes for use with scintillating crystals for detection of gamma rays
Solar Energy Centre, Ministry of Non - conventional Energy Sources, New Delhi.	Design and development of a Mechanical Load Tester for determining the ability of a PV module to withstand wind, snow and ice loads.
Defence Laboratory, Jodhpur	1. Development of Luminescent Screens 2. Preparation of Long Decay Phosphor
Dept. of Applied Physics, Guru Nanak Dev University, Amritsar	Collaborative R&D on gel polymeric electrolytes
Dept. of Microbiology, AIIMS New Delhi	Development of conducting polymer membrane
Maitreyi College (Delhi University), Chanakyapuri, New Delhi.	Development of Conducting polymer membrane, polymeric Schottky junction devices etc., Synthesis and Characterization of Conducting polymers and bio- compatible polymer composites.
Dept. of Physics and Astrophysics Delhi University, Delhi.	Synthesis and Characterization of Conducting Polymers
National Institute of Immunology New Delhi.	Development of bio compatible polymer composite
CEERI, Pilani (Rajasthan)	Silica-on-silicon waveguides.

Collaborating Agency	Title of the Project
Materials Characterization	
Overseas	
Institute of Inorganic Chemistry Siberian branch of the Russian Academy of Sciences, Novosibirsk, Russia.	Crystal growth and high resolution X-ray diffraction
Technical University of Darmstadt Germany.	High resolution X-ray diffraction
National Institute of Standard and Technology, Gaithersburg, U.S.A	High resolution X-ray diffraction
Naval Research Laboratory, Washington DC, USA	High resolution X-ray diffraction
ILTP-Indo-Russia, DST	Growing by MBE method epitaxial structure on the basis of compound $A_{III}B_V$ GaAs, AlInGaAs in different compositions for various applications
ILTP-Indo-Russia, DST	Semiconductor silicon for application in solar energy, microelectronics and power electronics
ILTP-Indo-Russia, DST	Growth of nearly perfect single crystals of oxide materials with technological applications
Indo-US	High resolution X-ray diffraction energy for advanced materials characterization
Swiss Federal Laboratories for Materials Testing and Research, Switzerland	CCQM-international key inter- comparison programme on chemical measurements
Institute of Experimental Physics, Slovak Academy of Sciences, Kosice, Slovak	Development of Ferrofluid Composite film and their Characterization
Indian	
Solid State Physics Laboratory Delhi.	Characterization of semiconducting Crystals and their epitaxial layer
University of Delhi, Delhi	Experimental and theoretical investigations of the effect of asphericity of electron density distribution in crystals on diffracted x-ray intensities
Bhabha Atomic Research Centre, Trombay Mumbai	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of Mono-elemental Solutions and Pesticide

Collaborating Agency	Title of the Project
Central Building Research Institute Roorkee	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of Mono-elemental Solutions and Gas
Central Food Technological Research Institute, Mysore	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of Mono-elemental Solutions and pesticide
Central Salt & Marine Chemicals Research Institute, Bhavnagar	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of Mono-elemental Solutions and Gas
Indian Agricultural Research Institute, New Delhi	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of Bharatiya Nirdeshak Dravyas of Pesticide & Gas
Indian Institute of Chemical Technology, Hyderabad	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of Mono-elemental Solutions and pesticide
Indian Institute of Petroleum, Dehradun	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of Mono-elemental Solutions and pesticide
Industrial Toxicology Research Centre, Lucknow	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of Mono-elemental Solutions and pesticides
National Environmental Engineering Research Institute, Nagpur	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of Mono-elemental Solutions, Pesticide and Gas
National Geophysical Research Institute, Hyderabad	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of Mono-elemental solution
National Institute of Oceanography, Goa	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of Mono-elemental solution and Gas
National Metallurgical Laboratory, Jamshedpur	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of Mono-elemental solutions
Regional Research Laboratory, Bhubaneswar	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of Mono-elemental Solutions, Pesticides & Gas
Regional Research Laboratory, Jorhat	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of Mono-elemental Solutions & Gas
Regional Research Laboratory, Thiruvananthapuram	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of Gas

Collaborating Agency	Title of the Project
Indian Oil Corporation, R&D Centre, Faridabad	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of Mono-elemental Solutions & Pesticides
National Thermal Power Corpn., R & D Centre, Gouttam Budha Nagar	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of Mono-elemental Pesticides & Gas
AES Testing & Research Laboratory Gouttam Budha Nagar	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of Mono-elemental Pesticides & Gas
Gharda Chemicals Ltd., Dombilvli	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of Pesticides
National Accreditation Board of Testing and Calibration Laboratories (NABL-DST)	Planning, Preparation and Dissemination of certified reference materials for quality control in analytical measurements for strengthening of BND programme
Rajeev Gandhi National Drinking Water Mission, New Delhi	Evaluation of Filter Tablet System for Removal of Arsenic from water
National Council for Cement Building Materials (NCCBM) Ballabgarh, Haryana	Proficiency testing of fly ash materials prepared to serve as Reference Materials
Physics Department, M.D. University Rohtak	Characterization of Materials

Radio & Atmospheric Sciences

Overseas

START, Washington, USA	Operation of the South Asian Regional Research Centre for Study of Global Change
NCAR, USA and DOS, Govt. of India	Indian Ocean Experiment (INDOEX)

Indian

Indian Agricultural Research Institute New Delhi	Free Air CO ₂ enrichment studies on crops and gas emissions using OTC and FACE facilities.
National MST radar Facility, Tirupati.	Lower atmosphere and F-region studies.
Central Pollution Control Board New Delhi	Study of fog/smog in and around the city of Delhi.
Indian Space Research Organization, Banglore and Universities of Osmania, Roorkee, Waltair, BHU, Dibrugarh, Kolkota, Saurashtra and Kerala.	SROSS-C2 Satellite RPA aeronomy payload data management and Data Analysis.

Collaborating Agency	Title of the Project
Indian Meteorological Department, New Delhi	Rain effects on microwave communication
Department of Ocean Development	Green house gases studies at Antarctica
Department of Ocean Development	PBL studies over Antarctica
Indian Statistical Institute, Kolkata	Estimation of rain characteristics using X band radar.
Space Application Center, Ahmedabad.	Ionospheric correction in sea surface temperature measurements by radiometer on board IRS Indian satellite.

APPENDIX: 5
SPONSORED / SUPPORTED R & D PROJECTS

New Projects

Sl. No.	Title	Agency/Client	Amount Received (Rs.in Lakhs)
1.	Faraday Correction for 6.6 Ghz Radiometer Data From IRS P4 Using Global Positioning System (GPS) Observations	DOS	3.530
2.	Development of Ultrathin Magnetic Films for Engineering Applications in Magnetic Recording & Sensing	DST	11.978
3.	Spin Fluctuations and High Temperature Superconductivity in Bilayer Cuprates	DST	5.000
4.	Photoinduced Superconductivity and Non-Equilibrium States	DST	13.380
5.	Low Pressure Synthesis of Cubic Boron Nitride (CBN)	DST-DAAD (GermanyAcad. Ex. Service)	1.424
6.	Development of Superconducting Magnet	IPR	0.750
7.	Development of Specific Methods to Identify Adulterants in Milk and to Develop a Spot Testing Kit	DMS	1.000
8.	Studies on Emission from Biomass Combustion in Cookstoves	AIT, Thailand	1.540
9.	Application of Carbon Nanotubes in Composites-Alignment and Adhesion Problems	DAE	15.900
10.	Synthesis and Properties of Conducting Polymers for Biosensors	Indo-Polish	0.751
11.	Development of Strain Gauge Force Transducer to Measure Forces up to 1 MN with Accuracy $\pm 0.03\%$	DST	7.500
12.	Application of Carbon Nanotubes in Composites-Alignment and Adhesion Problems	DST/NSF	1.155
13.	CdTe Passivation of HgCdTe by Electrodeposition Technique for use Photovoltaic FPAs : A Feasibility Study	DRDO/SSPL, Lucknow	3.075
14.	Self Assembled Layers of Conducting Polymers for Molecular Devices	DST	1.000
15.	Development of Optically Addressed Spatial Light Modulators for Photonics Applications	DRDO (IRDE)	22.798

