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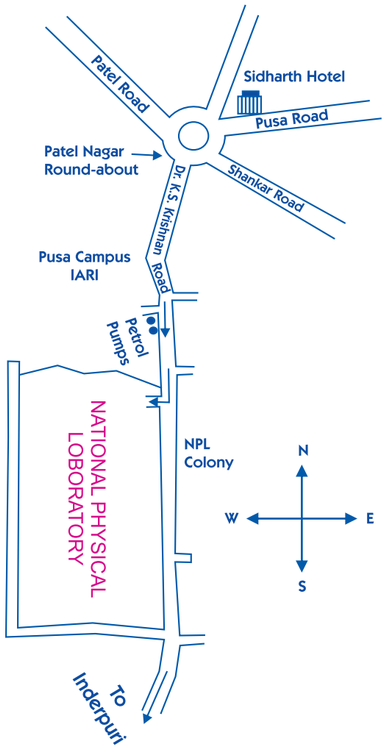
- Sidharth Hotel
- Pusa Campus



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Delhi Railway Station	:	09 km
Indira Gandhi International Airport	:	
Domestic (Terminal I)	:	11km
International (Terminal II)	:	19 km
I.S.B.T.	:	08 km
Connaught Place	:	05 km

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Dr. K.S. Krishnan Marg, New Delhi-110 012

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वार्षिक प्रतिवेदन ANNUAL REPORT 2005-2006

NPL

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annual report
2005-2006

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NATIONAL PHYSICAL LABORATORY, NEW DELHI – 110 012

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NATIONAL PHYSICAL LABORATORY

Dr. K.S. Krishnan Marg, New Delhi - 110 012

National Physical Laboratory

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Contents

प्राक्कथन

राष्ट्रीय भौतिक प्रयोगशाला की वर्ष 2005-2006 की वार्षिक रिपोर्ट सहर्ष प्रस्तुत है। एन.पी.एल. एक मुख्य प्रयोगशाला होने के कारण इसकी गतिविधियों के स्पेक्ट्रम के अन्तर्गत राष्ट्रीय मानक, पदार्थ विज्ञान और वायुमण्डलीय भौतिकी के क्षेत्र आते हैं।

भौतिकी के इन प्रमुख क्षेत्रों में उन्नत अनुसंधान, विभागीय संरचना जिसमें सात विभाग आते हैं, में किए जाते हैं फिजिको-मैकेनिकल स्टैण्डर्ड, इलैक्ट्रिकल एण्ड इलैक्ट्रॉनिक स्टैण्डर्ड, इंजीनियरिंग मैटीरियल्स, इलैक्ट्रॉनिक मैटीरियल्स, मैटीरियल्स कैरेक्टराइजेशन, रेडियो एवं वायुमण्डलीय विज्ञान, सुपर कंडक्टिविटी व क्रायोजेनिक्स।

जबकि मापन के राष्ट्रीय मानकों का अनुरक्षण एवं अपग्रेडेशन (माप एवं तोल अधिनियम 1956 एवं 1976 के विधान के अनुसार, संसद के 1976 के अधिनियम के अन्तर्गत 1998 में पुनः जारी) राष्ट्रीय भौतिक प्रयोगशाला की संवैधानिक जिम्मेदारी है। भौतिकी के फ्रंटियर क्षेत्रों में गहन अनुसंधान एवं विकास कार्य विभिन्न निधिबद्ध और इन हाउस प्रोजेक्ट के अन्तर्गत किए जाते हैं। सी.एस.आई.आर. द्वारा प्रारंभ की गई नेटवर्क परियोजनाओं में से कई में एन.पी.एल. निर्णायक भूमिका निभा रहा है जिसे इस वार्षिक रिपोर्ट में उल्लिखित गतिविधियों द्वारा देखा जा सकता है।

वर्ष 2005-2006 के दौरान तापमान तथा आर्द्रता मानक और निर्वात मानकों की अंशांकन मापन क्षमताओं का अन्तर्राष्ट्रीय तकनीकी विशेषज्ञों द्वारा पीअर रिव्यू किया गया ताकि इसे बी.आई.पी.एम-एम.आर.ए. (BIPM-MRA) के परिशिष्ट 'सी' में समाविष्ट किया जा सके। स्टैण्डर्ड के दो विभागों ने विभिन्न अन्तर्राष्ट्रीय स्तर पर आयोजित अन्तर्तुलना में भाग लिया। एन.पी.एल-एन.ए.बी.एल.एम.ओ.यू. (NPL-NABL MoU) के अन्तर्गत डी सी प्रतिरोधक के दक्षता परीक्षण के प्रथम चरण को और धारिता मापन का द्वितीय चरण भी एन.ए.बी.एल. अधिकृत प्रयोगशालाओं द्वारा पूरा किया गया है।

पदार्थ अभिलक्षणन प्रभाग ने एन.पी.एल. के विभिन्न ग्रुपों तथा इस प्रकार अन्य संस्थाओं/उद्योगों ने बृहत् विविध उन्नत पदार्थों पर XRD, HRXRD, SEM, TEM, EPR, FTIR, UVS, AAS, ICPES & SIMS तकनीकों का प्रयोग करते हुए अनुसंधान किया है। इस वर्ष के दौरान जिन पदार्थों का अभिलक्षणन किया गया उनमें कार्बन नैनो ट्यूब, WO_3 तथा InSb फिल्में, high Tc अतिचालक, संदीप्तिशील पदार्थ यथा अल्फा ऐल्युमिना, सरंध्र सिलिकॉन परतें, Si/Co/Si, Si/V/Si and Si/Fe/Si बहुपरतीय संरचनाएं, NLO एकल क्रिस्टल तथा फेरोफ्लयूड पॉलीमर कंपोजिटस इत्यादि शामिल हैं।

एक अन्तर प्रयोगशाला सहयोगी कार्यक्रम के अन्तर्गत प्रमाणित निर्देश द्रव्यों की योजना, तैयारी तथा प्रकीर्णन इस प्रभाग की एक अन्य महत्वपूर्ण गतिविधि है। NGRI तथा मैसर्स हट्टी गोल्ड माइन्स कंपनी लिमिटेड, कर्नाटक के सहयोग से उच्च ग्रेड स्वर्ण भू-रासायनिक निर्देश द्रव्य (BND 3401.01) का एक नया CRM, तैयार किया गया। NRSA, हैदराबाद के सहयोग से एशिया पैसिफिक नेटवर्क (APN) स्वास्थ्य परियोजना तथा इसरो जी बी पी (ISRO-GBP) प्रोजेक्ट के अन्तर्गत ऐरोसॉल का भौतिक-रासायनिक अध्ययन किया गया तथा ट्रेस गैसों को कार्यान्वित किया गया।

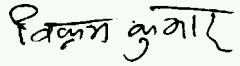
मोनोफिलामेंटरी Ag क्लैड high Tc अतिचालकीय (Bi, Pb)-2223 टेपस् जिसकी लंबाई 30 से 35 मीटर है और जो शुरू से अंत तक अतिचालक है तथा जिसे 4.2K पर 50A के क्रिटिकल करंट पर ले जाया जा सकता है, को विकसित किया गया है।

मानव संसाधन विकास में एन.पी.एल. ने विश्वविद्यालयों और अन्य शैक्षिक संस्थानों के विद्यार्थियों को उनके परियोजना कार्य एवं प्रशिक्षण के लिए सुविधाएं उपलब्ध कराने में अपना योगदान दिया है। सम्पूर्ण भारत में स्थित विभिन्न संस्थाओं से लगभग 250 (दो सौ पचास) विद्यार्थी जो M.Sc., M.E./M.Tech., MCA, B.E./B.Tech. आदि में अध्ययन कर रहे हैं, उन्होंने एन.पी.एल. से अल्पकालीन व दीर्घकालीन प्रशिक्षण प्राप्त किया है। चार रिसर्च फेलो के शोध प्रबन्ध पूर्ण होने पर उन्हें Ph.D. की डिग्री प्रदान की गई। सोलह प्रशिक्षण कोर्स आयोजित किए गए जिनमें 362 व्यक्तियों, जिसमें इण्डस्ट्री से भी शामिल हैं, ने भाग लिया। इसके अतिरिक्त एन.पी.एल. में आने वाले शैक्षणिक संस्थाओं/संगठनों के आगमन की व्यवस्था की गई।

वर्ष 2005-2006 के दौरान 172 विभिन्न जरनलूस में वैज्ञानिक एवं तकनीकी शोध पत्र प्रकाशित हुए। विभिन्न राष्ट्रीय एवं अन्तर्राष्ट्रीय सम्मेलनों में 248 पेपर्स प्रस्तुत किए गए जिनमें से 77 पेपर्स सम्मेलन का प्रोसीडिंग्स में प्रकाशित हुए। एन.पी.एल. ने संस्थानों/सोसाइटियों के संयुक्त रूप से दो सम्मेलनों का आयोजन एन.पी.एल. परिसर में किया। इसके अतिरिक्त दो सम्मेलनों का आयोजन किया गया जिनमें वैज्ञानिक प्रस्तुतीकरण हिन्दी में किए गए। भारत में आठ पेटेन्ट्स और विदेश में बीस पेटेन्ट्स पंजीकृत कराए गए। पूर्व वर्षों में पंजीकृत कराए गए आठ पेटेन्ट्स भारत में तथा चार पेटेन्ट्स विदेश में 2005-06 के दौरान स्वीकृत हुए। 26 (छब्बीस) नयी परियोजनाएं प्रारंभ की गईं और 977 (नौ सौ सतत्तर) लाख रुपए का ECF अर्जित किया गया।

मैं एन.पी.एल. के वैज्ञानिकों, इंजीनियरों और प्रशासन, वित्त, भण्डार एवं क्रय, वैज्ञानिक तथा तकनीकी सहायक सर्विसेज, राजभाषा यूनिट तथा इन्फ्रास्ट्रक्चर सर्विसेज स्टॉफ सदस्यों की रुचि एवं सहयोग के योगदान के प्रति आभार व्यक्त करता हूँ। श्री प्रेम चंद, श्री मनदीप सिंह, श्री एन.के. वाधवा और श्री अभिषेक का विशिष्ट प्रयास सराहनीय है।

अन्त में, मैं प्रकाशन समिति तथा सम्बद्ध टीमों का विशेष आभारी हूँ जिन्होंने इस रिपोर्ट को तैयार करने में अपना अमूल्य योगदान दिया है।



(विक्रम कुमार)

निदेशक

Foreword

It is my pleasure to present the NPL Annual Report for the year 2005-2006. NPL being a prime laboratory for physics, the spectrum of its activities covers the areas of National Standards, Material Sciences and Atmospheric Physics.

Advanced research in important areas of physics is carried out under the Divisional Structure comprising of seven divisions namely Physico-mechanical Standards, Electrical & Electronic Standards, Engineering Materials, Electronic Materials, Materials Characterization, Radio and Atmospheric Sciences, Superconductivity and Cryogenics.

While maintenance and upgradation of National Standards of Measurements remains the statutory responsibility of NPL (as mandated by the standards of weights and measures Act 1956 and 1976 and under the rules of 1988 for the standards of weights and measures Act 1976), intensive R & D in frontier areas of Physics is carried out under several externally funded and in-house projects. With the initiation of Network-projects programme of CSIR, NPL has been playing a crucial role in many of these projects as can be seen by the activities presented in this Report.

During 2005-06, Calibration Measurement Capabilities (CMCs) of Temperature & Humidity Standards and Vacuum Standards were peer-reviewed by technical experts for inclusion in the Appendix C of the BIPM-MRA. There was participation in various internationally organized inter-comparisons from the two divisions of Standards. Under the NPL-NABL MoU, the first phase of Proficiency testing on DC-resistance and the second phase of capacitance measurement was also completed for the NABL accredited labs.

In Materials Characterization Division a large variety of advanced materials from different groups of NPL as well as other Institutes/Industries were investigated mainly using XRD, HRXRD, SEM, TEM, EPR, FTIR, UVS, AAS, ICPES & SIMS techniques. Some of the materials characterized during this year include carbon nanotubes, WO_3 and InSb films, high Tc superconductors, luminescent materials like alpha alumina, porous silicon layers, Si/Co/Si, Si/V/Si and Si/Fe/Si multi layered structures, NLO single crystals and ferrofluid polymer composites etc.

Planning, preparation and dissemination of Certified Reference Materials under an inter-laboratory collaborative programme is another important activity of this division. A new CRM of high grade gold geochemical reference material (BND3401.01) was prepared in collaboration with NGRI and M/s. Hatti Gold Mines Co. Ltd, Karnataka. Physico-chemical studies of aerosol and trace gases were also carried out under Asia Pacific Network (APN) health project and ISRO-GBP project in collaboration with NRSA, Hyderabad.

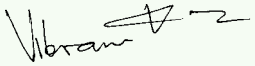
Mono-filamentary Ag clad High Tc superconducting (Bi, Pb) - 2223 tapes of length varying from 30 m to 35 m, which are superconducting end to end and can carry critical transport current of 50 A at 4.2 K have been developed.

In the human resource development, NPL has been contributing by providing facilities to students from Universities and other educational institutes for project-work and training. About 250 students studying M.Sc., M.E./M.Tech., MCA, B.E./B.Tech.etc. from various institutes located all over India have undergone short and long term training. Four research fellows on completion of their thesis work have been awarded Ph.D. Sixteen training courses were organized where 362 persons including persons from industry, other institutions and NPL participated. Besides number of visits by educational institutes/organization to NPL were arranged.

During 2005-2006, 172 scientific and technical papers were published in various journals. 248 papers were presented at various national and international conferences out of which 77 papers were published in conference proceedings. NPL organized three conferences jointly with institutes/society at NPL. Besides, two conferences were organized where scientific presentations were made in Hindi. Four patents were filed in India and twenty were filed abroad. Eight patents filed in India and four patents filed abroad in previous years were granted during 2005-2006. Twenty six new projects (sponsored and consultancy) were undertaken and an ECF of about Rs. 977 lakhs was generated.

I would like to acknowledge the contributions of NPL Scientists, Engineers, and the staff of administration, finance, stores and purchase, the Scientific & technical Services Support staff and the infra-structure services for their interest and cooperation. Special efforts made by Shri Prem Chand, Shri Mandeep Singh, Sh. N.K. Wadhwa and Sh. Abhishek are also appreciated.

Last, but not the least, I would like to acknowledge the contributions of the publication committee and the associated teams in bringing out this report.



(Vikram Kumar)
Director

Preamble

National Physical Laboratory was one of the first National Laboratories set up under CSIR. Its foundation stone was laid by the first Prime Minister of India, Late Pandit Jawahar Lal Nehru on 4th January 1947. Late Dr. K.S. Krishnan, FRS, was the first Director of the laboratory. The main building was opened by the then Deputy Prime Minister, Late Sardar Vallabhbhai Patel on 21st January 1950.

CHARTER

The main objectives of NPL has been a) to establish, maintain and improve National Standards of Measurements and to realize the Units based on International system, b) to identify and conduct research in areas of Physics, which are most appropriate to the needs of the nation and for the advancement of the field, c) to assist industries, national and other agencies in their developmental tasks by precision measurements, calibration, development of devices, processes and other allied problems related to physics and d) to keep itself informed of and study critically the status of physics.