Sl. No.	Title	Agency/Client	Amount Received (Rs.in Lakhs)
16.	R&D in Non-invasive Optical Fiber Probe Based Near-Infrared Spectroscopy (NIRS) for Accessing Brain Activity	DST	2.660
17.	Development of Piezoelectric Accelerometers for General Purpose Applications	M/S RCI/DRDO, Min of Def., Hyderabad	9.359
18.	Preparation of Long Decay Phosphor (LDP) and Adhesive Tape	DRDO, Jodhpur	4.655
19.	Monitoring of Green House Gases at Maitri-Antarctica	DOD, Goa	15.000
20.	Studies on Spatial-Coherence Spectral Filters and their Applications	DST	10.000
21.	Swift Heavy Ion Induced Mixing at the Interface	DST	3.900
22.	Development of Cholesterol Biosensors	Department of Biotechnology	16.100
23.	To Conduct Inter-Laboratory Proficiency Testing Amongst the NABL Accredited Calibration Laboratories in India	DST (NABL)	5.050
Total			157.505

Continuing Projects

Sl. No.	Title	Agency/Client	Amount Received (Rs.in Lakhs)
1.	Rain Characteristics and Estimation Using X-band Radar for Rain Attenuation in Microwave and Millimeter Bands	DST	2.750
2.	Role of Matrix Precursor in the Development of High Thermal Conductivity Carbon-Carbon Composites	Indo-UK	0.000
3.	Investigations aimed at Producing Stress Relieved Diamond Like Carbon Film of High IR Transmission (GA)	DST	2.000
4.	Research and Development on(a) Atomic Hydrogen Masers and (b) Precision Frequency Metrology (CP)	Indo-US	0.000
5.	Development of a Post Earthquake Rescue System by Wave CW Doppler Technique (GA)	DST	0.000

Sl. No.	Title	Agency/Client	Amount Received (Rs.in Lakhs)
6.	Development of an Acoustic Wind Profiler (with Multi Beam Acoustic array antenna) or Remote Atmospheric Wind Measurement (GA)	DST	6.000
7.	Programme of Technical Collaboration and Co-operation in Metrology with NIST (USA)	NIST	0.000
8.	Testing and Evaluation of a Superconducting Magnet for Making it Compatible unit FT-NMR Spectrometer	DST	0.000
9.	Development of Polymeric Optoelectronic Devices	INDO/UK FUND	0.000
10.	Development of an Automatic Self Locking NMR Gaussmeter	DST	0.000
11.	Interaction with Universities/Laboratories in the Area of Superconductivity	UGC	3.000
12.	Hydrogen Maser for VLBI Studies	NGRI, Hyderabad	0.000
13.	Fabrication and Supply of Underwater Pinger Unit	NSTL	0.000
14.	High Resolution X-ray Diffraction Imaging for Advanced Materials Characterization	Indo-US	0.000
15.	Development of HTSC RF SQUID Basic System Suitable for Operation at Liquid Nitrogen Temperature. (6 Nos)	DST	0.000
16.	On Line Determination and systematic Recording of Sugar Content in Sugarcane Juice and Sugarcane Solids	DST	0.000
17.	Laboratory Level Technology Development of some Biosensors and Related Bio-Materials	DST	0.000
18.	Measurement of Thermospheric wind and Temperature with Ground-Based Fabry-Perot Interferometer	DST	0.000
19.	Indian INDOEX Programme	ISRO/UCAR(USA)	36.847
20.	Deposition and Properties of Mixed Composition Infrared Optical Thin Films (GA)	DST	0.000
21.	Standardization of Techniques for Immobilization of Proteins and Enzymes in Conducting Polymers (CP)	Indo-US	0.000
22.	Development of the Beta Alumina Tubes for Sodium Metal Production	DAE (BRANS)	0.000

Sl. No.	Title	Agency/Client	Amount Received (Rs.in Lakhs)
23.	Continuous Measurement, Updating, Modelling and assessment of Greenhouse Gases	ME&F	0.000
24.	Ozone Over India - Change in the Past & Future (GA)	ME&F	0.000
25.	Development of Luminescent Screens i) Gaddinium Oxysulfide Based X-ray/Gamma Ray/Neutron Sensitive Phosphor Screens ii) Electro- luminescent Screens	DRDO	2.800
26.	Intensifying Screen; a New Dimension in X-ray Xerography (GA)	DST	0.000
27.	Carbon Composite Ring Based Ilizarov Fixator for Orthopaedic Application (GA)	DST	1.650
28.	Fabrication and Characterization of Real Time Image Processing Devices.	DRDO (DTSR)	0.000
29.	Total Spectral Reflectance, Total Spectral Transmittance and Spectral Emittance Study in the Infrared Region of Various Materials in Thin and Thick Films and bulk sample	Indo-Us	0.000
30.	A Major Upgradation of the Standard Time and Frequency Signal (STFS) Broadcast via INSAT Satellites	DAE (BRANS)	0.000
31.	SASCOM Activity as Meeting on Indo-genetic Plain Research Effort	Int. Start Secr.	0.000
32.	To Compose Monographs on Noise Pollution	DST	0.000
33.	Operation of the South Asian Regional Research Centre (SAS-RRC) for Study of Global Change Under SASCOM	Int. Start Secr.	10.330
34.	Surface Order and Structure Studies of Polymer Solid Interfaces	Indo-US	2.800
35.	To Improve Frequency Stability of Atomic Time and frequency Standards by Suppressing Quantum Noise Through Squeezed States	NIST	0.000
36.	A Study of Flare Triggering and Associated Hard X-ray Emissions and Other Flare -Related Phenomena for Modeling of Flares. (GD)	DST	0.000
37.	Asbestos Free Brake Material for Automobile Tailoring Characterization & Evaluation	DST	0.000
38.	A Study of QUAS; Horizontal and Vertical Transport of Air form Tropical Upper Troposphere and Stratosphere	ISRO	0.000
39.	Development of Carbon Monofilament Suitable for CVD-Based Sic Fibres	ARDB	0.000

Sl. No.	Title	Agency/Client	Amount Received (Rs.in Lakhs)
40.	Low Temperature Scanning Tunneling Microscopy and Spectroscopy of rare earth	DAE	0.000
41.	Development of Frequency Stabilized Diode Laser for Laser Cooling of Alkali atoms	DAE	2.090
42.	Development of High Thermal Conductivity Special Graphite for First Wall Components of SST-1 TOKAMAKIPR	(Ins. for Plasma Research.)	0.000
43.	Silica-on-Silicon Based Integrated Optic Components for Wavelength Division Multiplexing (WDM) Application (Part-I)	DOE	8.250
44.	Development of a Portable Analytical X-Ray Imaging Instrument for Biomaterials	DST	0.000
45.	Growing by MBE Method of Epitaxial structure on the Basis of Compound A"B" GaAs, Al In GaAs of Different Composition for Various Applications	Indo-Russia	0.000
46.	Feasibility Study on Various Petroleum Refinery Stream as Picture for High Performance Carbon Fibre	IOC	5.948
47.	To Develop 10 pF Capacitor Using ule Quartz for Use by Accredited Calibration Laboratory	DST	0.000
48.	Study of Doped Rare Earth Manganese Oxide Films for Enhorning 10W Field Magnetoresistane Effect	DST	0.000
48.	One Year Village Level Trial of Filter Tablet for Arsenic Removed From Ground Water	RGNDWM (Rajiv Gandhi National Drinking Water Mission)	0.000
50.	PBL Problems Over Antarctica	DOD	0.000
51.	Tetrahedral Amorphous Carbon (ta-c) Films Deposited by a Filtered Vacuum are Discharge (FVAD) technique	DST	0.000
52.	Budgeted Studies on Surface Layer in Relation to Turbulent Kinetic Energy Budgeting	DST	0.500
53.	Effect of Atmospheric CO ₂ Enrichment on Rice Varieties Grown Under Various Cropping Ecosystemsand their Biogenic Emission Using Several Open Top Chambers	APN (Asian Pacific Network)	16.000
54.	Planning Preparation and Dissemination of Certified Reference Materials for Quality Assurance in Analytical Measurements	DST (NABL)	5.000

Sl. No.	Title	Agency/Client	Amount Received (Rs.in Lakhs)
55.	Development of Oval Shape Tubes as Said Landing Gear for Advanced Light Helicopter (Phase II)	HAL	0.000
56.	Development of Porous Conducting Carbon Paper	NMRL	0.000
57.	Studies on Bio-Mass Burning and Related Trace Gas Emissions Using IRS-P3 Satellite Data	NRSA	1.200
58.	SROSS-C2 Satellite RPA Aeronomy Payload Data Management	ISRO	0.000
59.	Studies on Fog Occurrence on Delhi	CPCB (Central Pollution Control Board)	0.000
Total			107.165

Completed Projects

Sl. No.	Title	Agency/Client	Amount Received (Rs.in Lakhs)
1.	Studies on Potentialities of Glonass for Positioning and timing vis-à-vis Application of GPS	DOE-DRDO	3.025
2.	Development of Oval Shape Tubes as Said Landing Gear, for Advanced Light Helicopter-Phase-I	HAL (PSU)	0.000
3.	Transport Behavior of Strongly Corrected Electron Systems (GA)	DST	0.000
4.	Metallization of Fabrics as Shield Against Electromagnetic Interference	(EMI) ISRO	0.000
5.		DST	0.000
6.	Development of Titanium Fasteners Using Warm Forging	HAL	0.000
7.	Study of Droplet Dynamics and Heat Flow Characteristics during Spray Atomization and Deposition	DST	0.400
8.	Development of Ultrasonic Nebulising Spray System for Medical Application	DST	0.000
9.	Dimensional Metrology Co-ordinate Measurement	DST	0.000
Total			3.425
Grand Total			268.095

APPENDIX: 6

RECEIPTS THROUGH CONSULTANCY

Client	Title	Amount Received (Rs.in Lakhs)
M/s Sabero Organics Gujarat Ltd.	Inversion Monitoring at Vapi (Gujarat)	0.473
M/s Central Board of Irrigation & Power	Studying in the effect of AC/DC Magnetic Induction on the performance of various types of energy meters.	0.300
M/s Bharat Aluminium Co. Ltd.	General consultancy relating to characterization of coal tar pitched w.r.t. Mesophase	0.440
M/s AIMIL Pvt. Ltd. New Delhi	Instrumentation and Automation (Phase III)	0.500
M/s Thapar Institute of Energy & Technology P.B. No.32, Patiala	Establishment of a Hydraulic Pressure Calibration Laboratory	1.900
M/s Analog Devices India (Pvt.) Ltd. Bangalore	To optimize the performance of GPS Receiver for PTI application	0.300
CPWD, Ghaziabad	To remove the Stove Enamel Coating from Aluminium Samples received for chemical analysis.	0.150
M/s AIMIL Pvt. Ltd. New Delhi.	Instrumentation and Automation (Phase IV)	0.500
M/s NTPC Ltd.	Assistance in Synchronization to IST of the Computer system used for disturbance recording and event logging at S/Y control	5.100
M/s CMC Ltd.	Assistance in Synchronization to IST of the computer system used for disturbance recording and event logging at (MP State Electricity Board SLDC, Nayangaon, Jabalpur (2) CMC Centre Old Mumbai Highway, Gochibowli Hyderabad	8.483
Dept. of Lighthouses and Lightships	Consultancy with DGLL for commissioning DGPS System (Phase-II)	0.750
R&D Centre for Bicycle & Sewing m/c	Development of Calibration facilities and methodology in Dimensional Metrology	0.930
M/s ADTRANZ, New Delhi	Locomotive strain gauge and displacement measurements	4.624

Client	Title	Amount Received (Rs.in Lakhs)
M/s Si Tarc, Coimbatore	Consultancy in developing trained staff and calibration laboratory in the field of electrical, thermal and dimensions.	4.685
M/s AIMIL Pvt. Ltd. New Delhi	Instrumentation and Automation	0.500
M/s CMC Ltd.	The master clock and the Frequency counter at WRLDC Andheri, Mumbai to be modified in terms of hardware and software so as to give serial output in RS 232C protocol.	0.940
Total		30.575

APPENDIX: 7

EARNINGS FROM CALIBRATION / TESTING

Activity	Gr. Code	Reports	Charges (Rs.)
<i>Calibration</i>			
I Physico-Mechanical Standards			
Length Standards	1	30	393050
Dimensional Metrology	2	707	3608700
Mass, Density, Volume & Viscosity	3	548	2017450
Force & Hardness Standards	4	473	3497700
Pressure & Vacuum Standards	5	175	2384700
Temperature Standards	6	405	1734700
Optical Radiation Standards	7	257	1432200
UV Radiation Meas. Standards	8	8	25700
IR Radiation Standards	9	6	43000
Acoustics Standards	10	142	658950
Ultrasonic Standards	11	10	187100
Humidity Standards	12	26	60500
Fluid Flows Standards	13	4	37600

Total	2791	16081350
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II Electricals & Electronics Standards

AC & LF Standards Power / Energy	20	387	2378250
AC & LF Standards (CT / PT)	21	75	861600
D.C. Standards	22	57	487600
HF & Microwave Attenuation and Impedence Standards	23	10	129200
LF & HF Impedence Standards	24	71	344200
HF & Microwave Standards of Power, Voltage, Frequency & Noise	25	52	1003200
Magnetic Measurement Activity	26	11	44500
Time & Frequency Standards	27	39	388600

Total	702	5637150
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Activity	Gr. Code	Reports	Charges (Rs.)
<i>Testing</i>			
Material Characterisation	30	1	1500
Chemical Analysis	31	53	591700
Indian Referance Material	32	22	184500
Electron Microscopic Analysis	34	9	96000
Carbon Technology	42	1	2400
Metal & Alloys Group	43	11	23000
Electric Engineerings	45	6	40400

Total		103	939500
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Job Work

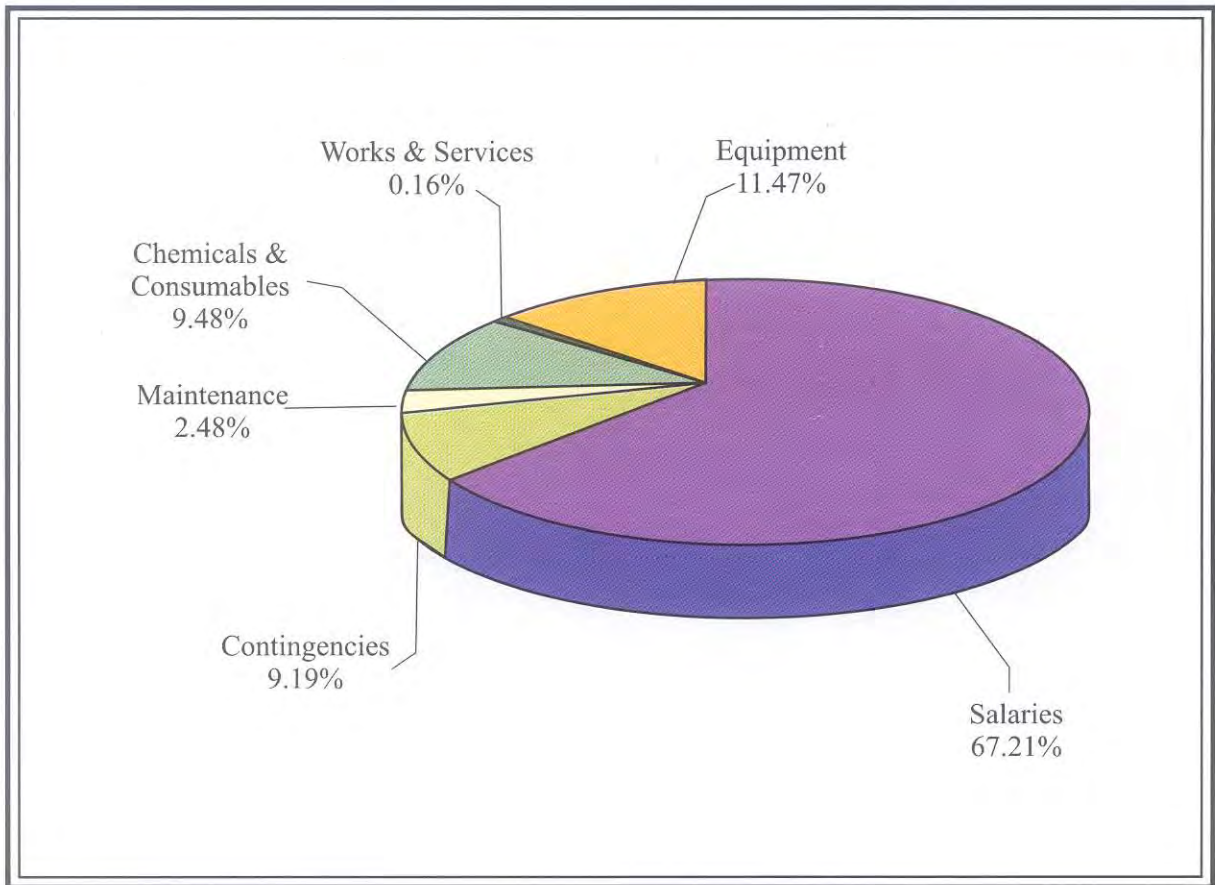
Piezoelectric Accelarometer	46	2	49800
Central Workshop	47	7	12400

Total		9	62200
Grand Total		3605	22720200

APPENDIX: 8

ACTUAL EXPENDITURE

Budget Head	Rs. in Lakhs
Salaries (Pay & Allowances)	1753.607
Contingencies	239.813
Maintenance	64.823
Chemicals and Consumables	247.420
Works & Services	4.149
Equipment	299.310
Total	2609.122
Sponsored Projects	229.077



APPENDIX: 9

HONOURS & AWARDS

Physico - Mechanical Standards

Dr. V. Mohanan, Scientist F:

Re-elected as General Secretary, Acoustical Society of India, 2001-2002.