CUSTODIAN OF NATIONAL STANDARDS OF MEASUREMENT

National Physical Laboratory has the responsibility of realizing the units of physical measurements based on the International System (SI units) under the subordinate legislations of Weights & Measures Act 1956 (reissued in 1988 under the 1976 Act). NPL also has the statutory obligation to establish, maintain and update the national standards of measurement & calibration facilities for different parameters. The Seven SI base units are metre, kilogramme, second, kelvin, ampere candela, mole (mol) and the SI supplementary units are radian (rad) & steradian (sr). The other derived units for physical measurement that the laboratory currently maintains are: force, pressure, vacuum, luminous flux, sound pressure, ultrasonic power; ac voltage; current and power; low frequency voltage; impedance and power; high frequency voltage; power; impedance; attenuation and noise; microwave power; frequency. impedance; attenuation and noise.

NATIONAL APEX BODY FOR CALIBRATION

The laboratory provides apex level calibration services in the country; offering National Accreditation Board for Testing and Calibration Laboratories (NABL), the national accreditation body in the country (i) its qualified assessors as needed for establishing best measurement capability of the applicant laboratory (ii) its technical input to enable NABL to decide the suitability of the applicant laboratory for accreditation, and (iii) its faculty to train testing laboratories for estimation of uncertainty in their measurements.

Besides, the laboratory is engaged in development of Certified Reference Materials to ensure high quality measurement and traceability of analytical measurements to national/international measurement system (SI unit) in order to fulfill the mandatory requirement of quality system (ISO/IEC 17025) and of the NABL.

MAJOR ACHIEVEMENTS

National Physical Laboratory has to its credit innumerable number of achievements. A few major achievements are: a) Introduction of Metric system of measurements in India, b) Development of Indelible ink – the indelible contribution to Indian democracy, c) Estimation of methane gas emission from India – a nationwide measurement campaign giving countrywide advantage in environment protection, d) Setting up a pilot plant for development of Electronic components (ferrites), which led to setting up a public sector Unit called Central Electronics Ltd. (CEL) in 1973, e) Development of know-how of the Electrostatic Photocopying machine using indigenous materials and f) Indian Standard Time.

R & D ACTIVITIES

The main running projects in NPL are in three major areas:

(A) Metrology

- Calibration & Testing Services to Industries
- Electrical & Electronic Standards
- Physico-mechanical Standards
- Certified Reference Materials (CRMs)
- Primary Standards
- Realization of SI units

(B) Materials

- Metals & alloys
- Metal-metal composites
- Carbon & Carbon composites
- Plasma processed materials
- Superconductivity, Superconducting materials and devices
- Conducting Polymers & Composites
- Organic Light emitting diodes
- Organic Solar cells
- Smart windows
- Fuel cells
- Silicon, Photovoltaic
- Sensors e.g. Bio, Gas, Chemicals, MEMS
- Advanced Characterization

(C) Atmospheric Sciences

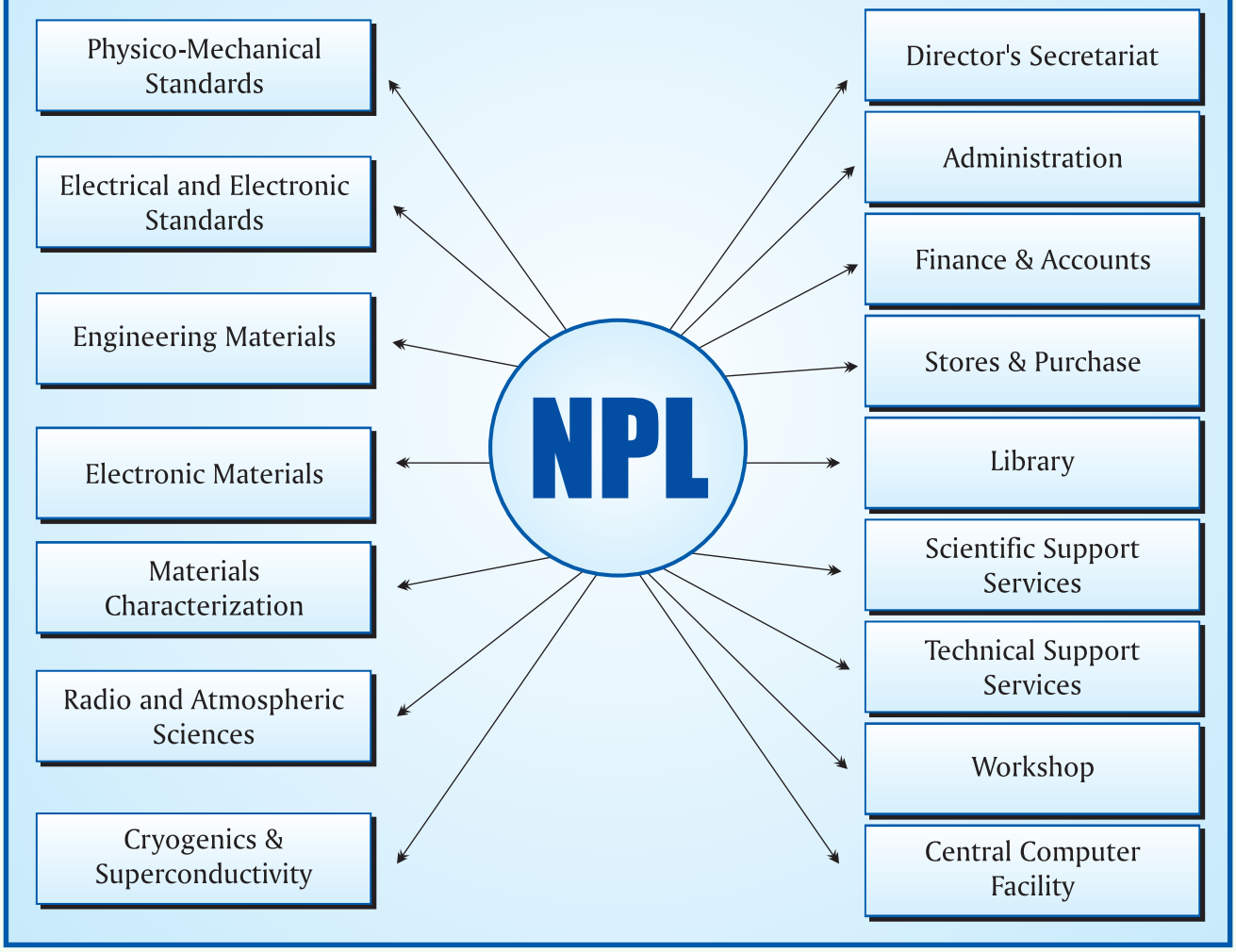
- Ionosphere & Troposphere
- Global Climate Change
- Antarctica Studies
- Radio – Propagation
- Communications (Mobile)

ORGANIZATION AND MANAGEMENT

The laboratory has structured its total activities under seven scientific decision units. These are: (i) Physico-mechanical standards, (ii) Electrical and Electronic Standards, (iii) Engineering materials, (iv) Electronic materials, (v) Material characterization, (vi) Radio and Atmospheric sciences and (vii) Cryogenics and Superconductivity.

In addition, it has set up nine support units for its organization and management. These are (i) Director's Secretariat, (ii) Administration, (iii) Finance & Accounts, (iv) Stores & Purchase, (v) Library, (vi) Scientific Support Services, (vii) Technical Support Services, (viii) Workshop and (ix) Centre Computer Facility.

R & D GROUPS & MANAGEMENT



भौतिक - यांत्रिक मानक

PHYSICO-MECHANICAL STANDARDS

भौतिक - यांत्रिक मानक

भौतिक - यांत्रिक मानक प्रभाग, राष्ट्रीय भौतिक प्रयोगशाला, भारत के सात आर एण्ड डी प्रभागों में से एक है। प्रभाग निम्न पैरामीटर्स सहित यांत्रिक मापन गतिविधियों से संस्थापित है :-

1. द्रव्यमान, आयतन, घनत्व और श्यानता मानक
2. लम्बाई एवं विमीय मापिकी
3. तापमान और आर्द्रता मानक
4. प्रकाशीय विकिरण मानक (दृश्यमान अवरक्त और पराबैंगनी क्षेत्र)
5. बल, टार्क और कठोरता मानक
6. दाब एवं निर्वात मानक
7. ध्वनिक मानक
8. तरल बहाव मानक (केवल पानी माध्यम)
9. पराश्रव्य मानक
10. प्रघात एवं संवेदकों पर अनुसंधान एवं विकास

इस प्रभाग का उपरोक्त गतिविधियों से सम्बन्धित मापन के राष्ट्रीय मानकों की स्थापना, उनका अनुरक्षण और लगातार अपग्रेड करने और मानकों का प्रचार करने व उसके द्वारा देश के उद्योगों और संस्थानों को उच्च स्तर की अंशाकन सेवाएं उपलब्ध कराने का उत्तरदायित्व है और इस प्रकार इनसे निर्मित मापन की अनुमार्गणीयता को सुनिश्चित करना है।

मापन और अंशाकन में संलग्न सभी की मापन और अंशाकन क्षमताओं का समकक्ष (पीअर) पुनरीक्षण विश्व की अग्रणी NMI के तकनीकी विशेषज्ञों द्वारा किया गया। इस प्रकार राष्ट्रीय भौतिक प्रयोगशाला BIPM के परस्पर मान्यता देने सम्बन्धी व्यवस्था की अपेक्षाओं को पूरा करती है, जिसकी राष्ट्रीय भौतिक प्रयोगशाला एक हस्ताक्षरकर्त्ता (Signatory) है। परिणाम स्वरूप उपरोक्त गतिविधियों के CMCs को BIPM वेबसाइट (www.bipm.org) पर डाला गया है और राष्ट्रीय भौतिक प्रयोगशाला की इन गतिविधियों द्वारा जारी किए गए अंशाकन प्रमाण-पत्र पूरे विश्व में स्वीकार्य हैं ।

इन गतिविधियों ने BIPM और अथवा APMP (एशिया पेसीफिक मैट्रोलॉजी प्रोग्राम) / RMO (रीजनल मैट्रोलॉजी आर्गेनाइजेशन ऑफ एशियन रीजन) द्वारा आयोजित/समन्वित अन्तर्राष्ट्रीय अन्तर्तुलना संगोष्ठियों में नियमित रूप से भाग लिया ताकि एस आई (SI) यूनिट, यूनिट की अन्तर्राष्ट्रीय प्रणाली की यूनिट और मात्राओं को नियमित रूप से क्रॉस चैक किया जा सके व मान्यता प्रदान की जा सके।

वर्ष 2005-2006 में प्रभाग की विभिन्न गतिविधियों ने चार अन्तर्तुलनाओं में सफलतापूर्वक भाग लिया, उद्योगों, संस्थानों और प्रत्यायित प्रयोगशालाओं को 2907 अंशाकन रिपोर्टें जारी की, मापिकी सम्बन्धी समस्याओं को हल करने के लिए दो प्राइवेट/पब्लिक उद्यमियों को परामर्श संबंधी सेवाएं प्रदान की, देश में मापिकी के क्षेत्र में दक्ष मानव शक्ति (man power) के विकास में योगदान देने के लिए विभिन्न पैरामीटर्स में आठ प्रशिक्षण कार्यक्रम आयोजित किए।

प्रभाग ने जरनलस् में 22 लेख प्रकाशित किए और राष्ट्रीय व अन्तर्राष्ट्रीय सम्मेलनों में 49 पेपर्स प्रस्तुत किए, 67 आमंत्रित वार्ताएं प्रदान की और मापिकी के क्षेत्र में उनके द्वारा अर्जित ज्ञान का प्रचार करने, गुणवत्ता प्रणाली और अंशाकन प्रयोगशालाओं को स्थापित करने में सहायता प्रदान की।

ताप व आर्द्रता और निर्वात मानकों की अंशाकन मापन क्षमताओं का पीअर पुनरीक्षण क्रमशः PTB, Germany, NIST, USA के तकनीकी विशेषज्ञों द्वारा किया गया। BIPM वेबसाइट के परिशिष्ट 'सी' पर CMCs को डाले जाने से पूर्व CIPM MRA के दिशा निर्देशों के अनुसार APMP सचिवालय और उनके तकनीकी समिति के अध्यक्ष द्वारा CMC का सूक्ष्म परीक्षण किया गया।

इस प्रभाग के वैज्ञानिक परीक्षण और अंशाकन प्रयोगशालाओं के लिए राष्ट्रीय प्रत्यायन बोर्ड (NABL), भारत में अंशाकन और परीक्षण प्रयोगशालाओं के प्रत्यायन के लिए एक सरकारी निकाय, के मार्गदर्शक और तकनीकी निर्धारक हैं जो राष्ट्रीय मापन प्रणाली के नेटवर्क को विकसित कर रहे हैं।

ग्रुप के द्रव्यमान, लंबाई, दाब और ताप गतिविधियों ने NABL द्वारा अनुमोदित इन प्रयोगशालाओं की बेहतरीन मापन क्षमताओं/अनुमोदित अनिश्चितताओं की तुलना में NABL प्रत्यायित अंशाकन प्रयोगशालाओं की तकनीकी क्षमताओं का आकलन करने के लिए एक दक्षता परीक्षण कार्यक्रम का आयोजन किया। इस प्रकार एन पी एल देश की राष्ट्रीय मापन प्रणाली को ससशक्त बनाने में NABL को वैज्ञानिक एवं तकनीकी सहायता प्रदान कर रही है।

इस प्रभाग के वैज्ञानिकों को BIS, नई दिल्ली की विभिन्न विभागीय समितियों का अध्यक्ष/सदस्य नामांकित किया गया है और वे मापिकी व अन्य क्षेत्रों से सम्बन्धित विभिन्न भारतीय मानकों को सूत्रबद्ध करने की आवश्यकता को सुनिश्चित करने के लिए BIS को तकनीकी और वैज्ञानिक जानकारी उपलब्ध करा रहे हैं।

PHYSICO-MECHANICAL STANDARDS

Physico-Mechanical Standards Division is one of seven R & D Divisions of National Physical Laboratory, India. The division constitutes of mechanical measurement activities involving the parameters of

1. Mass, Volume, Density and Viscosity Standards
2. Length and Dimensional Standards
3. Temperature and Humidity Standards
4. Optical Radiation Standards (visible, infrared and ultraviolet region)
5. Force, Torque and Hardness Standards
6. Pressure and Vacuum Standards
7. Acoustic Standards
8. Fluid Flow Standards (Water medium only)
9. Ultrasonic Standards
10. R & D on Shock and Vibration Sensors

The division is responsible to establish, maintain and continually upgrade the National Standards of Measurements related to above said activities and disseminate the standards by providing the apex level calibration services to the industry and institutions of the country and thus ensures the traceability to measurements made in the country.

The calibration and measurement capabilities (CMCs) of all the activities except Fluid Flow engaged in measurement and calibration have been peer-reviewed by Technical experts of leading NMIs in the world. NPL has thus met the requirements of Mutual Recognition Arrangement (MRA) of BIPM of which NPL, India is the signatory. As a result, the CMCs of the peer reviewed activities are posted on BIPM website (www.bipm.org) and the calibration certificates issued by these activities of NPL are acceptable world over.

The activities regularly participate in international inter-comparison organized/coordinated by BIPM and or APMP (Asia Pacific Metrology Program) / RMOs (Regional Metrology Organization of Asian region) regularly to cross-check and to validate the units and quantities of International System of Units, SI units.

In 2005-06 various activities of the division successfully participated in four intercomparison, issued 2907 Calibration reports to industries, institutions and accredited laboratories, provided consultancy to two private/public entrepreneur in solving the metrology related problems, eight training programs in various parameters were organized contributing to the development of skilled man power in the field of metrology in the country.

The scientists of the division published 22 articles in Journals and presented 49 papers in national and international conferences, delivered 67 invited talks and helped in disseminating the knowledge acquired by them in the field of metrology, quality system and setting up of calibration laboratories.

Calibration Measurement Capabilities (CMCs) of Temperature & Humidity and Vacuum Standards were peer-reviewed by technical experts from Physikalish-Technische Bundesapstalt (PTB) Germany and NIST, USA respectively. The CMCs are being scrutinized by APMP Secretariat and respective Technical Committee Chairman as per guidelines laid down by ClPM MRA before CMCs are placed on Appendix 'C' of BIPM website.

The scientists of this division are the Lead and Technical Assessors for National Accreditation Board for Testing and Calibration Laboratories (NABL), a Govt. body for accreditation of the Calibration and Testing Laboratories in India which is developing the network of National Measurement System. The scientists have helped NABL in assessing technical capabilities of several laboratories.

Mass, Length, Pressure and Temperature activities of the group have organized proficiency testing program in assessing the technical competence of NABL accredited calibration laboratories vis-a-vis the approved uncertainties / best measurement capabilities of these laboratories as approved by NABL. NPL have thus been providing scientific and technical support to NABL in strengthening the National Measurements System in the country.

The scientists of this division are nominated as Members/Chairmen of various Sectional Committees of Bureau of Indian Standards (BIS), New Delhi and have been providing technical and scientific inputs to BIS for deciding the requirements for formulating the various Indian Standards related to Metrology and other areas.

MASS, VOLUME, DENSITY AND VISCOSITY STANDARDS

Periodic calibration of the National Standards of Mass and Precision Balances/Mass Comparators, Volume Density and Viscosity as per Internal Calibration Schedule of our quality system was maintained. Two new sets of Density Hydrometers (20 hydrometers per set) were purchased and calibrated against the transfer solid density standards. These serve as Reference Grade Hydrometers for calibration work. A Set of Standards of Mass (50 kg to 1 mg) was calibrated during the Year for United Arab Emirates (UAE).

APMP.M.M.K2 Intercomparison

The group is coordinating and piloting the APMP.M.M.K2 intercomparison in mass. Two sets of Mass Standards (each with five weights) are in use. One of these two sets is under circulation among 11 participating countries for intercomparison. This set has been recalibrated by us during June 2005 and then again in March 2006 to check the stability of the mass values of this set against the second set maintained by us for this purpose.

APMP.M.M.K6 Intercomparison

Participated in APMP.M.M.K6 intercomparison in mass measurements in which 13 countries of Asia-Pacific region have participated. The Comparison has been completed in September 2005 by us at NPL and its report is awaited.

NPL-NABL Proficiency Testing Program

NPL is coordinating PT program in Mass measurements where 20 calibration laboratories will participate. The artifact to be used for this intercomparison has been procured and a revised protocol is being prepared.

LENGTH AND DIMENSIONAL STANDARDS

Length and Dimensional standard realizes SI Unit 'metre' definition, maintains apex level standards and disseminates traceability by way of calibration and testing services. This section, participated in measurement campaign (C-II, 2005) for BIPM intercomparison, LK-11 for iodine stabilized He-Ne Laser during November 2005. Detailed investigations were carried out on NPL-I (1) 633nm iodine frequency stabilized He-Ne laser used to realize definition of 'metre'. This involved calibration of Iodine finger temperature display; Measurement of output power; Electronic offset; Frequency stability of laser and measurement of Frequency shift with respect to modulation width and iodine cell temperature to estimate sensitivity coefficients of laser frequency w.r.t. these parameters. Finally, the laser frequency was measured with respect to BIPM frequency Comb. The results of intercomparison were satisfactory and will be published soon by BIPM.

A project "Generic Development of Nano metrology for nanotechnology at NPL-I" has been initiated. The aim of the project is to develop infrastructure and standards to disseminate traceability to the instruments & artifacts used in measurement for nanotechnology, materials and devices. This project is funded by DIT for an estimated amount of Rs 11.50 crores. The first installment of Rs. 5.5 crores was received in Jan. 2006. The procurement of various items for project is in progress.

A preliminary facility for study of thermal expansion behaviour of metallic blocks and rod was setup. The set-up utilizes a temperature controlled oil Bath with ±0.04 °C stability, Temperature sensors with better than 0.1 °C accuracy and a probe with resolution of 0.01mm. An uncertainty of ± 6% in thermal expansion measurement was achieved. This facility has been setup in NPL first time.

The Coordinate Measuring Machine is being upgraded under network project CMM 24. Now this machine is equipped with the window based software which offers ease of CNC programming and curve measurement. The performance evaluation of machine is in progress.

The calibration services were provided to industries, institutions and other organizations and over 400 calibration reports were issued.

New software has been developed entitled "Gauge Block Interferometry, A software tool for research" and copy right SW-2353 through CSIR, New Delhi has been obtained.

TEMPERATURE AND HUMIDITY STANDARDS

The activities of Temperature & Humidity Standards Group have been peer reviewed by the international technical expert Dr. Joachim Fischer from PTB, Germany during 2-4 August 2005. 14-CMC claims were audited namely 4 in Glass thermometry, 8 in Thermocouples, 2 in Radiation Pyrometry and 1 in Humidity during the peer review. The CMCs will be published in the BIPM website Appendix 'C' after review by APMP.

Calibration facilities were provided to NABL accredited laboratories and industries in the area of temperature measurement in the overall range from –90°C to 2200°C. This included high precision thermometers, noble metal thermocouples and digital thermocouple indicators, liquid baths, Beckman thermometers, digital temperature hygrometers, optical and infrared radiation thermometers and tungsten strip lamps. An ECF of about 16.6 Lakh has been realized through calibration and 191 calibration reports issued.

A three-day "Advance Training Course on Temperature & Humidity Measurement" was organized for participants of NABL accredited laboratories in the area of temperature and humidity parameters at NPL, New Delhi during 8-10 November 2005. About 44 participants from different laboratories and industries attended this training course.

OPTICAL RADIATION STANDARDS

Calibration facilities for the photometric parameters were extended to various lamp and lighting industries, R and D institutions etc. The research and developmental work on studying the photometric characteristics of light emitting diodes including their color characteristics, wavelength and intensity variations on the environmental conditions were carried out. The calibration facility for the photometric parameters of the LEDs a frontier area is being planned. Calibration & Measurement facilities in air UV spectral region were maintained and extended to user industries and institutions.

Sponsored projects

Birla Management Corporation Limited, Bombay Sponsored project entitled "NIR spectroscopy technique for cellulosic materials"

The project is in progress and is likely to be concluded soon.

DST sponsored project on "Studies on the effect of dynamic multiple scattering on the frequency shift of spectral lines and applications"

Doppler-like wavelength shift by dynamic multiple scattering of radiation (Hg lines emanated from Hg discharge source) by a medium whose dielectric susceptibility is a function of both time and space called an anisotropic plasma medium (the source and the medium are at rest with respect to the observer) has been observed in the redshift and broadening the lines emanated from Hg discharge source. These results are expected to produce new insights for the astronomical domain, particularly for discordant redshifts in quasars.

Space Application Sponsored project on "Development of Calibration-Validation (CAL-VAL) site at Kavaratti Island"

Performance evaluation of the instruments (sources and detectors) procured by SAC, Ahmedabad for the parameters and uncertainties as per manufacturer's certificate was done at NPL, New Delhi. Research on the determination of the immersion factor was also carried at various levels of water and various type of water Calibration procedures.

Special achievements

Information encoding by spectral anomalies of spatially coherent light diffracted by an annular aperture

Study has been carried out to investigate spectral behavior of spatially polychromatic coherent light diffracted by an annular aperture. It is found that the spectrum of the radiation at observation plane exhibits anomalous behavior after passing through an annular aperture. Experimental observations show that at some diffraction angle, the diffracted spectrum splits into two lines, while at other diffraction angles the spectrum either shifts towards lower frequencies or shifts towards higher frequencies. These spectral changes take place in the vicinity of the dark ring of the Airy pattern. Moreover, the behavior of the spectrum in far zone along a circle crossing a critical direction is also studied and

it is found that these spectral changes are qualitatively different from the spectral changes of spectrum of focused waves on a circle centered at a singular point. It is discussed that such spectral anomalies of spatially coherent light may be exploited for information encoding and information hiding for free-space communications.

Construction of spatial - coherence spectral filters

The schematics of the experimental setup for the generation of special type of filters called spatial coherence spectral filters is shown in Fig.1.1 and the filters realized are shown in the Figs. 1.2 and

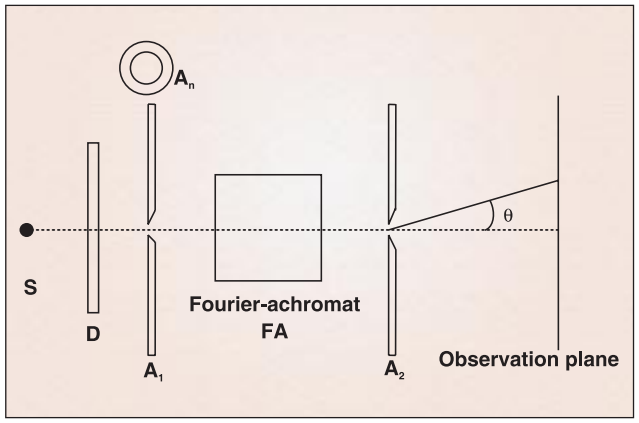


Fig.1.1 Schematics of the experimental setup for observation of spatial-coherence spectral filters (SCSF) using a Fourier-achromat. S is a tungsten halogen lamp, A_1, A_2 and A_3 are the circular apertures, A_n is the annular aperture (which replaces circular aperture A_1, for producing no-uniform band pass filter), FA is the Fourier -achromat.

1.3. Results of the observation for producing low pass filter (passing lower frequencies or higher wavelengths) are shown in Fig. 1.2 using a circular source A_1, The filtered spectrum of the high intensity tungsten halogen lamp was obtained with optics (A) at an angle of observation equal to 0^0, (B) in the direction of 14^0 from the optic -axis and (C) in the direction of 28^0 from the optic -axis. Results of the observation for producing bandpass filters (passing a band of frequencies or wavelengths)are shown in Fig. 1.3 using an annular source A_1, The filtered spectrum of the high intensity tungsten halogen lamp was obtained with optics (A) at an angle of observation equal to 12^0 (B) in the direction of 20^0 from the optic -axis (C) in the direction of 25^0 from the optic -axis. In these figures solid dots show the average value of ten observation and error bars

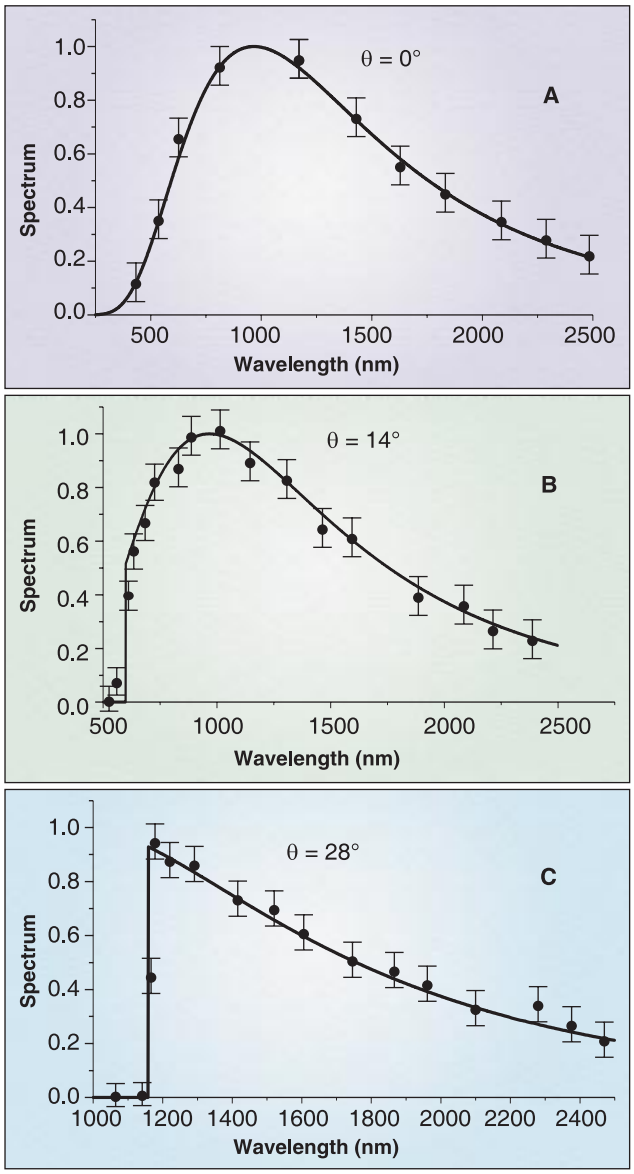


Fig. 1.2. Low pass SCSF at different angles

show the scatter in the values of ten measurements. These filters might find applications in (i) astronomy (in the search of particular spectral lines) (ii) developing spectrum-selective optical interconnects or (iii) in cryptography.

The experimental setup for the generation of special type of filters called spatial coherence spectral filters and the filters realized are shown in the Figs. 1.1, 1.2 and 1.3. Theses filters might find applications in (i) astronomy (in the search of particular spectral lines) (ii) developing spectrum-selective optical interconnects or (iii) in cryptography.