Dr. Santa Chawla, ScE-I

Honored as one of the '2000 Outstanding Scientists of 21st Century' by International Biographical Centre, Cambridge, First Edition, England.

Included in Who's Who in Science and Engineering, 6th Edition, Marqui's, USA

Dr. A.K. Bandyopadhyay, Sc F

Member, TCM MRA Review Working Group of APMP and CCM Working Group on High Pressure and Medium Pressure.

Sh. Subodh Kumar Singh, Sc. EII

Received appreciation letter from ISRO Satellite Centre for the Piezoelectric Accelerometer indigenously developed by him.

Conferred honorary appointment to the Research Board of Advisors 2001, by the American Biographical Institute.

Tripurari Lal, Sc. E-II

Member, Standing Advisory Committee on Preparation of Specifications of Weights and Measuring Instruments, Department of Legal Metrology, Ministry of Food and Consumer Affairs, Govt. of India.

Dr. Ashok Kumar, Sc. F

Conferred the honour of Chief Editorship of *Journal of Acoustical Society of India*.

Electrical & Electronic Standards

Dr Ashok K. Gupta, Sc. G

Elected as Vice-President, Metrology Society of India
Served as Secretary, Indian Cryogenic Council (North Zone)

Member, Editorial Board, *Indian Journal of Cryogenics*

Dr. V.R.Singh, Sc. G

Served as a Member of IPC (International Program

Committee), IEE International Conf on Medical Signals & Information Processing (MEDSIP-2000), Bristol, UK, Sept 4-6, 2000.

Member, Editioal Review Committee of IEEE Trans on Instrumentation and Measurements (USA). and now elected as Associate Editor.

Re-elected as Chairman of Fellowship & Awards Committee, IEEE- Delhi.

Member of the Senate, Thapar Institute of Engg. & Tech., Patiala

Vice-Chairman of IFUMB (Ind Fed Ultr Med Biolog), Delhi.

Zonal Member, Indian College of Medical Ultrasound, Mumbai.

Re-elected as Vice-President, Ultrasonic Society of India.

Elected on executive councils of NAFEN , IEEE-Delhi, and Metrology Society of India.

Continues to serve on Research Degree Committees of University of Delhi (Faculty of Technology), GND Univ, Amritsar and CCS Univ, Meerutt.

Member, Board of PG Studies, Faculty of Science, Kurukshetra University.

Member, Board of Studies (Electronics Engg), Instt. of Technology, Banaras Hindu Univ, Varanasi.

Member, International Advisory Committee, CERA-2001 (Int Conf on Computers in Elect Engg), Univ of Roorkee (now IIT-Roorkee)

Dr P. Banerjee, Sc. G

Associate Editor, (Commission A), *Radio Science Bulletin*, URSI, Belgium

Served as Director of SERC School on Precision Physical Measurement and Measurement Science

Dr A. Sen Gupta, Sc. F

Elected as a Fellow of the National Academy of Sciences, Allahabad.

Elected a Senior Member, IEEE, USA.

Engineering Materials

Dr. Anil K. Gupta, Sc G

Member, "National Task Force on Down Stream Processing of Aluminium" of Jawahar Lal Nehru Aluminium Research & Design Centre, Nagpur, from April 2000.

Member, International Advisory Committee of "7th Asian Symposium on Precision Forging", Guilin, China, Organized by Forging & Stamping Institute of CMES, China, October, 2000

Member, National & International Advisory Committee of "3rd International Conference on Advances in Composites" (ADCOMP 2000), Bangalore, Aug.24-26, 2000.

Materials Characterization

Dr. Krishan Lal, Director

Re-elected as President, Metrology Society of India for 2000-2002.

Elected as Executive Member, ICSU Committee for Data in Science and Technology (CODATA), 2000-2002.

Member, Task Group on Data Sources in Asia Oceanic region of the CODATA (an ICSU Body), 2000-2002.

Vice President, Indian Crystallography Association, 2000-2003.

Council Member, Asian Crystallography Association, 1999-2002.

Member, Task Group on Materials Data Management of CODATA, 1990-2002.

Has been appointed Director, National Physical Laboratory, New Delhi w.e.f 1st October, 2000

Dr. A.K. Sarkar, Sc. F

Conferred honorary appointment to the Research Board of Advisors 2001, by the American Biographical Institute, USA

Honored with Outstanding Professional Award in Analytical Chemistry by American Biographical Institute, USA

Dr. A.K. Agrawal, Sc. E-II

Conferred honorary appointment to the Research Board of Advisors 2001, by the American Biographical Institute, USA

Radio & Atmospheric Sciences

Shri S. C. Garg, Sc. G

Member, Research Council, Central Scientific Instruments Organisation

Dr. S. L. Jain, Sc. F

Member, Programme Committee, SPIE's Second International Asia-Pacific Symposium on: Remote Sensing of the Atmosphere, Environment, and Space held during 9 - 12 October 2000 at Sendai International Ctr., Sendai, Japan.

Listed in the International Directory of Distinguished Leadership by American Biographical Institute, Inc.

Biography included in Marquis Who's Who in the World

Member, Steering Committee on LIDAR project constituted by Department of Electronics, Govt. of India.

Dr. D. R. Lakshmi, Sc. G

Member, Programme Advisory Committee (PAC) of Atmospheric Sciences, DST

Member, National Committee of SCOSTEP (INCOSTEP)

Member, Research Advisory Committee (RAC) of Indian Institute of Geomagnetism, Bombay

Leader, Working Group on the International Environmental Services (ISES), Boulder, USA. (upto Aug. 2001)

Superconductivity & Cryogenics

Dr. S.K. Agarwal, Scientist EI

Invited as a Visiting Professor at the Science University of Tokyo, Noda, Chiba, Japan during October 2000 to January 2001

Has been appointed as the Ph D. Examiner at Anna University, Chennai.

APPENDIX: 9

HONOURS & AWARDS

Physico - Mechanical Standards

Dr. V. Mohanan, Scientist F:

Re-elected as General Secretary, Acoustical Society of India, 2001-2002.

Dr. Santa Chawla, ScE-I

Honored as one of the '2000 Outstanding Scientists of 21st Century' by International Biographical Centre, Cambridge, First Edition, England.

Included in Who's Who in Science and Engineering, 6th Edition, Marqui's, USA

Dr. A.K. Bandyopadhyay, Sc F

Member, TCM MRA Review Working Group of APMP and CCM Working Group on High Pressure and Medium Pressure.

Sh. Subodh Kumar Singhal, Sc. EII

Received appreciation letter from ISRO Satellite Centre for the Piezoelectric Accelerometer indigenously developed by him.

Conferred honorary appointment to the Research Board of Advisors 2001, by the American Biographical Institute.

Tripurari Lal, Sc. E-II

Member, Standing Advisory Committee on Preparation of Specifications of Weights and Measuring Instruments, Department of Legal Metrology, Ministry of Food and Consumer Affairs, Govt. of India.

Dr. Ashok Kumar, Sc. F

Conferred the honour of Chief Editorship of *Journal of Acoustical Society of India*.

Electrical & Electronic Standards

Dr Ashok K. Gupta, Sc. G

Elected as Vice-President, Metrology Society of India
Served as Secretary, Indian Cryogenic Council (North Zone)

Member, Editorial Board, *Indian Journal of Cryogenics*

Dr. V.R. Singh, Sc. G

Served as a Member of IPC (International Program

Committee), IEE International Conf on Medical Signals & Information Processing (MEDSIP-2000), Bristol, UK, Sept 4-6, 2000.