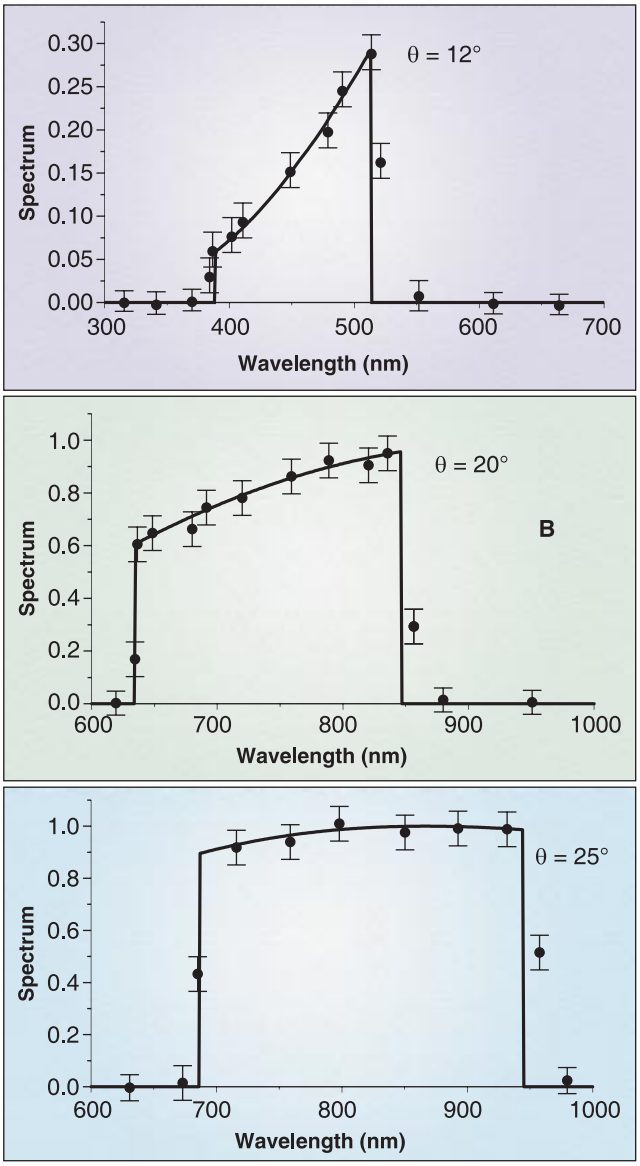


Fig. 1.3. Bandpass SCSF at different angles

FORCE, TORQUE AND HARDNESS STANDARDS

Design, Development and fabrication of torque transducers of capacity 1000 Nm

Torque is an important physical parameter, largely used in mechanical, automobile, infrastructures and power industries. In the recent past there has been an increasing demand from the industries to measure torque more precisely particularly on rotating parts. The commercially available torque measuring instruments are of mechanical type and have an accuracy of ± 1% to ± 5 %. It is inevitable to develop high accuracy torque transducers to be used as transfer torque standard for harmonizing the unit of torque and to disseminate the torque scale to the user industries timely and economically.

Reaction type torque sensing elements having a capacity of 1000 Nm were indigenously designed and fabricated using a strain gauge technology (Fig. 1.4). The metrological characterization of the torque transducers so developed (Fig. 1.5) are found to show a repeatability of ± 0.03 % and reproducibility of ± 0.12 %. The overall estimated uncertainty associated with the torque measuring device is found to be better than ± 0.10% (k=2), taking into account the best measurement capability (BMC) of the machine ± 0.05% (k=2). The designed and fabricated sensing elements can be used as a reference standard for precise measurement of torque by user industries where the uncertainty in the measured torque is not required to be better than ± 0.10%. Further work is in progress to develop torque transducers for the extended torque range and also to lower down the uncertainty in the torque measurement.

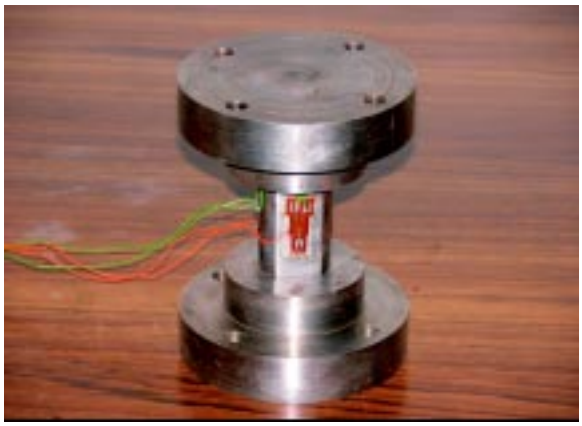


Fig. 1.4. Indigenously designed and developed Torque transducer

Indigenous development of 500 kg dead weight machine with lower uncertainty

To meet the requirement of standardization of load cells, the National Physical Laboratory (NPL), New Delhi, has indigenously designed, developed and fabricated a fully automatic dead weight machine, for Regional Reference Standard Laboratories at Ahmedabad & Bhubaneshwar, Min. of Consumer Affairs, and Food & Public distribution, Govt. of India.

The machine uses a novel method for loading and unloading of dead weights individually using pneumatically operated cylinders, there by reducing the stabilization time and enhancing the repeatability considerably. These features have led

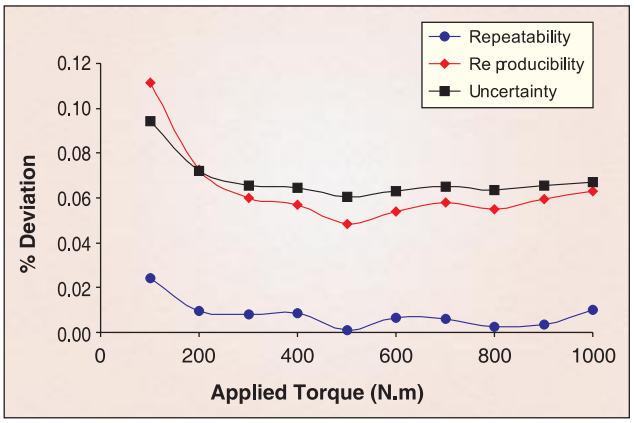


Fig.1.5. Performance characterization of the indigenously desgined and developed 1000 Nm in Torque transducer

to development of a machine with lower uncertainty of ± 40 ppm (0.004%) throughout the range of measurement and improved efficiency of calibration process using window-based software.

Establishment of a new Torque primary standard facility at NPL (Among the First One in Asia Pacific)

A new torque primary standard has been established by supporting a lever on a strain controlled elastic hinges as shown in Fig. 1.6. The machine can be used to calibrate the torque transducer in the range of 20-2000 Nm with an uncertainty of ±0.01% (k=2). A preliminary comparison measurement between the PTB, Germany and NPL, India in 2000 Nm torque range using a 2000 Nm torque transfer standard are in significant agreement.

Establishment of Hardness primary standard for Vicker's and Brinell scales

The group is providing national traceability for Rockwell Hardness but a need was felt to cover all the scales of hardness i.e. Brinell and Vikers. A special grant of Rs. 2.15 crore was obtained from DST through NABL to establish these facilities at NPL. The order for both the machines has already been placed and the L/C is opened. It is expected that these facilities would be in operation before the end of 2006.

Extramural Human Resource and Development

The Central Manufacturing Technology Institute, Bangalore is involved in manufacture of standard hardness blocks for meeting the requirement of the Indian industry. The institute, though manufacturing good quality blocks, was facing the difficulty of assigning precision and accurate hardness values traceable to national standards. To solve this problem, an MOU was signed between CMTI, Bangalore and NPL, India under which it was agreed that CMTI would manufacture good quality hardness blocks and NPL, India would assign standard hardness value to the blocks, which would enable NPL to add additional ECF of about Rs. 4-5 lakh every year, besides providing traceability to hardness blocks in the country.

Fig.1.6. Newly established Torque primary standard

PRESSURE AND VACUUM STANDARDS

Characterisation and Establishment of Hydraulic Controlled Clearance Primary Pressure Standard up to 1.0 GPa and computation of associated uncertainties

Controlled clearance type piston gauge (CCPG) is an ultimate primary instrument for the hydrostatic pressure measurements and its use as reference or primary standard is well established and internationally accepted. However, the rheological properties, mainly, the viscosity and density of the pressure transmitting fluids contribute significantly above 500 MPa. Systematic studies were carried out to characterise such a controlled clearance piston gauge, established at NPL, India, in the hydraulic pressure region up to 1000 MPa. During this process,

the combination of several working fluids viz. pure J-13 and mixture of J-13 and aviation turbine fuel (ATF) (one part of J-13 and 2 parts of ATF), pure di-ethyl hexyl sebacate, pure unleaded white gasoline, mixture of white gasoline and sebacate oil were used as pressure transmitting fluids and finally the mixture of white gasoline, J-13 and sebacate oil was found suitable to generate the pressure upto 1.0 GPa. Using the mixture of 5 % straight run unleaded white gasoline, 10 % pure J-13 and 85 % di ethyl hexyl sebacate, it was possible to generate the hydrostatic pressure up to 1.0 GPa, the ultimate full scale pressure of our primary pressure standard. The detailed studies were carried out on the measurement of piston fall rate as a function of the applied jacket pressure (p_j) for each of several loads (50 kg.). Following the W & H method, the cube root of the fall rate was plotted as a function of applied p_j and extrapolating the linear portion of the curve to zero fall rate which provides the values of p_z for different loads. From the p_z at different loads, the zero clearance between the piston and cylinder

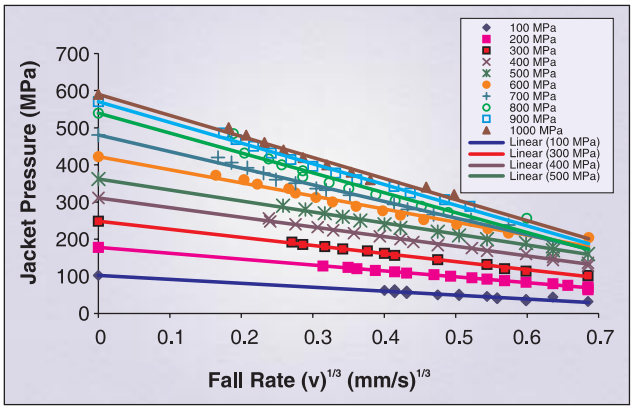


Fig. 1.7. Fall rate data at ten different loads

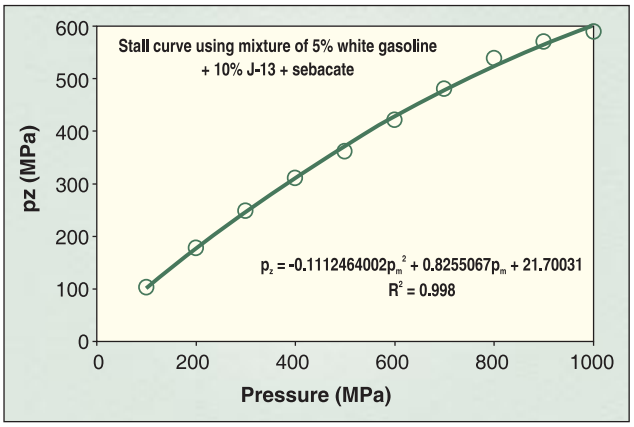


Fig. 1.8. P*j* as a function of *Pm*

was determined. The values of jacket coefficient are computed by analyzing the dependence of effective area and the jacket pressure, p_j using a theoretical method as well as an experimental method. The detailed uncertainty budget is prepared at 1.0 GPa using all the possible associated uncertainty contributions. Some of the results obtained during the period under report are shown in Fig. 1.7 and Fig. 1.8.

Supplementary Comparison APMP.M.P-S2 (bilateral comparison) at a nominal pressure of 0.05 Pa (Collaborative R & D work with NIST(USA))

Nominal pressures of 0.05 Pa are generated (i) at the NPLI by their Static Expansion System (SES) using the method of single stage expansion and (ii) at the NIST by their mid-range orifice flow standard. NPLI had recently made a fresh determination of the volume ratio of their SES using two resonance silicon gauges of different full-scale ranges to measure the initial and the final pressures. NPLI carried out bilateral comparison with NIST, USA. This comparison is listed as a supplementary comparison APMP.M.P-S2 in the BIPM data base. NPLI served as the pilot lab for the comparison. At each laboratory, multiple measurements of the accommodation coefficients of two rotors were made using the respective high vacuum standards of NPLI and NIST. In this comparison, the degree of equivalence between the nominal pressure generated by the vacuum primary standards of NPL of India and NIST was tested. Both standards were fully equivalent for the pressure 0.05 Pa.

Coordination of Proficiency Testing in the Hydraulic Pressure Measurements up to 70 MPa under MoU with NABL

NPL, is coordinating four more NABL sponsored proficiency testing program, these are PT004, PT005, PT006 and PT007 in the pressure range 0 – 70 MPa using one dead weight tester, digital pressure calibrator and two pressure dial gauge, respectively as artifacts. The total number of 65 NABL accredited pressure laboratories form all over India have agreed to participate in these programmes. The technical protocols have been prepared. The characterization of the artifacts have been completed. The artifacts will be circulated to the participants soon.

Characterisation of a compact 200 MPa controlled clearance piston gauge as a primary pressure standard using the Heydemann and Welch method (Collaborative R & D work with NIST(USA))

Controlled-clearance piston gauges are used as primary pressure standards at many National Metrology Institutes. The National Institute of Standards and Technology (NIST), in collaboration with the National Physical Laboratory (India), are studying the performance of a new generation of controlled clearance gauges that offer the potential for reduced uncertainties. The gauges are also well suited for inter-laboratory comparisons because of their smaller, integrated design, and use of existing mass sets. The characterization of a 200 MPa oil-operated controlled clearance gauge using a 2.5 mm nominal diameter piston and cylinder was carried out. The gauge is operated with an external cylinder pressure of 0 MPa to 80 MPa. The piston fall rate measurements, deformation measurements, piston diameter measurements, and modeling calculations using the Heydemann-Welch (HW) method on two occasions over a two-year time period have been studied in details. The relative standard uncertainties in the effective area (A_e) using the HW method range from $17x10^{-6}$ at 20 MPa to $24x10^{-6}$ at 200 MPa. We have compared results of the HW method to the present NIST hydraulic pressure scale. For pressure of 180 MPa and lower, there is agreement in A_e within the combined standard uncertainty; at 200 MPa there is agreement within the combined expanded (k=2) uncertainty.

ACOUSTICS STANDARDS

The Acoustics Section continued with the following activities, viz.

i) Maintenance of Primary Standards of Sound Pressure & Vibration Amplitude
ii) Calibration & Testing of electro-acoustical items and acoustic products.
iii) Rendering consultancy in Building Acoustics, Noise & Vibration & Sodar.
iv) R & D in Technical Acoustics.

Preparations were carried out towards renovating the acoustics laboratories and undertaking internal audit prior to International Peer Review scheduled for September, 2006.

During the period 246 calibration/ Test Reports were issued and the ECF realized was to the tune of Rs.66 lakh including three consultancy projects undertaken.

The following consultancy / R&D projects were of national importance in view of the press coverage and publicity obtained for the same.

1. Tentative Noise Control Measures for the Commonwealth Games Village near NOIDA Mor.

A 'package of noise control measures' were proposed to bring down the expected noise levels in and around the Games Village within acceptable limis. These measures include the following options:

1. Erection of a **half-Y noise barrier** of **4 m** height and **1 m** projection slanting at 30° towards the traffic side near the rail corridor, NH24 and Link Road. The barrier can be of **modular construction**, fabricated elsewhere and joined at site.
2. A **thick plantation** should be grown on the sloppy terrain stretching over 50-100 m along the railway track / highways. It should consist of non-deciduous straight growing trees with dense bushes / shrubs in between.
3. **An environmental noise barrier** can also be constructed along the Games village boundary facing the rail corridor with suitable mound / earth berm and a noise barrier erected at the top. This could well be integrated into the surrounding with proper landscaping /plantation
4. The residential units should be designed based on **'self protecting'** concept with critical areas located away from facing noise sources with buffer zones housing in less critical areas.
5. The **sound insulation** of buildings elements of upper floors of residential units facing the rail corridor / highways should be enhanced by using double glazing, cavity walls, insulating gaskets etc.
6. As the farthest line of traffic / rail tracks dominates the noise at the receiver, it is highly desirable to erect an **additional noise barrier** (with dense shrubs / bushes grown on both sides) of height **1.5 m** between the two carriage ways / rail tracks to contain tyre / wheel rail noise effectively.

7. As **absorptive barriers** are preferred to plain barriers, it is desirable to grow some dense bushes or shrubs along the track / road side of the noise barriers.
8. Improved signaling , fencing and proper security arrangements can definitely help to declare the rail corridor a '**horn free**' zone
9. Similarly **proper maintenance** of track and rolling stock will definitely help to reduce the emitted source noise levels.
10. It is also important to consider **quieter road surfaces** for NH 24 and Link Road. These include porous asphalt, rolled asphalt, whisper concrete etc.

2. Noise Control Measures for Delhi Metro

It was observed that the operation of metro trains in underground corridor created higher interior noise levels inside the cars by about 5-10 dB from the specified values. Hence a package of noise control measures was suggested to reduce the higher noise levels. The major stress was given to the following immediate measures like i) acoustic treatment of the tunnel side walls in a composite fashion, ii) provision of ballast beds and ballast mats, iii) improved sound isolation of the various elastomeric mounts / pads used in the car, iv) systematic maintenance of the wheel & rail surfaces , v) installation of wheel tread condition monitoring system etc. Also certain long term measures were proposed. These included introduction of disc brakes, wheel skirts, acoustic enclosures for auxiliary units, bogie shrouds, installation of low movable noise barriers, spiked wheels etc.

ULTRASONICS STANDARDS

The ultrasonic Standards continued to provide services to the industries for the calibration of ultrasonic non-destructive testing equipment, ultrasonic medical equipment and underwater acoustic equipment. Method of measurement and associated uncertainty in measurement was established in evaluating the mass of milligram weights in water as a function of time. This will help in reducing the uncertainty in evaluation of change in mass of target due to irradiation of ultrasonic power in milliwatt range. Design of transducer holder was also modified for ultrasonic low power measurement to accommodate probe of any diameter provided with mini UHF connector. Uncertainty in the ultrasonic power measurement due to drift of float target was reduced and brought to nearly zero by introducing a specially designed glass aperture which arrests the drift within 1 mm. Development of ultrasonic transducer to work at 2, 5 and 10 MHz with high power output levels was studied. Material selection and procurement has been completed besides the cutting, polishing, etc. Samples of carbon fibre composites were subjected to very large number of experimental studies. Water was let to ingress in steps and measurements were made for increase in mass and ultrasonic parameters using Lab View software. Correlation between various parameters up to a moisture level of 1% has been established.

FLUID FLOW STANDARDS

The primary Standard Facility for Fluid Flow (water) is under up gradation and modernization to make it operator friendly, with indigenous software so that the system is understandable and in full control to enable the in house maintenance. Significant modifications in the domestic water meter facility have been made in the existing facility to enhance the rate of testing of the meters. Testing of the water meters was carried out for the water meter industry. A consultancy project entitled "Augmentation of the domestic water meter facility at Aman Engineering Works Jalandhar "was successfully completed and the detailed project report submitted for future use.

R&D ON SHOCKS AND VIBRATIONS

Piezoelectric Accelerometers

The pioneer work on the development of various accelerometers has always been a proud of the laboratory. The availability of indigenous accelerometers with proven overall excellent characteristics comparable to the International quality at reasonably affordable prices has contributed significantly towards the economic growth of the country by way of saving the large amounts of precious Foreign Exchange. As a result of the efforts of NPL and the confidence shown by the users in its accelerometers, the world's largest manufacturers of this device have reduced their prices

in the Indian market. One of the world best manufacturers M/s Kistler Instruments (Pte) Ltd, Singapore, has also approached NPL for a protocol to get their accelerometers manufactured by NPL, for its prospective sale in the Asia-Pacific Region. This high-tech development is therefore expected to foresee export potential (generation of usable resources through exports) in the near future.

This year, M/s Techno Instruments Co., Delhi, has acquired the technology. The firm is manufacturing the accelerometers successfully, based on the technological know-how developed at the laboratory. Many other industries are also in the queue to acquire this unique technology. In the current year, a very special module of voltage mode accelerometer is developed with an in built low cost charge to voltage preamplifier, and is designated as PL-1100CV. The developmental work of PL-1100CV was completed by successfully integrating the miniature charge amplifier circuit with in the accelerometer housing followed by performing extensive quality evaluation and endurance tests on the unit satisfactorily. Characteristic specifications of voltage mode accelerometer type PL-1100CV are given in the table below, along with other modules developed previously. Technological Process Know-Hows for commercial production of all of these low cost, high performance accelerometers are readily available from NPL. Many high profile potential users from the core sectors, Defence, Space, Nuclear, Power, and Aerospace, etc., have also requested us to develop specific accelerometers for their intrinsic requirements.

As part of its regular on going activities the group continued to provide its specialized scientific services to the users from almost every sector, and provided them low cost, high value solutions for their requirements. Test and Calibration services are also provided to a number of industries and other organizations.

विद्युत तथा इलेक्ट्रॉनिक मानक

ELECTRICAL AND ELECTRONIC STANDARDS

विद्युत तथा इलेक्ट्रानिक मानक

विद्युत एवं इलैक्ट्रॉनिक मानक प्रभाग में निम्न मानक गतिविधियां आती हैं :-

1. समय तथा आवृत्ति
2. क्वांटम हाल प्रतिरोध व अति चालक साधन
3. जोसेफसन वोल्टेज व डी सी करंट, वोल्टेज़ एवं प्रतिरोध मानक
4. डी सी हाई वोल्टेज़ मानक
5. ए सी पावर व ऊर्जा मानक
6. ए सी उच्च धारा और उच्च वोल्टता मानक
7. एल एफ तथा एच एफ प्रतिबाधा मानक
8. एल एफ तथा एच एफ वोल्टता, धारा और आर एफ पावर मानक
9. आर एफ तनुकरण व प्रतिबाधा मानक
10. चुम्बकीय मानक
11. जैव चिकित्सा मापन व मानक

प्रभाग विभिन्न विद्युत और इलैक्ट्रॉनिक मानदण्डों के मुख्य/राष्ट्रीय मानकों का अनुरक्षण करता है और अंशाकन के माध्यम से अनुमार्गणीयता प्रदान करते हुए उनका प्रचार करता है।

प्रभाग के विभिन्न क्षेत्र यथा BIPM, APMP इत्यादि अन्तर्राष्ट्रीय निकायो द्वारा आयोजित अन्तर्राष्ट्रीय अन्तर्तुलनाओं में सक्रिय रूप से भाग लेते हैं और अन्तर्राष्ट्रीय अनुमार्गणीयता और समानता की श्रेणी को स्थापित करने में द्विपक्षीय तुलनाओं में भी भाग लेते हैं।

प्रभाग के अन्तर्गत आने वाले अधिकांश मानदण्डों को अंशाकन और मापन क्षमताओं को अन्तर्राष्ट्रीय स्तर पर स्वीकार किया गया है और वह BIPM बेबसाइट पर उपलब्ध है। यह APMP दिशा निर्देशों के अन्तर्गत संचालित पीअर रिव्यु का एक परिणाम है।

ELECTRICAL AND ELECTRONIC STANDARDS

Electrical and Electronic Standards Division covers the following Standards activities:

1. Time and Frequency
2. Quantum Hall Resistance & Superconducting Devices
3. Josephson Voltage and DC Current, Voltage & Resistance Standards
4. DC High Voltage Standards
5. AC Power and Energy Standards
6. AC High Current and High Voltage Standards
7. LF and HF Impedance Standards
8. LF and HF Voltage, Current & RF Power Standards
9. RF Attenuation & Impedance Standards
10. Magnetic Standards
11. Biomedical Measurement & Standards

The Division maintains Primary/National Standards of various electrical and electronic parameters and disseminates them by providing traceability through calibration.

Various areas in the Division are also actively involved in the international intercomparisons organized by international bodies like BIPM, APMP and so on and also the bilateral comparisons to establish international traceability and the degree of equivalence.

The Calibration and Measurement Capabilities of most of the parameters covered in the Division are internationally accepted and appear on the BIPM website. This is a result of Peer Reviews conducted under APMP guidelines.

Time and Frequency Standards

One of the commercial Cesium atomic clocks is used to maintain UTC(NPLI). With the procurement of two multi-channel GPS Receivers calibrated by BIPM, the uncertainty of UTC(NPLI) has improved to ± 7.6 ns. The cesium clock has been steered to follow the UTC within ±100 ns.

NPLI participated in GPS Receiver calibration campaign conducted by APMP during January-February 2006. Result of this campaign is awaited.

NPLI disseminates standard time and frequency signals (STFS) via geostationary satellite INSAT with an accuracy of ±10 μs, which can be improved to ± 1 μs using differential mode. Another time service via telephone line (known as Teleclock service) is also being provided by NPLI.

Development of Laser cooled Cesium Fountain clock has been undertaken by NPLI. The overall design of the optical setup and the physics package has been finalized. The system is in process of integration.

Work has been done on the application of squeezed states for enhancement of laser cooling force. For Coherent Population Trap (CPT) atomic clock electronic circuits for 1.5 GHz Synth, VCSEL driver has been developed. The VSCEL chip packaging got completed. A new compact vacuum system for filling Rb^{85} cells has been developed.

Quantum Hall Resistance Standard & Superconducting Devices

Quantum Hall Resistance Standard

NPL is maintaining primary standard of dc resistance based on quantum Hall effect which provides a reference standard of resistance linked to fundamental constants. The quantum Hall resistance standard is used to calibrate a secondary 1kΩ resistor by using a room temperature direct current comparator bridge, at different temperatures with uncertainty of 0.08 ppm. To improve the accuracy and extend the range of calibration, the system is being upgraded with the development of cryogenic current comparator (CCC).

Low Temperature Transport Study of Double Layered Manganite

The bulk samples of double layered $La_{2-2x}Ca_{1+2x}Mn_2O_7$ manganite for different compositions x = 0.1, 0.2, 0.3 and 0.4 were prepared by solid state reaction method. X-ray diffraction studies showed phase purity with tetragonal structure. The temperature dependence of resistivity in low temperature region ($4.2 \leq T \leq 50$ K) have been studied. At low temperatures the resistivity increases with the decrease in temperature. The resistivity minima were observed at temperatures of 13, 16, 17 and 19 K for composition x = 0.1, 0.2, 0.3 and 0.4 respectively. Studies were also made for temperature dependence of real part of AC susceptibility for $La_{2-2x}Ca_{1+2x}Mn_2O_7$ (x=0.1, 0.2, 0.3 and 0.4) in the temperature range from 4.2 K to 50 K. The real part of AC susceptibility decreases slowly with the decrease in temperature and then at a temperature it decreases sharply for all compositions. This is attributed to the onset of antiferromagnetic ordering in the sample. The antiferromagnetic ordering temperature (T_N) at which sharp decrease of ac susceptibility occur, is found to be 21, 16, 14 and 37 K for samples with dopant concentration x=0.1, 0.2, 0.3 and 0.4 respectively. For analyzing the experimentally observed temperature dependence of resistivity, the resistivity - temperature curves were simulated using weak localization, electron - electron scattering and electron – phonon scattering mechanisms.

Josephson Voltage Standard and DC Current, Voltage and Resistance Standards

Josephson Voltage Standard

Josephson series array voltage standard is being maintained at 1 volt level. The "National Standard" of volt is calibrated at regular intervals against the Josephson Voltage Standard. The establishment of the Josephson series array voltage standard at 10 volt level is in progress.

DC Current, Voltage and Resistance Standard

National Standards of unit volt and ohm are being maintained in the form of a bank of 1Ω resistors and bank of zener reference standards. These are monitored and calibrated at regular intervals to maintain the traceability.

The second phase of proficiency testing program under NPL-NABL MoU on DC resistances (1 Ω, 100 Ω, 1 kΩ and 10 kΩ) has been completed and the report is under process. A total of 18 laboratories participated and NPL was coordinating this program.

NPL received a project entitled "Generic development of nanometrology for nanotechnology at NPLI" from Department of Information Technology, New Delhi. This project aims at establishing a nanometrology laboratory to provide high precision calibration for some parameters.

DC High Voltage Standards

The aim of this activity is establishment, realization, upgradation and maintenance of National Standard of DC high voltage through continuous research and development. It is providing calibration facility for High Voltage DC equipments ie. DC High Voltage probe, DC High Voltage divider, DC High Voltage Power Supplies and DC Volt meter, upto 100 kV. Primary standard of DC High Voltage is the Resistive Divider, which is traceble to Josephson voltage standard.

Peer Review of DC high voltage laboratory was conducted as per APMP guidelines. The claimed Calibration and Measurement Capabilities have been uploaded on the BIPM website after review.

AC Power & Energy Standard

Calibration facilities, traceable to PTB Germany, have been established for Active Power & Energy in the frequency range of 70 Hz to 400 Hz using reference AC Power & Energy standard (ILM-03) for 0.01 W to 69120 W (voltage: 10 V to 576 V, current: 0.01 A to 120 A, power factor : 0.1 I/C to 1.0 for power and 0.25 I/C to 1.0 for energy). The uncertainty of measurement is (200 to 500) cos∅ mW/W. This facility will be mainly utilized for defence departments.

To solve the problem of influence of magnetic fields (AC/DC) on the performance of energy meters, a detailed study has been done by applying different magnetic field strengths (AC/DC) on all the accessible surfaces of different energy meters. It was observed that by applying AC magnetic fields of more than 10 milli Tesla and DC magnetic field of 100 milli Tesla, in general the energy meters record less energy, either due to the influence on the CTs and other components used inside the meters or influence on the servomotor used for driving the mechanical registration counters. By applying proper soft iron shielding and by maintaining proper air gap, the influence was minimized. Based on our report Central Board of Irrigation and Power has included several AC/DC magnetic influence tests in Technical Report CBIP – 88 (a technical specification for static energy meters) and Technical Report 69 (a technical specification for electromechanical energy meters).

AC High Current & High Voltage Standards

This section is maintaining National Standards of AC High Current & High Voltage Ratios at power frequency (50 Hz) by using Reference Standard Current Transformers and Reference Standard Voltage Transformers.

LF and HF Impedance Standards

This activity is maintaining the primary standards of capacitance, inductance and ac resistance. Value to the 10 pF capacitor is assigned through primary standard, calculable cross capacitor, with an uncertainty of 0.6 ppm using precision ac bridges. Scale of capacitance is build up from 10 pF to 1 F using transformers bridges. The unit of inductance, Henry, is realized from capacitance and resistance using Maxwell-Wien Bridge.

The unit of ac resistance, Ohm, is also realized from capacitance. using Quadrature Bridge and other precision ac bridges at 1kΩ . The scale of resistance from 1Ω to 1 MΩ is build up with Kelvin double arms ac bridge.

Precision reference airlines are being used as primary standards of HF impedance in frequency range of 10 kHz to 250 MHz.