Member, Editorial Review Committee of IEEE Trans on Instrumentation and Measurements (USA). and now elected as Associate Editor.

Re-elected as Chairman of Fellowship & Awards Committee, IEEE- Delhi.

Member of the Senate, Thapar Institute of Engg. & Tech., Patiala

Vice-Chairman of IFUMB (Ind Fed Ultr Med Biolog), Delhi.

Zonal Member, Indian College of Medical Ultrasound, Mumbai.

Re-elected as Vice-President, Ultrasonic Society of India.

Elected on executive councils of NAFEN , IEEE-Delhi, and Metrology Society of India.

Continues to serve on Research Degree Committees of University of Delhi (Faculty of Technology), GND Univ, Amritsar and CCS Univ, Meerutt.

Member, Board of PG Studies, Faculty of Science, Kurukshetra University.

Member, Board of Studies (Electronics Engg), Instt. of Technology, Banaras Hindu Univ, Varanasi.

Member, International Advisory Committee, CERA-2001 (Int Conf on Computers in Elect Engg), Univ of Roorkee (now IIT-Roorkee)

Dr P. Banerjee, Sc. G

Associate Editor, (Commission A), *Radio Science Bulletin*, URSI, Belgium

Served as Director of SERC School on Precision Physical Measurement and Measurement Science

Dr A. Sen Gupta, Sc. F

Elected as a Fellow of the National Academy of Sciences, Allahabad.

Elected a Senior Member, IEEE, USA.

APPENDIX: 10

VISITS ABROAD

Name	Country	Duration	Programme
Dr. K. Lal Sc., Director Grade	France	4-7 April 2000	To Attend the 6 th Meeting of CCQM at BIPM at Serves, Paris, France
Dr. R.B. Mathur Sc. E-II	U.K	4 April 2000 (2 months)	To do research at University of Leeds under U.K.-INDIA, S & T Research Fund Co-operation Programme
Dr. K.K. Jain Sc. E-II	U.S.A.	10 April 2000 (6 months)	To carry out R & D work with Dr. Albert Lee on sabbatical leave
Prof. A.K. Raychaudhuri, Former Director	Saudi Arabia	15-17 April 2000	To discuss, review and renew the programme of co-operation in the area of metrology and standards.
Dr. B.S. Mathur Sc. G	Saudi Arabia	15-17 April 2000	To discuss, review and renew the programme of co-operation in the area of metrology and standards.
Dr. Mahesh Chander Sc. F	Saudi Arabia	5 June 2000 to 15 Dec. 2000	To act as Coordinator for CSIR SASO Technical Co-operation Programme at SASO.
Dr. V.N. Ojha Sc. E-II.	Singapore	7-9 June 2000	On equipment training by Fluke Company
Sh. Ajeet Singh Sc. C.	Singapore.	7-9 June 2000	On equipment training by Fluke Company
Sh. H.K. Maini Sc. E-I	Japan	24 June 2000 to 1 July 2000 E.L.2-7 July 2000	To attend the Face 2000 Conference.
Dr. A.K.Srivastava Sc. B	Singapore	26-30 June 2000	Attend the 7 th Asia Pacific Electron Microscopic Conference.
Dr S. K. Singhal Sc. E-II	Germany	1-31 July 2000	Under DST-DAAD Project based Personnel Programme Exchange Programme for 2000-2002. To work on the joint project "Low Pressure Synthesis of Cubic "Boron Nitride Using Super Critical Fluids"
Dr. Rajeev Chopra Sc. E-I	Germany	1-31 July 2000	Under DST-DAAD Project based Personnel Exchange Programme for 2000-2002. To work on the joint project "Low Pressure Synthesis of Cubic Born Nitride using Super Critical Fluids".
Dr. S.L. Jain Sc. F	Japan	3-8 July 2000	To attend the Quad-Recial Ozone Symposium 2000

Name	Country	Duration	Programme
Dr. Jayant Kar Sc. E-I.	Poland	16-23 July 2000	To attend the 33 rd Committee on Space Research Scientific Assembly (COSPAR)
Dr. R.S. Dabas Sc. E-II.	U.K.	1 October 2000 to 31 July 2001	Leverhulme Trust Visiting Fellowship in the Department of Physics, University of Wales, U.K. for a period of six months on EOL under GIMHA.
Sh J.K. Gupta T.O.C	Sri Lanka	4-6 October 2000	To hand carry SPRT and discuss the technical details of the intercomparison under APMP International Intercomparison.
Dr.S.K. Agarwal Sc. E-I	Japan	6 October 2000 (3 months)	To visit the Science University of Tokyo, Japan for a period of three months on grant of leave due & admissible.
Dr S.L. Jain Sc. F	Japan	9-16 October 2000	<ol style="list-style-type: none"> 1. To attend 2nd International Asia Pacific Symposium on Remote Sensing of the Atmospheric environment and Space at Sendei, Japan 9-12 Oct. 2000. 2. To attend 2nd International Workshop on Radar and Lidar Remote Sensing Technology in Asia at Tokyo, Japan on 13 October 2000 3. To visit National Institute of Polar Research at Tokyo, Japan on 16 October 2000.
Dr Krishan Lal Sc. Director Grade	France	15-18 Oct. 2000	To attend the 125 th anniversary of the Metre Convention at BIPM, Paris
Dr. Rama Devi Ramachandran Sc. E-II	U.S.A.	17-22 Oct. 2000 E.L. 23-28 Oct. 2000.	<ol style="list-style-type: none"> 1. To attend the Berm-2000 Int. Conference at U.S.A., from 17-22, Oct. 2000] 2. To meet friends and relatives from 23-28 Oct. 2000 on E.L.
Dr P. Banerjee Sc. F	Japan	30 October 2000 to 2 November 2000	To attend Asia pacific Time & Frequency Workshop (ATF -2000)
Dr T. L. Dhami Sc. E-II	U.K.	3 Nov. 2000 to 30 Dec. 2000	To visit University of Leeds, U.K. under Joint Indo-UK Collaboration Research Project on "Role of Matrix Precursor in the Development of High Conductivity Carbon Carbon Composites".

Name	Country	Duration	Programme
Dr. Jayant Kar Sc. E-I.	U.S.A.	6. Nov. 2000 to 31 July 2001.	Fellowship Grant, EOL, Under GIMHA to work as Research Associate at the University of Arizona, U.S.A.
Dr. P.K. Ashwini Kumar Sc. E-II	Switzerland The Netherlands & U.S.A.	06-07 Nov. 2000 08-17 Nov.2000 18-21 Nov. 2000	1. To attend WIPRO/ERO Training Seminar on Administrative Issues in the Patent & Trade Mark Procedures at Switzerland 2. 08-17 Nov. 2000 at Hague, The Netherlands 2. 18-21 Nov. 2000 to U.K. for personal reasons on E.L.
Dr S.P. Varma Sc. F	Thailand	6-11 Nov. 2000	To attend the 16 th APMP General Assembly & Workshop
Sh Arun Kumar S.T.A	Poland	07 Nov. 2000 (One month)	To visit for the Immobilization of Enzymes for Fabrication of Biosensors Under the Collaborative Project "Synthesis and Properties of Conducting Polymers for Biosensors" under Indo-Polish Inter-Governmental S & T Agreement.
Sh Prabhat Kumar Gupta Sc. E-II	Thailand	14 Nov. 2000 to 16 Dec. 2000	To visit under the Bilateral programme of CSIR & Collaborative under NPL Contract Project "Studies on Emission from Bio-Mass Combustion in Corkstoves"
Dr Anil K Gupta Sc. F	Japan	19 Nov. 2000 to 7 Dec. 2000	To visit Mechanical Engineering Laboratory, Tsukuba, Japan under CSIR-DIST Co-operation
Dr Rajeev Chopra Sc. E-I	Japan	19 Nov. 2000 to 7 Dec. 2000	To visit Mechanical Engineering Laboratory, Tsukuba, Japan under CSIR-DIST Co-operation
Dr K.L. Yadav, Sc.B.	USA	03 Jan. 2001 to 02 Jan 200203 Jan. 2001 to 02 Jan 2002	Boyscast Fellowship offered by DST to carry out research work at Materials Research Laboratory, Pennsylvania State University, USA for a period of one year
Sh M.K. Chaudhuri, Sc. E-II	Germany	20 Jan. 2001 to 04 Feb. 2001	To carry out Intercomparison of Force standard of range 1MN
Sh. Prabhat Kumar Gupta Sc. E-II	China	25-27 Feb. 2001	To participate in the International Workshop on CHG Emission from Rice Fields in Asia in Nonjing, China