LF & HF Voltage, Current & RF Power Standards

Facility for calibration of ac-dc current shunts and measurement of ac current up to 100 amperes in the frequency range 40 Hz to 10 kHz has been established. For this the transconductance amplifier and ac-dc current shunts have been procured through funds under CSIR Networking Project CMM0024. The reference standard current shunts have been made traceable to the primary standard of ac-dc current transfer using ac-dc substitution technique. The photograph (Fig 2.1) shows the set up for inter comparison of a 30 ampere current shunt against a 20 ampere current shunt.

Fig. 2.1 : Set up for comparison of 30 A shunt against 20 A shunt.

RF Attenuation and Impedance Standards

The Calibration facilities have been established for Broad-band complex S- parameter measurements using Vector network analyzer system (Fig. 2.2). We have participated in the CCEM International Key Comparison CCEM.RF-K5b.CL "Scattering Coefficients by Broad-Band Methods 2 – 18 GHz - Type N connector ". Under this comparison, the real and imaginary components of complex S-parameters were measured for one-port and two port components (Seven artifacts) at 17 frequency points. Also the studies of the covariance matrix and correlation coefficient have been done for the comparison. Nineteen NMIs all over the World have participated in the BIPM Key comparison.

Fig. 2.2. Complex S-parameter measurement facility

Magnetic standards

An active research participation with Delhi University has been fostered on the nano-particles of iron in colloidal form to investigate its magnetic behavior using Vibrating Sample Magnetometer. The iron nanoparticles have been synthesized by exploding wire technique for the purpose. Room temperature magnetic hysteresis measurements upto a field of 1 Tesla were performed on these nano particles in the form of powder. The M-H loop , indicated that the particles are super paramagnetic in nature. The saturation magnetic moment was found to be of the order of 60 emu/gm. Transmission electron microscopy revealed the size of the nono particles to be in the range of 10 nm to 50 nm.

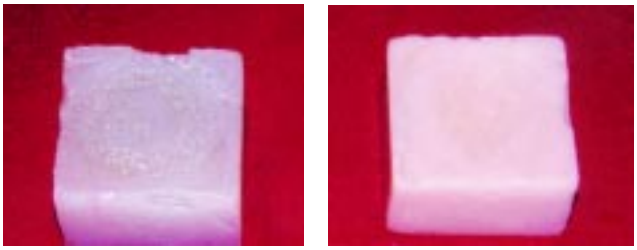
This study will help in decontamination of ground water.

Besides, industrial metrology of different tests on magnetic measurements have been undertaken by the group and is also undertaking the testing of magnetic materials received from industries for intrinsic magnetic material properties measurements which have been investigated using Vibrating Sample Magnetometer (VSM). Facilities are available for the measurement of M-H loop upto magnetic field 1.4 T .

Biomedical Measurements and Standards

Basic Tissue Characterization

Extensive research has been pursued on ultrasonic, acoustic, electrical, and dielectric parameters of tissue equivalent phantoms for biomedical applications. These parameters will be highly useful for developing standard phantoms of vital human organs such as lever, kidney etc. A few samples of tissue equivalent phantoms developed by this group are shown in Fig. 2.3.



Sample 1 Sample 2

Fig. 2. 3. Samples of tissue equivalent phantoms

Independent Component Analysis

Biomedical signals like ECG and EEG are usually weak signals, which are often contaminated by artifacts and noise, pose a great challenge to diagnose

properly the root cause of EEG related problems. The group has developed an ICA algorithm for removing EEG, ECG artifacts and noise from the biomedical signals for better understanding and accurate diagnosis of the problem.

ECG Standard Facility

The laboratory has undertaken the task of setting up a centralized state of the art facility for providing to the user agency, the best of calibration services of electro-medical equipments. A standard bio-simulator system with 1mV in built signal generating capability, calibrated at NPL, is used as a secondary reference source for calibrating the ECG machines. The set up of ECG calibration facility will look like as shown in Fig. 2.4.

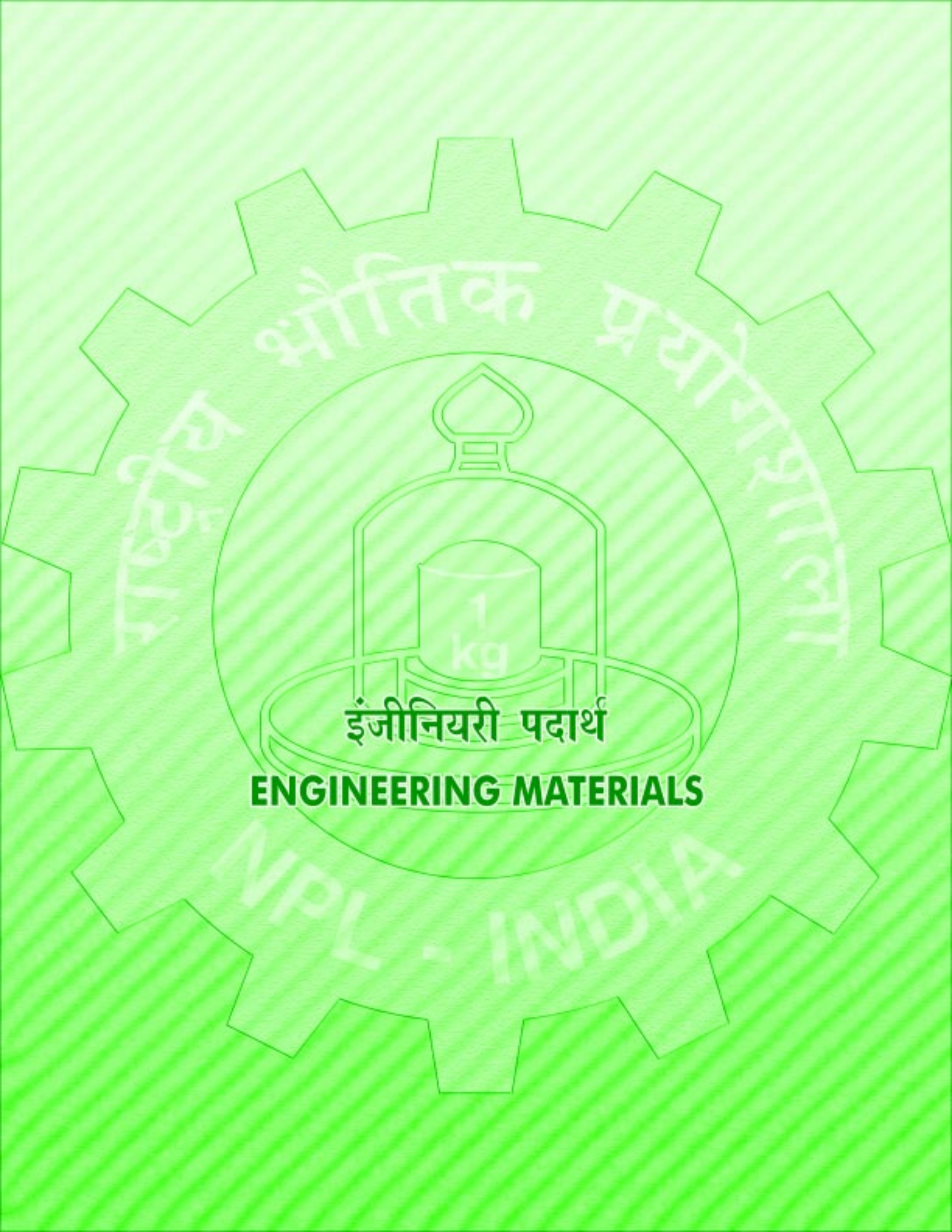
Fig. 2.4 ECG calibration set up

Quality System

NPLI has been following Quality System based on the international standard ISO/IEC 17025, in the area of Test and Calibration. From the standards area, seventeen activities have been Peer Reviewed by technical experts from other NMIs. A total of 445 Calibration and Measurement Capabilities (CMC) claimed by NPLI have been verified, found correct and appear on the BIPM website. Similarly, 58 key and other comparisons, wherein NPLI participated, appear on the BIPM website. All the test/calibration areas of NPLI are periodically audited to confirm the continued compliance to the international standard.

A revised Quality Manual based on the revised standard is under preparation. Efforts are on to include material and chemical testing and calibration activities in the Quality System.

A delegation from NPLI participated in APMP General Assembly and related meetings in 2005, held in Jeju, Korea.



इंजीनियरी पदार्थ

ENGINEERING MATERIALS

इंजीनियरी पदार्थ

इंजीनियरी पदार्थ प्रभाग में मुख्यतः धातु एवं मिश्र धातु, उन्नत कार्बन पदार्थ, पालिमेरिक व मृदु पदार्थ और द्रव क्रिस्टल ग्रुप समाविष्ट होते हैं। इस प्रभाग का उद्देश्य पदार्थों, घटकों के लिए प्रक्रिया और प्रौद्योगिकी व उपरोक्त क्षेत्रों में युक्तियां और प्रणाली को विकसित करना है। प्रभाग के अनुसंधान एवं विकास उत्पादन में एयरोस्पेस मैटेलिक सामग्री, कंपोजिटस् (उच्च) उन्नत कार्बन उत्पाद, द्रव क्रिस्टल, चालक पालिमर्स, ऑप्टो इलैक्ट्रॉनिक्स युक्तियां, आर्गेनिक प्रकाश उत्सर्जन डायोड्स, सैंसर्स, स्वास्थ्य की देखभाल करने वाली युक्तियां आदि शामिल है। इन पदार्थों का प्रयोग सामरिक व औद्योगिक अनुप्रयोगों में किया जाता है। जनरल मोटर्स ने आटोमोबाइल अनुप्रयोगों के लिए मिश्रधातु की निष्कासन प्रौद्योगिकी के विकास पर एन पी एल के साथ एक सहयोगी परियोजना को प्रायोजित किया है। अन्य उद्योगों जैसे रिलायंस इंडस्ट्रीज, राणे ग्रुप ऑफ इंडस्ट्रीज के साथ और अधिक ऐसे औद्योगिक अनुबंधों पर भविष्य के लिए विचार करना है।

कई विकासशील परियोजनाओं में जैसे सी एस आई आर नेटवर्क, प्रायोजित सहायता अनुदान (ग्रांट इन एड), सहयोगी और परामर्शी पायोजनाओं को विभिन्न अनुसंधान एवं विकास संगठनों जो सरकारी और निजी दोनों क्षेत्रों के हैं, के लिए सफलतापूर्वक लागू/पूरा किया जा चुका है।

ENGINEERING MATERIALS

The Division of Engineering Materials mainly comprises of Metals & Alloys, Advanced Carbon Products, Polymeric & Soft Materials and Liquid Crystal groups. The objective of this division is to develop materials, processes and technologies for components, devices and systems in the above mentioned areas. The R&D output of the division includes the development of aerospace metallic materials, composites, advanced carbon products, liquid crystals, conducting polymers, optoelectronic devices, organic light emitting diodes, sensors, health care devices etc. These materials find applications in strategic and industrial applications; General Motors have sponsored a collaborative project to NPL on the development of extrusion technology of Mg alloys for automobile applications. More such industrial linkages with other industries like Reliance Industries, Rane Group of Industries are envisaged for future.

Several developmental projects, such as, CSIR network, sponsored, grant-in-aid, collaborative and consultancy are successfully being implemented/ completed for different R&D organizations, both in the public and private sectors.

A. METALS & ALLOYS

Development of different grades of Magnesium and Aluminium light weight alloys and their composites

Work was extended during the year to develop light weight Magnesium and Aluminium alloys for their possible application in aerospace and automobile sectors, with emphasis both on material and component development. The thrust, however, is on developing Mg-alloys under various Consultancy, Network and Sponsored projects, primarily due to the resurgence of Mg-alloys as a structural material for automobile and aerospace applications. Under the General Motors consultancy project, the effect of die design, alloy composition and extrusion parameters were studied in order to develop extruded Mg-alloys circular rods and tubes. Under CSIR Network project on Mg-alloy development of rare-earth doped Mg-alloys using spray forming, most of the target properties, as laid down under the project, pertaining to the porosity, yield and grain size have been met. Work was also continued under an in-house project on the development of Functionally Gradient Metal Matrix Composites using the modified stir-casting technique. MMC composites work was also continued in another CSIR Network Project under which Cu-based MMCs are being developed using the powder metallurgy technique.

Magnesium Alloys

General Motors Sponsored Project entitled "Advanced Magnesium Extrusion Alloys"

Magnesium alloy development is currently been extensively driven by aerospace & automobile industry requirements for lightweight materials to operate under increasingly demanding conditions. As a result, several automobile companies world wide, have launched massive R & D initiative in this direction in order to achieve potential weight savings to reduce vehicular emission and increase fuel efficiency. However, one of the main limitations of Mg-alloys, currently faced by industry, is the poor formability of these alloys due to limited room temperature ductility (owing to its hcp structure). In this context General Motors sponsored a project to NPL on "Advanced Magnesium Extrusion Alloys". Under this project, effect of die design, alloy composition and extrusion parameters is to be studied to develop Mg alloys possessing high strength and high ductility.

Extensive experimentation were conducted using Mg alloy billets to fabricate hollow circular tubes using a conical/dish shaped and a porthole die. Detailed characterization including microstructural examination and evaluation of mechanical properties was carried out and it was found that although port-hole die is more industrially common, the Mg-alloy tubes extruded using conical/dish shaped dies gave comparable results. The interesting results have been obtained in the case of circular extruded rods of Mg alloys. The rods were extruded at different extrusion ratios, i.e., 9:1, 25:1 and 36:1. It was found that optimum properties are obtained at the extrusion ratio of 25:1, achieving high ductility. A typical SEM of tensile fractured surface of this Mg-alloy extruded rod is shown in Fig. 3.1, clearly showing features of a ductile fracture.

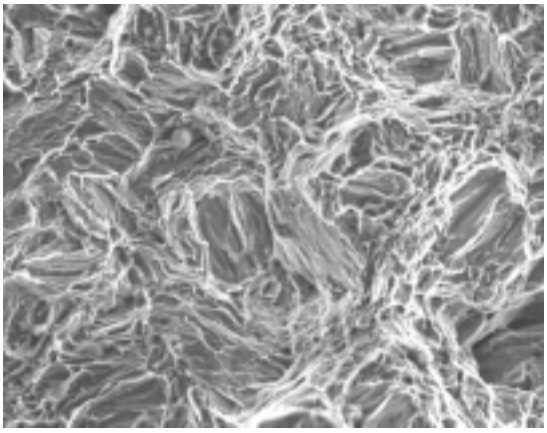


Fig. 3.1 : SEM of tensile fractured surface of Mg-alloy extruded rod showing ductile fracture

The main advantage of this high ductility observed is that such extruded alloys can further be secondary processed with ease for development of various components for specified automobile applications, using hydroforming, bending and other forming operations. The investigations on more alloy compositions and extrusion-processing parameters are under progress.

CSIR Network project on "Synthesis of Mg-alloys using rapid solidification and employing spray forming followed by secondary processing"

Under this Network project on development of

Mg-alloy L126 (Mg-RE-Zn-Zr), experiments was taken up using spray-forming technique by depositing the atomised droplets on a water-cooler copper substrate employing the spray atomisation and deposition unit. Various spray forming process parameters are being optimized like, melt temperature, flight distance, diameter of delivery tube (Gas to metal ratio), protrusion of the delivery tube, substrate motion, etc., in order to obtain conical deposits with equiaxed microstructure, low porosity, high yield and improved mechanical properties. All these processing parameters were found to have considerable effect on the shape, microstructure and mechanical properties of the spray formed deposits.

After taking several precautions, it was possible to eliminate the formation of MgO-phase in all the spray formed deposit, as indicated by X-ray diffraction study. Typical spray forming yields were found to be in the range of 60-65% of the weight of the melt. After optimising the process parameters, the porosity levels in the deposit were found to be around 2-3%, which is a considerable improvement over 5-7% that were obtained in spray forming experiments last year. The microstructure of the spray-formed deposit exhibits a fine equiaxed microstructure having grain size of 20-40 microns throughout the core of the deposit, although grain size of 5-20 microns were also observed in some experiments. Fig. 3.2 shows the microstructures of spray-formed Mg-alloy deposits showing equiaxed microstructure with different grain sizes depending on the process parameters. However, the mother cast alloy used for melting exhibited a non-uniform microstructure with grain size of ~ 150-600 microns.

The values of mechanical properties of the spray formed deposits were found to be : UTS = 215-228 MPa with elongation of 8-9%, as compared to the properties of the cast alloy used for spray forming which are : UTS = 117-123 MPa with a elongation of 2.8-3.3%. These results are taken from at least ten different longitudinal and transverse regions of the spray-formed deposit, suggesting thereby that the properties are reasonably uniform throughout the spray-formed deposit. These mechanical properties are expected to improve after secondary processing which would eliminate the residual porosity in spray formed deposits.

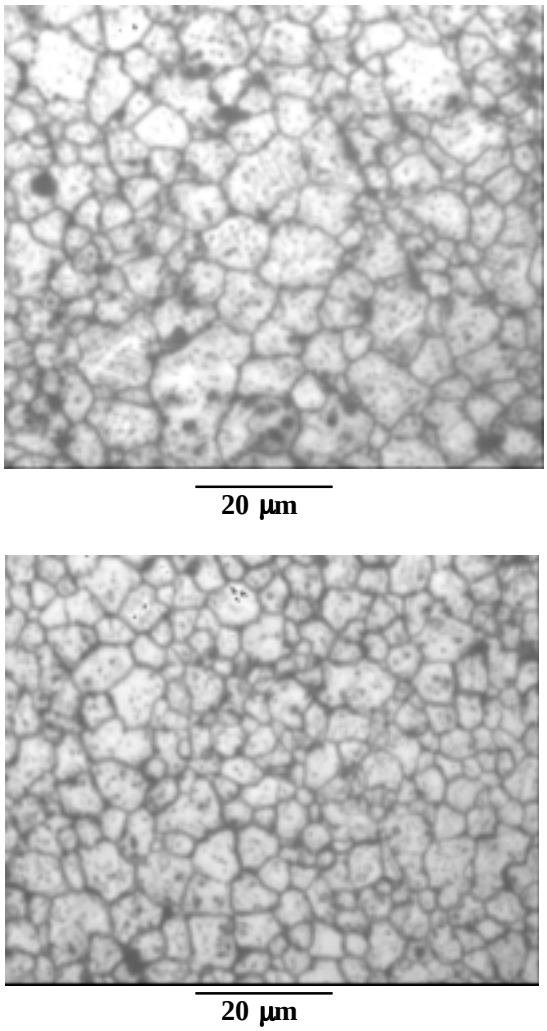


Fig. 3.2 : Microstructures of spray-formed rare-earth doped Mg-alloy deposits showing equiaxed microstructure with different average grain sizes depending on the process parameters (a) 10-30 mm (b) 5-20 mm

This project was reviewed twice during the last year in the project monitoring committee meetings held in NAL, Bangalore.

Vikram Sarabhai Space Centre (VSSC) sponsored project on "Spray forming technology of Mg-alloys"

Under this project, spray-forming experiments to synthesize AZ31 Mg-alloy (Mg-Al-Zn) were conducted using the smaller crucible size with lower melt weight. After optimising the process parameters it was observed that porosity in the spray formed deposit was found to be quite low ~2-3% in the

core of the deposit as compared to 4-5% obtained earlier. Similarly the grain size also was found to be considerably reduced in these spray formed deposits. Work is being continued under this project to reproduce these results over a few experiments and to attain the target properties.

Aluminium Alloys

In-house project on Spray atomisation and deposition of Al-Si alloys

Under this in-house project, work was commenced and a few experiments were conducted to spray deposit hypereutectic Al-Si alloys with Si ~ 17 wt%, on the spray atomisation and deposition unit. The master alloy of Al-Si, used for spray-forming was made using liquid metallurgy based stir-casting technique. The spray formed deposits are being characterized for their metallurgical, mechanical and wear characteristics, the results of which will be used in optimizing the process parameters.

Composites

CSIR Network project entitled, "Development of Cu-based MMCs using Powder Metallurgy technique for brake pad applications

The CSIR Network project was continued and under this project a Vacuum Sintering Furnace with maximum operating temperature of 1350 °C at a Vacuum of 10^{-6} mbar has been procured. This furnace has been installed and commissioned. Cu-based Metal Matrix Composites (MMC) have been fabricated using Powder Metallurgy technique and these have been sintered at different temperatures in the Vacuum Sintering Furnace in an inert atmosphere. These composite discs are being characterized using optical microscopy and microhardness. MMCs with different volume fraction of reinforcement are being synthesized and their wear properties of these MMCs discs will be now be evaluated on the wear and friction monitor.

In-house project on the synthesis of 2124Al/SiC_p functionally gradient metal matrix composite (MMC) material

Work was continued under this in-house project in which functionally gradient 2124Al/SiC_p MMCs were synthesized using conventional stir-casting technique with bottom melt pouring arrangement. Several experiments were conducted to study the effect of stirring speed on the gradient of reinforcement in the synthesized FGM material. Different stirring speeds in the range of 200-450 rpm were used for the synthesis of these FGMs. It was observed that on increasing the stirring speed the gradient of reinforcement in the FGM along the direction of pouring becomes steeper although the volume fraction of reinforcement at the bottom of the FGM billet increases sharply.

An experimental set-up was also made to synthesize one-dimensional Functionally Gradient MMC Material of 2124Al/SiCp using the modified Gradient Slurry Disintegration and Deposition technique. In this technique a slurry of molten matrix metal and ceramic reinforcement, stirred at high speeds is disintegrated by high velocity gas jets from an atomizer and the resultant droplets are deposited on a substrate placed at a specified distance below the atomizer. Different atomizer configuration were fabricated and exploratory experiments have been conducted to study the disintegration and deposition process using Al-alloy. This work will now be extended to make FGM MMCs of 2124Al-alloy/SiCp system.

Synthesis of BN nanotubes

Work was initiated to synthesize BN nanotubes using Mechanothermal Process as well as by chemical process. In the Mechanothermal process fine powder of hBN was ball milled for about 100 hours using a high-energy ball mill to transform it into a disordered state (100-200nm). This disordered sample was annealed at temperatures 950-1350°C in nitrogen atmosphere to get an ordered BN structure. Some work on the synthesis of BN nanotubes was also initiated using KBH_4 and NH_4Cl at high temperatures under nitrogen atmosphere. In this process the disordered BN of nearly the same grain size (100-200 nm) were obtained in just two hours, which were annealed to a temperature of 1300°C in nitrogen to get BN nanotubes. The samples were characterized by XRD. It is a planned to continue the work on both these processes next year.

B. ADVANCED CARBON PRODUCTS

A leading centre in India dedicated to research in both pure and applied science of Carbon with

Principal motives :

(i) To develop the process technology of newer carbon products which hold strategic importance and are not available to the country at any cost

(ii) To develop products which can be made cost-effective by innovative process suitable to available infrastructure, expertise and resources in India

(iii) To promote overall growth of carbon science and technology in the country through sustained R&D, research publications, patents, technology transfer, consultancy to industry, national & international conferences and refresher courses etc.

Silicon Carbide Nanofibres

Silicon carbide nanofibers were synthesized from coal tar pitch blended with sol-gel derived silica. Substituted silicon alkoxide was hydrolyzed to obtain the silica sol, which was blended with the pitch dissolved in a suitable solvent. The pitch silica mixture was heat-treated to 1400°C followed by oxidation at 700°C to get silicon carbide nanofibers. IR, Raman and X-ray studies reveal (Fig.3.3) the formation of silicon carbide while SEM and TEM studies show silicon carbide nanofibers having the diameter in the range 45-60 nm.

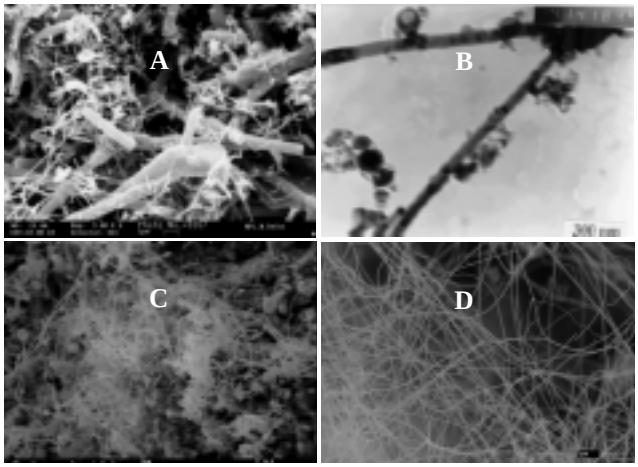


Fig.3.3
A – SEM Photograph of Pitch + MTEOS derived SiC Nanofibers (Pyrolysed at
HTT = 1400° C)
B – TEM Photograph of Pitch + MTEOS derived SiC Nanofibers (Pyrolysed at
HTT = 1400° C)
C – SEM Photograph of Jute + MTEOS (HTT = 1400° C)
D – SEM Photograph of Carbonised Jute + TEOS (Mixture Pyrolysed)

Silicon carbide nanomaterials were also synthesized using jute cloth and silicon alkoxides. Jute cloth and carbonized jute cloth were evacuated and impregnated with sol-gel silica derived from silicon alkoxides and pyrolysed at 1400°C. It was found that the non-carbonized jute cloth + sol-gel silica gave silicon carbide whiskers while the carbonized jute cloth + sol-gel silica yielded silicon carbide nanofibres as revealed by SEM studies.

Synthetic of carbon nanotubes and their applications in composites

(Indo-US and In-house project)

Synthesis of Carbon nanotubes by CVD technique

CNTs have been synthesized by using different hydrocarbons namely toluene, benzene, and xylene in the presence of ferrocene catalyst by CVD technique in two-zone reaction furnace with different diameter of quartz reactor. CNTs with different characteristics have been observed with the variation of process parameters and type of precursor material. These parameters have been optimized for CNTs preparation to maximize the yield. In this study upto 5.0 gm of CNTs are synthesized per batch with little amount of catalytic impurities in a 42 mm dia quartz reactor placed in a suitable electric furnace by using toluene as the carbon feed source and ferrocene as the catalyst precursor. The synthesized CNTs are 90 % pure with < 8% of metallic impurities. Small amount of catalyst was also observed in the form of nanowires inside the nanotube cavity.

Carbon Nanotubes Reinforced Polymer Composites

As synthesized carbon nanotubes by CVD technique were dispersed into different polymers, such as Phenolic resin, PMMA and molded into composites. Two techniques, dry mixing and wet mixing followed by solvent evaporation were tried to uniformly disperse the nanotubes in the polymer matrix. Various proportions of carbon nanotubes (1 wt.% to 50 wt.%) were molded into composites of size 50 mm x 5mm x 3mm. The curing temperature in case of phenolic resin was kept as 180°C. For comparison composites with neat phenolic resin (0% CNTs) were prepared of similar

dimension. These samples have been characterized for their mechanical properties. Mechanical properties of the composites was measured on INSTRON tensile testing machine and the fracture surface of the broken composites was observed under SEM for analyzing the nature of the nanotube/ polymer bonding.

Fig. 3.4 shows the SEM picture of the fractured surface of one of the composites. It is quite evident from the micrograph that the CNT/matrix bonding is not very strong and there are regions where considerable tube pull out has taken place. Flexural strength as well as flexural modulus of the resulting composites as shown in Fig.3.5. As shown in the Fig. 3.5 both the flexural strength and the flexural modulus of the nanotube reinforced composites registers an increase of 100% with only 4% by wt. of CNT reinforcement. The strength value of 127 MPa with multi-walled carbon nanotube reinforced phenolic resin composites has not been reported so far.

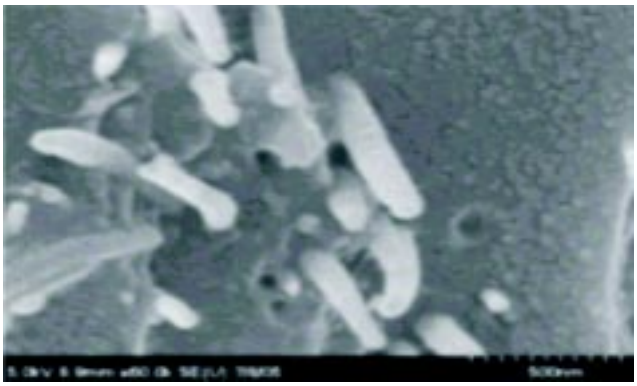


Fig.3.4 SEM of the fractured CNT composite

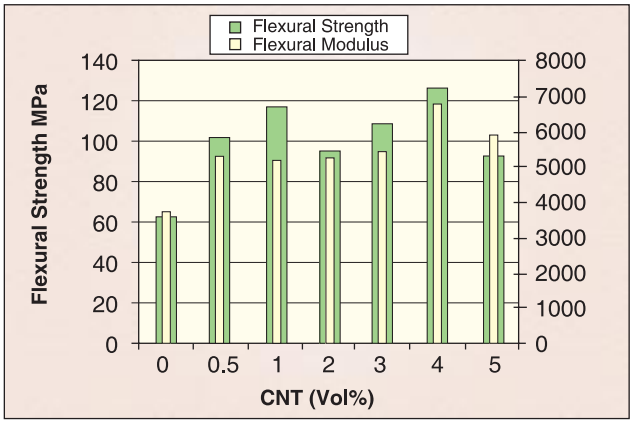


Fig. 3.5 Flexural strength as well as flexural modulus of the CNT composite

Development of High Thermal Conductivity Carbon Materials for specialized applications

Studies on the development of high thermal conductivity carbon materials, namely Carbon-Carbon Composites and Special Graphite were continued under the special project sanctioned by CSIR in lieu of NPL winning the 1999 CSIR Process Technology Shield.