Name	Country	Duration	Programme
Dr Krishan Lal Director	USA	5-8 March 2001	To attend the meeting of Directors of NMIs (BIPM) and to participate in the Centenary celebrations of NIST, USA.
Dr. A.K. Srivastava Sc. B	France	20 March 2001 to 19 March 2002	Boyscast Fellowship offered by DST to carry out research work at University of Paris, France for a period of one year
Dr. A.C. Gupta Sc. F	Japan	12-17 March 2001	To visit National Research Laboratory of metrology in USA, Japan to attend APMP Pressure Vacuum Meeting

APPENDIX-11

Ph.D. AWARDS BASED ON RESEARCH WORK DONE AT NPL

Title	Awardee	University/Institute	Guides
Investigation of materials under high pressure metrological applications	Dhrambir Singh	Jamia Millia Islamia Delhi	Dr. A. K. Bandyopadhyay
Studies on high temperature superconductors	Arvind Pandey	University of Rajasthan	Dr. R. G. Sharma and Dr. I. P. Jain (Univ. of Rajasthan)
Magnetic transport properties of high T _c cuprate superconductors doped with 3d transition metals and rare earth elements.	Rajvir Singh	Jamia Millia Islamia Delhi	Dr M. Shahabuddin (JMI) and Dr A.V. Narlikar
A study of the tropical E-region fieldaligned irregularities using Indian MST radar	Raj Kumar Choudhary	University of Delhi	Dr. K.K. Mahajan and Dr. O.P. Nagpal (Delhi Univ.)
Study of gravity waves, Kelvin-Helmholtz instability and turbulence using Indian MST radar	Sachchidanand Singh	University of Delhi	Dr. K.K. Mahajan and Dr. O.P. Nagpal (Delhi Univ.)
Stratosphere - troposphere interchange of chemically active minor species	Tuhin Kumar Mandal	University of Delhi	Dr. A.P. Mitra and Dr. O.P. Nagpal (Delhi Univ.)
Photovoltaic properties of large area silicon solar cells and luminescence and surface morphology studies of porous silicon.	Kuastav Chakrabarty	BITS, Pilani	Dr S.N. Singh

APPENDIX-12

TRAINING PROGRAMMES ORGANISED & NPL PARTICIPATION IN VARIOUS EVENTS

Training Programmes/Functions organized

- CSIR Foundation Day Celebration on 26 Sep. 2000.
- SERC School on Condensed Matter Physics & Material Science during 4-12 Dec. 2000
- CSIR Programme for Youth Leadership in Science (CPYLS) during 9-10 Jan. 2001.
- Around 30 students from various educational institutions carried out projects and received training towards the fulfillment of their degrees, during their vacation periods.

Training Courses Organized for Industry

- Training Course on Dimensional Metrology on 24-25 April 2000
- Training Course on Mass Metrology on 10-14 July 2000
- Training Course on Dimensional Metrology on 13-17 Nov. 2000

Participation of NPL Staff in Various Events

- Around 200 persons were deputed to participate in various seminars / symposia / conferences / training programmes held within India.

CSIR Examination

- Coordinated CSIR-UGC NET Examination at Delhi Center on 25 June 2000
- Coordinated CSIR Limited Departmental Examination 2000 for Administrative Posts at Delhi Centre during 17-20 August 2000

Post Graduate Dissertation work Completed at NPL

- V.R.Singh and P.P.Pathak (supervisors), "Ultrasonic Therefore Amplifier used in Receiver side of a Pulse Generator", M.Sc (Physics) dissertation by A.K.Verma, Gurukul Kangri Vishwavidyalaya, Hardwar, May, 2000.
- V.R.Singh and P.P.Pathak (supervisors), "Ultrasonic RF Generator used in Transmitter side of Biomedical Equipment", M.Sc (Physics) dissertation by Vineet Saxena, Gurukul Kangri Vishwavidyalaya, Hardwar, May, 2000.
- V.R.Singh and Ms Hilda Mayrose (supervisors), "Thermal Profile Monitoring System under Focussed Ultrasound for Tumour Therapy, M.Tech (Biomedical Engg) dissertation by Ms Sweta Shalinee, Manipal Institute of Technology, Manipal, 2001.

APPENDIX-13

CONFERENCES, SYMPOSIA AND WORKSHOPS ORGANISED BY NPL

26-27 April 2000

Workshop on Recent Trends on Electron Microscopy organized at Shillong

20 May 2000

World Metrology Day & 125 Years of Metre Convention

10-13 October 2000

International Tropical Environmental Problem Workshop organized by NPL under the INDOEX Programme and held at IHBT, Palampur

8 December 2000

One Day Workshop on 'Nano-phase Materials' at NPL, New Delhi

8-10 February 2001

3rd International Conference on Metrology in New Millennium and Global Trade held at NPL, New Delhi

26-28 February 2001

International Workshop on Preparation and Characterization of Technologically Important Single Crystals held at NPL, New Delhi.

29 March 2001

A brain Storming session was organized on "Remote Sensing of Atmosphere Using Lasers" with Keynote address by Prof. S.K. Sharma, Prof. & Assoc. Director, Hawai Institute of Geophysics & Planetology, Honolulu, U.S.A.

APPENDIX: 14

SPECIAL LECTURES BY GUEST SPEAKERS

S. No	Name	Date	Topic
1.	Mr. Sam Kaushik M/S Alliance Canada, Ontario, Canada	19 May 2000	Opportunities for Professionals in Canada.
2.	Prof. A.R.Verma Ex-Director, N.P.L.	29 Sept. 2000	What does N.P.L. Stands For ?
3.	Dr. Beata Miksa Centre of Molecular & Macromolecular Studies, Sienkiewicza, Ludz, Poland	3 Oct. 2000	Immobilization of Glucose Oxidase & Urease on Conducting Polyrole Micro-Spheres.
4.	Dr. W. Takasima Kyushu Institute of Technology, Lizuka, Japan.	23 Oct. 2000	Electronic Characteristics for the Application of Polythiophene.
5.	Dr. (Mrs.) Renu Sharma Senior Research Scientist, Electron Microscopy Facility, Centre for Solid State Science Arizona State University, Tempe, Arizona, USA	22 Nov. 2000	Studies on Reaction Mechanisms using Transmission Electron Microscopy.
6.	Dr. R. Chidambaram Former Chairman Atomic Energy Commission.	13 Dec. 2000	Importance of Nuclear Energy.
7.	Prof. R. Shashidhar Naval Research Laboratory U.S.A.	22 Dec. 2000	New Advances in Materials for Liquid Crystal Displays.
8.	Prof. V.G. Mokerov Russia.	9 Jan. 2000	New Hetrostructure - Quantum Transistor.
9.	Prof. A.J. Pozela Russia.	9 Jan. 2001	New Type of X-Ray Detector.
10.	Prof. Steven T. Walsch Director, Technological Entrepreneurship Programme University of New Mexico	10 Jan. 2001	Focus on Technology management and IPR
11.	Prof. Phil Warner Biotechnology Centre Cranfield Institute of Technology, Cranfield, U.K.	6 Feb. 2001	Cranfield in Diagnostics
12.	Prof. R. Dalal Iowa State University, USA	12 March 2001	Recent Trends in the Amorphous Silicon Photovoltaics
13.	Dr. Sreve Appleyard Department of Materials Science, University of Leeds, U.K.	30 March 2001	High Thermal Conductivity Carbon Carbon Composites - New Measurement Techniques and Modelling

APPENDIX: 15

INVITED TALKS, LECTURES BY NPL SCIENTISTS

Speaker's Name	Topic	Event/Venue
Dr Krishan Lal, Director	Traceability in accurate measurement and certified reference materials	National Seminar on Reference Materials - A mandatory requirement under Quality Systems, India International Centre, New Delhi (2000)
Dr Krishan Lal, Director	Certified reference materials: Current status and trends	Seminar on World Metrology Day and 125 Years of Metre Convention, National Physical Laboratory, New Delhi (2000)
Dr Krishan Lal, Director	Structural characterization of thin films and interfaces of advanced materials	XXX National Seminar on Crystallography, Tirupati (2000). (Lecture in honour of Prof. A.R Verma)
Dr. S.P. Varma, Sc F	Infrared measurement techniques	SERC School on Precision Physical Measurement Science, National Physical Laboratory., New Delhi, December 13, 2000
Dr. S.P. Varma, Sc F	Length standards in NPL	CSIR Programme on Youth Leadership in Science (CPYLS)", National Physical Laboratory, New Delhi, January 10, 2001.
Dr. S.P. Varma, Sc F	Physico-mechanical standards of NPL	Sixth CIMET - NAM - NPL Training Programme on Metrology, Quality Assurance and Global Trade, National Physical Laboratory, New Delhi, January 22 - February 2, 2001.
Dr. S.P. Varma, Sc F	Physico - mechanical standards at NPL: An Overview.	3 rd International Conference on Metrology in New Millennium and Global Trade (MMGT 2001), National Physical Laboratory, New Delhi, Feb. 8 - 10, 2001.
Dr. S.P. Varma, Sc F	Global MRA: A Discussion	National Workshop on Measurement Arrangement and Quality Assurance, National Physical Laboratory., New Delhi, March 14 - 15, 2001.
Dr. S.P. Varma, Sc F	APMP 16 th General Assembly	APMP 16 th General Assembly General Body of Standards Division, National Physical Laboratory, New Delhi, January 16, 2001.

Speaker's Name	Topic	Event/Venue
Dr. R.P. Singhal, Sc G	Traceability and calibration interval	8 th Quality Summit Conference, Building Capabilities in Measurement, Confederation of Indian Industry, Bangalore, 18 th Nov.,2000.
Dr. R.P. Singhal, Sc G	Aspects of dimensional metrology	Sixth NAM-CIMET-NPL Training Programme, National Physical Laboratory, New Delhi, 22 January - 2 February 2001.
Dr. R.P. Singhal, Sc G	Proficiency testing : comparison of gauge blocks	National Workshop on Inter-Laboratory Confederation of Indian Industry, (CII), New Delhi., 12-13 th March, 2001.
Dr. R.P. Singhal, Sc G	Modern trends in metrology and testing	ISO:9000 and Calibration, Regional Engineering College, Surathkal, Karnatka, 9 th April, 2000
Dr. R.P. Singhal, Sc G	Uncertainty in dimensional calibration : Beginners guide	National Test House, Parliament Street, New Delhi, 18-07-2000.
Dr. R.P. Singhal, Sc G	Building capabilities in measurement	Traceability and Calibration Interval. 8 th Quality Summit Conference, Confederation of Indian Industry, Bangalore, 18 th Nov.,2000.
Mr A.C. Gupta, Sc G	Pressure and vacuum standards at NPL and their international compatibility	1st APMP Pressure/Vacuum Workshop Meeting & Symposium 2001, NRLM, Japan, 13 - 16 March 2001.
Mr A.C. Gupta, Sc G	High pressure and low pressure (vacuum) measurements	SERC School on Precision Physical Measurements and Measurement Science, National Physical Laboratory, New Delhi, Dec. 4 -23, 2000.
Mr A.C. Gupta, Sc G	Mutual Recognition Arrangement and key comparisons	Sixth NAM-CIMET-NPL training Program during National Physical Laboratory, New Delhi, Jan. 1-2, 2001.
Dr Janardan Singh, Sc F	Recent development in characterization of materials by ultrasonic techniques	Tenth National Symposium on Ultrasonics (X-NSU), Department of Physics, Osmania University, Hyderabad, March 15-16, 2001.
Dr Ashok Kumar, Sc F	Futuristic ultrasonic transducers for NDE	National Seminar - NDE 2000, Calcutta, December 14-16, 2000
Shri Tripurari Lal, Sc E-II	Mass metrology and calibration of weights	SERC School on Precision Physical Measurement and Measurement Science, National Physical Laboratory, New Delhi, Dec. 13, 2000.

Speaker's Name	Topic	Event/Venue
Shri Tripurari Lal, Sc E-II	Mass metrology	CIMET-Group Training Programme, National Physical Laboratory, New Delhi, Feb. 2001.
Shri Tripurari Lal, Sc E-II	Inter-laboratory proficiency testing- Case study in mass	National Workshop on Inter-Laboratory Proficiency Testing - March 2001.
K.P. Chaudhary, Sc E-II	Non-contact dimensional measurement	Sixth NAM-CIMET-NPL training Programme, National Physical Laboratory, New Delhi, 22 nd January - 2 February 2001.
Dr A.K. Bandyopadhyay, Sc F	Uncertainty of measurements	NABL Workshop on ISO/IEC 17025 and Uncertainty in Measurements, India International Center, New Delhi, 26 th September, 2000.
Dr A.K. Bandyopadhyay, Sc F	Uncertainty of measurements: New NABL criteria	NABL Assessors' Conclave, NABL, Jamia Hamadrad Convention Centre, New Delhi, May 29-20, 2000.
Dr A.K. Bandyopadhyay, Sc F	Raman Spectroscopy and its various applications including high pressure studies up to 20 GPa.	Seminar on " Latest Trends in Raman Spectroscopy', Hotel le Meridian, New Delhi, November 17, 2000.
Dr A.K. Bandyopadhyay, Sc F	Model calculation for estimation of uncertainty in measurements	SERC School, National Physical Laboratory, New Delhi, 8 th December 2000.
Dr A.K. Bandyopadhyay, Sc F	Pressure standard - An establishment of the National practical scale up to 500 Mpa	NAM-NPL Joint Workshop, National Physical Laboratory, New Delhi, 25 th January 2001.
Dr A.K. Bandyopadhyay, Sc F	Uncertainty as applied to measurement of pressure/vacuum.	NABL Workshop on ISO/IEC 17025 and Uncertainty in Measurements, Sophisticated Test and Instrumentation Center, Kochi University, Kochi, Kerala, 23 -24 February 2001.
Dr P. Banerjee, Sc G	Time in WAAS	GNSS Workshop (ICAO), Asho Hotel, New Delhi, 13-14 October, 2000.
Dr P. Banerjee, Sc G	GPS timing and applications	National Seminar on Advances in GPS Technology and its Application Potential, HAL Staff College, Bangalore, 24.11.2000.
Dr P. Banerjee, Sc G	GPS: Its potentiality and its applications	New Millennium All India Police Wireless Meet 2001, Chandigarh, 21-23 Feb. 2001.

Speaker's Name	Topic	Event/Venue
Dr V.R. Singh, Sc G	Sensors and transducers in telemedicine	Technical Workshop on Biomedical Instrumentation, IETE, New Delhi, Feb 17, 2001.
Dr V.R. Singh, Sc G	Mobile ultrasonic lithotripters: evolution in lithotripters	National Conf. on Biomedical Engg., Roorkee, April 21-22, 2000.
Dr V.R. Singh, Sc G	A smart biomedical sensor for monitoring pressure amplitudes of kidney stone	8 th National Seminar on Physics & Technology of Sensors (NSPTS-8), Kalpakkam, Feb 27-March 1, 2001.
Dr V.R. Singh, Sc G	Recent advances in smart sensors	National Conference on Materials and Semiconductor Technologies in Electronic Research, Pantnagar, Nov 8-10, 2000.
Dr S M Shivaprasad, Sc E-I	Structure of solid surfaces to atomic resolution	Seminar on "Probing Atomic Surfaces: Characterization of Solid Surfaces, Indian Institute of Technology (IIT), Delhi, on 15 th Sept. 2000.
Dr S M Shivaprasad, Sc E-I	Probing surfaces with atomic resolution.	Dept. of Physics, S.B. College, Gulbarga University, Gulbarga, , on 26 th Dec. 2000.
Dr S M Shivaprasad, Sc E-I	Surface Modifications in Heteroepitaxial Growth	Workshop on "In-situ Studies of Surface Modifications by Swift Heavy Ions, Nuclear Science Centre, New Delhi, on 16 th June 2000.
Dr S M Shivaprasad, Sc E-I	Seeing Surface Atoms: An Introduction to STM	Dept. of Physics, Jamia Millia Islamia, Delhi, in March 2000.
Sh. S. C. Garg, Sc G	Space payloads: Design & fabrication considerations	Presidency College, Calcutta, May 5, 2000.
Sh. S. C. Garg, Sc G	Recent developments in space sciences, Indian scenario	National workshop on Recent Developments in Atmospheric and Space Science, Dept. of Physics, Univ. of Roorkee, Roorkee, 19-21 March 2001 '.
Dr. D.R. Lakshmi, Sc G	RWC and short term forecasting activities	Workshop on Space Weather and ACE Real Time Data', ISRO, Bangalore, 25 April 2000
Dr. D.R. Lakshmi, Sc G	Tropical Ionosphere - Radio communications	R & T Unit for Navigational Electronics, Osmania University, Hyderabad, September 2000
Dr. D.R. Lakshmi, Sc G	Space weather issues relevant to India	Meeting on National Space Weather Programme, ISRO, Bangalore, March 2001.

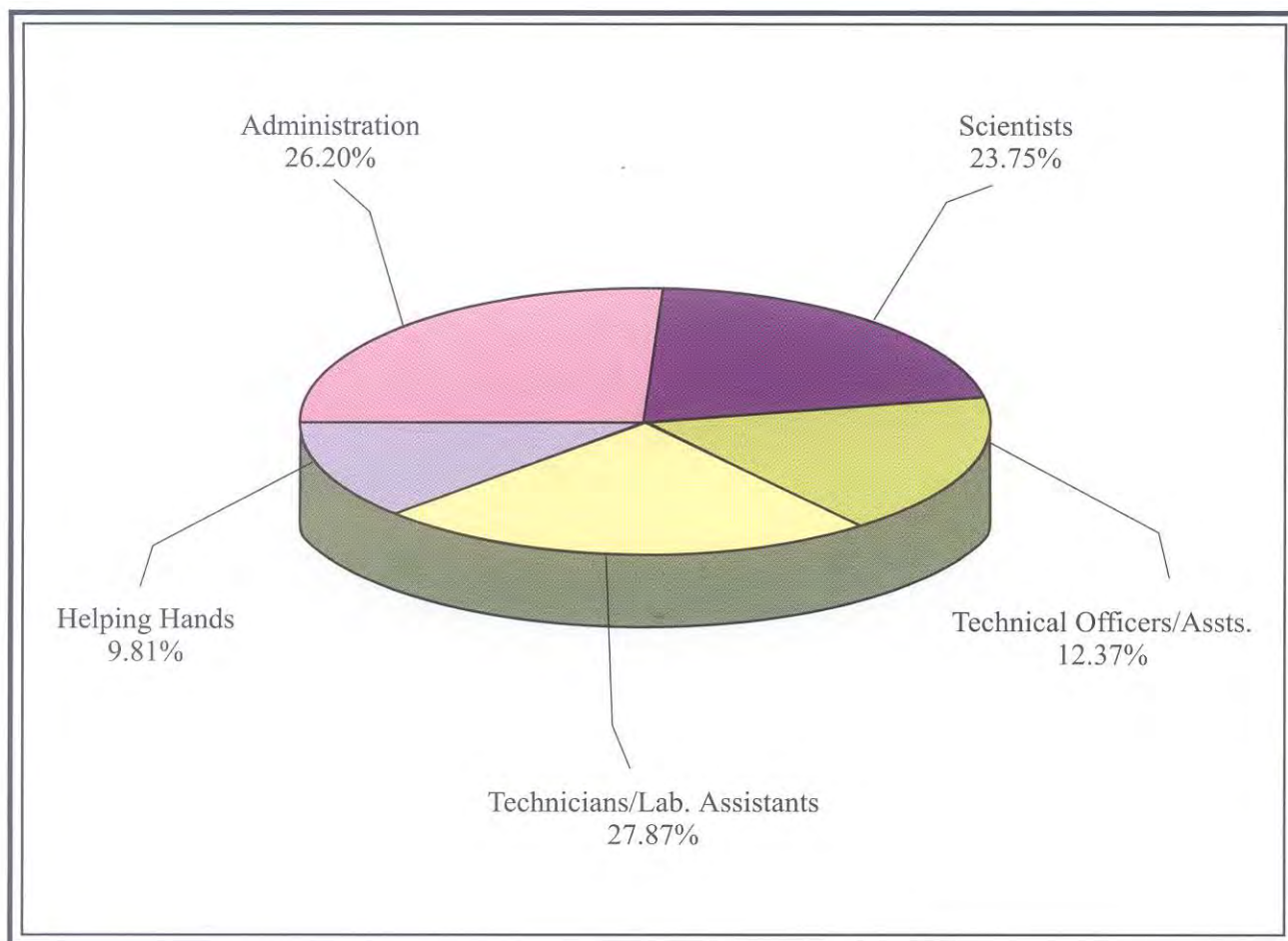
Speaker's Name	Topic	Event/Venue
Dr. H. N. Dutta, Sc. F	Acoustic sounding technology in India	University Scientific Instrumentation Centre, Kurukshetra University, Kurukshetra, April 2000
Dr. H. N. Dutta, Sc. F	Antarctic research	Administrative Staff College, Jawaharlal Nehru University, New Delhi, August 9, 2000
Dr. H. N. Dutta, Sc. F	Commercial exploitation of Antarctica	CDC (DSIR, Govt of India), New Delhi, September 2000
Dr. H. N. Dutta, Sc. F	Role of acoustic sounding in environmental sciences	UGC Refresher Course, School of Zoology, Kurukshetra University, Kurukshetra, December 2000.
Dr. H. N. Dutta, Sc. F	Antarctic environment	UGC Refresher Course, School of Zoology, Kurukshetra University, Kurukshetra, December 2000.
Dr. H. N. Dutta, Sc. F	Acoustic sounding technology	Dept of Electronics & Instrumentation, Kurukshetra University, Kurukshetra, January 2001

APPENDIX : 16

HUMAN RESOURCES

(as on 1.4.2001)

1. Group IV : Scientists	242	2. Group III : Technical Officers/Asstts.	126
3. Group II : Technicians / Lab. Assistants	284	4. Group I : Helping Hands	100
5. Administration	267		
Grand Total (1+2+3+4+5)			1019



**Scientists and Officers as on 1.4.2001
(Listed in order of Gp. IV to Gp. III)**

DIRECTOR

Krishan Lal

STANDARDS

Chief Metrologist
B.S. Mathur

PHYSICO - MECHANICAL STANDARDS DIVISION

Head: S.P. Varma

Length

V G Kulkarni, Sc. E-II
Santa Chawla, Sc.E-I
Rina Sharma, Sc. C
B K Roy, TOE-I

Dimension Almetrology

R P Singhal, Sc.G
K P Chaudhary, Sc. E-I
M Karfa, Sc. E-I
V Roonwal, TOE-I
N K Aggarwal, TOE-I
S L Thind, TOC

Mass

Tripurari Lal, Sc. E-II
M L Das, Sc. E-II
S Sinha, Sc. C
T K Parameshwaran, TOB

Fluid Flow

J N Som, Sc. E-II
Raj Singh, Sc.E-I
Virendra Babu, TOE-II
I S Tak, TOA

Force

K K Jain, Sc. F
S K Jain, Sc.F
J K Dhawan, Sc. E-II
M K Chaudhuri, Sc. E-II
Anil Kumar, Sc. E-II
Ganga Prasad, Sc. E-II
S S K Titus, Sc. B
Rajesh Kumar, Sc. B

Pressure & Vacuum

A C Gupta, Sc. G
A K Bandyopadhyay, Sc.F
D R Sharma, Sc. F
B R Chakraborty, Sc. F
Pardeep Mohan, Sc. E-II
S M Shivaprasad, Sc. E-I
D Arun Vijay Kumar, Sc. C
Sanjay Yadav, Sc. B
Nita Dilawar, Sc. B

Temperature

Y P Singh, Sc. E-II
N K Srivastava, Sc. E-II
S K Nijhawan, TOE-I
J K Gupta, TOC
Gurcharanjit Singh, TOA

Optical Radiation

J S Vaishya, Sc. F
H C Kandpal, Sc.F
Jai Bhagwan, TOC

Ultraviolet Radiation

R S Ram, Sc.F
Om Prakash, F
R K Garg, Sc. E-II

Infrared Radiation

S P Varma, Sc. F
D Gupta, Sc. E-II
Ranjana Mehrotra, Sc. E-II

Acoustics

V Mohanan, Sc. F
B S Gera, Sc. F
R M Khanna, Sc. F
Omkar Sharma, Sc. E-II
S.K. Singhal Sc. E-II
Mahavir Singh, Sc. C
V K Ojha, TOB
Gurbir Singh, TOA

Ultrasonics

Janardan Singh, Sc. F
Ashok Kumar, Sc. F
Mukesh Chandra, Sc. E-II
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APPENDIX: 17

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