Carbon-Carbon Composites

The C-C composites envisaged to be developed are to have a bulk density of 1.7 g/cc, compressive strength of 150–200 MPa and a thermal conductivity of 100–150 W/mK. The mesophase pitch based fibers (dialed type) of high thermal conductivity of the order of 540 W/m.K were used in the chopped form alongwith special high softening pitch (developed in house) as well as imported mesophase pitch to obtain the C-C composites. The samples of dimensions 15mmx15mmx3mm were prepared using the above fibers and both types of pitches separately. These green samples possessed bulk densities of 1.50-1.60 and 1.55-1.65 g/cc for the two types of pitches respectively. These samples when carbonised to 1000^{0}C and successive impregnated (five times) led to bulk density of 1.70-1.75 and 1.75-1.80 g/cc respectively and electrical resistivity values of 0.55-0.60 mohmcm for the two of pitch matrix systems respectively which correspond to a very high estimated value of K (>200 W/mK)of the composites. The thick samples 15mmx15mmx8mm prepared from dialed chopped fibres and inhouse developed high softening pitch give a density of 1.7 g/cc and electrical resistivity of 0.40 mohmcm at a HTT of 2500^{0}C and three successive impregnation which again indicate high thermal conductivity of the composites. Three dimensional (3-D) performs of size 100mmx50mmx50mm were also prepared from (dialed) pitch based fibres which were impregnated with a special pitch to obtain density of 1.40 g/cc at 1400^{0}C after two impregnation cycles. The composites are being processed further to obtain bulk density of 1.70 g/cc along with other desired characteristics.

Special Graphite

The special graphite to be developed is to have a thermal conductivity of 90–120 W/mK, besides a bulk density of ≥ 1.80 g/cc, bending strength of

≥ 40 MPa, Young's modulus of 8–12 GPa, Shore hardness of 50–75, electrical resistivity of 1.0–2.5 mWcm, etc. The work was continued to produce the graphite by isostatic pressing green coke mixed with (prepared inhouse) natural graphites two types in different proportions graphite followed by carbonisation to 1000^{0}C and 2500^{0}C. Isostatically moulded block possess a bulk density of 1.85 g/cc at 15% addition of natural graphite beyond which it decreases to 1.78 g/cc at 30% addition of natural graphite.

Development of High thermal conductivity carbon-carbon composites for thermal Management (CSIR network project)

Studies on the development of high thermal conductivity carbon-carbon composites possessing thermal conductivity values of the order of 250-275 W/m.K in the longitudinal direction and 75-90 W/m. K in the transverse direction and bulk density of

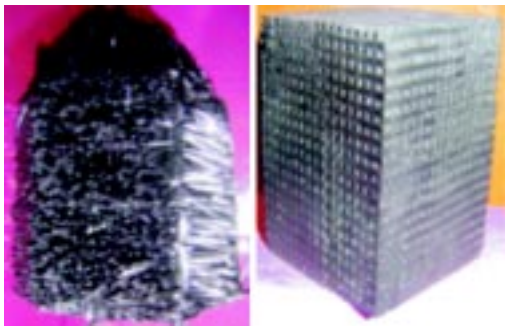


Fig.3.6 Photographs of the 3D Carbon fibre preform and the resulting C-C composite

1.75-1.80 g/cc were continued. Carbon composites possessing such high thermal conductivity values make them suitable as the first wall material in a fusion reactor. Efforts were made to develop bigger size of composite samples using pitch based carbon fibers and PAN based carbon fiber as reinforcement for 3D preform of size 100 mm x 50 mm x 50 mm. One of the performs was balanced weave while the other two were unbalanced weave. In case of balanced weave all the fibre tows in all the three directions i.e. x, y and z were from high modulus pitch based carbon fibers, while it was pitch fibres in x direction T-300 PAN based carbon fibres in the y and z directions in case of unbalanced weave. Fig. 3.6 shows the 3D carbon fiber preform and the resulting C-C composites developed at NPL.

Development of fuel cells based on hydrogen (NMITLI Project)

Development of porous conducting Carbon paper and advanced composites bipolar plate

The objective of the project is to develop a technology on batch scale for producing (i) Porous conducting carbon paper of size 100mm x 100mm x 0.3mm and (ii) advanced composite bipolar plate of similar size for use as two important components in Polymer Electrolyte Fuel Cell (PEM) under the New Millennium Indian Technology Leadership Initiative (NMITLI) programme.

A bipolar plate is one of the key components of proton exchange membrane fuel cells. Development of suitable material for use as bipolar plate is scientifically and technically exigent due to the need to maintain high electrical conductivity, better mechanical properties and low manufacturing cost. At NPL, advanced composite bipolar plates were prepared by compression molding technique. Natural graphite, synthetic graphite, carbon fiber, carbon black is used as different types of reinforcing

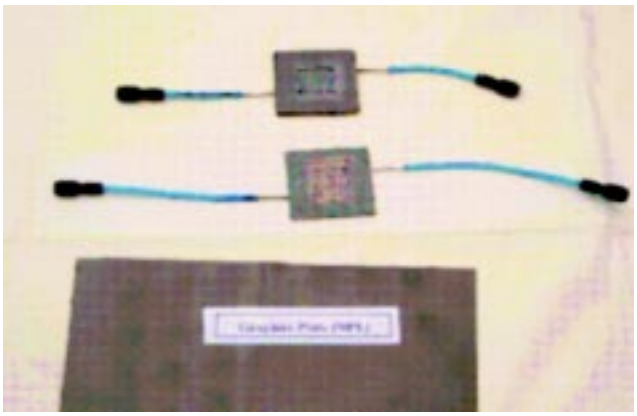


Fig.3.7(a): Advanced composites bipolar plate prepared at NPL

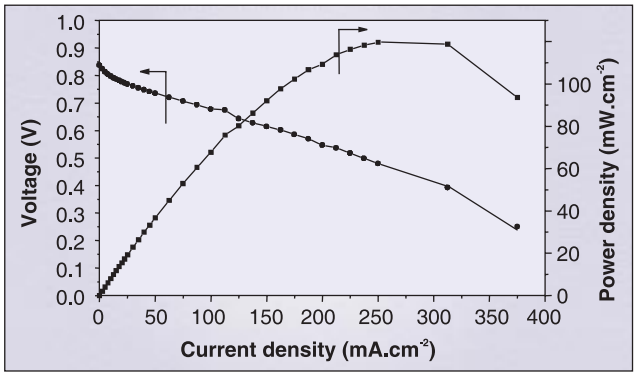


Fig.3.7 (b) I-V characteristics

constituents and phenolic resin as polymer matrix. It is found that single filler in natural graphite–phenolic resin composites does not give desired properties to satisfy the requirement of bipolar plate for use in fuel cells. A judicious combination of reinforcing fillers such natural graphite, synthetic graphite, carbon fiber and carbon black with can produce a bipolar plate with characteristic as bulk density >1.80 g/cc, electrical resistivity between 0.002-0.007Ω cm, shore hardness ~65, flexural strength~45MPa and modulus ~12GPa respectively. The current density performance of the composite bipolar plates depends upon the bulk density of the composites. The higher is the bulk density better is current density performance of bipolar plate. By applying the pressure during the processing of bipolar plate, one can develop the bipolar plate of much better physico-mechanical properties and therefore the power density performance. Composite bi polar plates of size 100mm x 100mm x 5mm developed at NPL by using suitable combinations of various components discussed above were supplied to CECRI, Fuel Cell Research Center, Chennai (our Collaborators in the project) for unit cell evaluation. Fig.3.7 (a) shows the composites bipolar plate prepared at NPL and Fig.3.7 (b) their I-V characteristics, and its performance was found comparable to the standard commercial "Schunk" plate.

Development of Speciality Carbon Materials for novel nuclear reactor (BARC project)

The objective of the project to develop the carbon fiber reinforced composites tubes for novel nuclear reactor as flow fluid channels. The nuclear rector operators at high temperature, therefore there is requirement of stringent materials, which can withstand high temperature. This should be stable under irradiation, constant mechanical strength, low atomic weight with high scattering probability etc. Graphitic carbons derived from C-C composites are suitable material as compared to monolithic graphite. In this direction NPL is developing the carbon-carbon composites tubes of length 100 mm, OD 50 mm and ID 25 mm by filament winding technique using different type of carbon fibers. So, for NPL is developed (Fig.3.8) the C-C composites using different type PAN based carbon fibers and from woven carbon fabric. Phenolic resin as well as coal tar pitch is used as a carbon matrix precursor. The properties of C-C composites tubes after three cycles of densification / carbonization are given follows.

Bulk Density	:	1.60 g/cc
Real density	:	1.75 g/cc
Open porosity	:	9.1 %
Shore Hardness	:	28
Deg. of graphitization	:	68 %

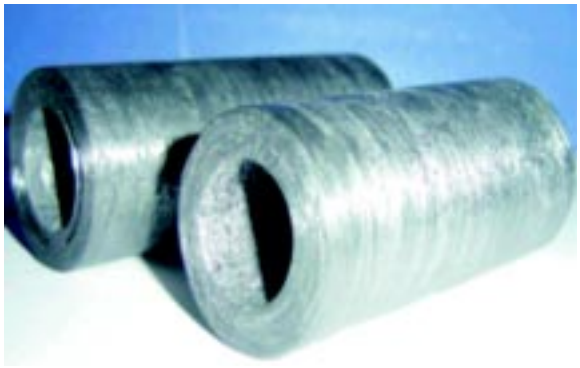


Fig.3.8 : Carbon/Carbon Composites tubes developed at NPL

Consultancy Projects

(1) The Consultancy project entitled "upscaling of the NPL's technology on green coke based high density graphite" sponsored by M/s Graphite India Ltd, Bangalore was completed. The consultancy was provided to the firm in respect of raw materials, type of reactor for the production of green coke, modification of green coke by physico-chemical treatments and other processing conditions. The green coke fine powder was isostatically pressed into blocks which were carbonised to 1000^{0}C and graphitised to 2500^{0}C without any impregnation treatment. The graphites so produced possessed an apparent density of more than 1.85g/cc alongwith high bending/compressive strengths and fine microstructure. The final report was submitted to the industry.

(2) The consultancy project relating to impregnating grade coal tar pitch from coal tar sponsored by M/s Coalchem Industry, Bhilai was undertaken. The coal tar raw materials provided by the party were characterised and used to prepare

impregnating grade coal tar pitch. Optimization of process is under progress.

New Project Initiated

A new project entitled "Development of Carbo-Graphite for Aerospace Applications" was sanctioned by DMSRDE, Kanpur for use as carbon seal in the Kaveri Engine. Preliminary work was initiated on the characterization of carbo-graphite with respect to various physical characteristics. The developmental efforts for this special graphite are in progress

C. POLYMERIC AND SOFT MATERIALS

Ferroelectric Liquid crystal

A number of practical applications of FLCs such as displays, image control, spatial light modulators or memory devices make them popular in today's world. But these too come with respective constraints. One has to work with constraints of thickness such as Surface Stabilized Ferroelectric Liquid Crystals (SSFLCs) geometry. Recently at NPL, it has been found that thickness independent memory effect is predicted in the FLC materials where Electroclinic coefficient $C_E = d\grave{e}/dE$ is very large and such type of materials are also called Electroclinic liquid crystal materials. Though investigation at this stage does not reveal the exact mechanism behind the memory in these materials, probably on application of bias field the molecules get clamped to one position and do not come back to their original scattering state due to electrically induced inertia of the molecules. It can be visualized from Fig. 3.9(a) that dechiralization lines are present in a virgin cell in deep Sm C^* phase. On application of 30 V bias for 2-3 minutes at the same temperature, the dechiralization lines completely vanish as shown in Fig. 3.9(b). It clearly shows the cell is in one of the stable states. Now when the bias has been removed we find no such lines (Fig. 3.9(c)). In fact Fig. 3.9(c) very much resembles Fig. 3.9(b) in which bias is being continuously applied. Figure 3.9(d) shows the appearance of dechiralization lines after the interval of nearly half an hour. One can say that the molecules have been clamped on to one side due to electrically induced inertia. Further investigation is still going on to find the basic mechanism, which is causing the molecules in the constraint state even after the removal of the bias.

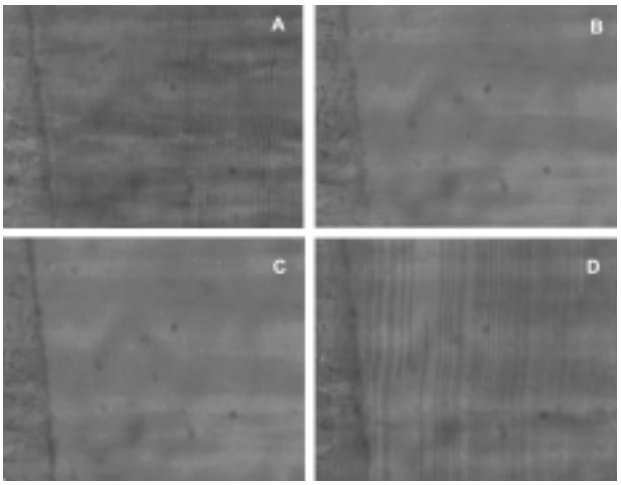


Fig. 3.9 Optical micrograph of Electroclinic liquid crystal in Sm C* phase at 14°C at (a) 0 V (b) 30 V bias (c) five minutes after removal of bias (d) Half an hour after removal of bias.

Conducting Polymers

Synthesis of Conducting Polymer-nano ferrites composites for its applications in Micro Wave Absorption coatings

Conducting polymer composites with nanoclusters of ferrite constituent in which ferrite constituents act as a core and conducting polymer make the shell of the composite have been synthesized. Different formulations of conducting polymer composites have been designed in order to see the effect of electrical conductivity on the loading levels of ferrite constituents. The resulting conducting ferrimagnetic composite possess the unique magnetic as well as electrical properties. VSM studies and electrical conductivity measurements have revealed that these composites have a magnetization saturation (Ms) value of the order of 48.9 emu/g and conductivity of the order of 1.2 S/cm. X-ray diffraction studies of the powder sample shows a crystallite size of the ferrite constituent of the order of 9.4 nm. The characterization of the composite has been carried out by FTIR, UV-Visible, SEM, X-ray diffraction, TGA and DSC techniques.

Modified Growth parameters for the synthesis of polyanilines and its copolymer and achieved thermal stability of 280-300°C

The processing and solubilization of conducting polymers are still the major unsolved problems from scientific and industrial point of view. The reason for this is the extensive delocalization of ð-electrons

which in turns gives the formation of rigid structure. To solve the unprocessible nature of these conducting polymers, synthesis has been carried by certain specific dopants and substitution has been carried out in the monomer moiety so that the resultant polymer so obtained is soluble in organic solvents like MEG, DMF, NMP, isopropanol etc. The conducting polymer so obtained was found thermally stable upto 280-300°C and hence can be easily melt blended with insulating polymers like PC+PPO, HIPS, PAN etc.

Synthesized copolymers of PEDOT and PANI for ESD

Copolymers of ethylene dioxythiophene (EDOT) and aniline have been synthesized by emulsion polymerization which can be used for making composites with conventional polymers like PS, PMMA, and HDPE etc. These conducting composites have been tested for static decay time measurements.

Synthesized copolymers of perylene and pentacene with substituted aromatic hydrocarbons for OLED devices and polymer solar cells

Copolymerization of toluene, xylene with perylene and pentacene has been carried out via oxidative coupling mechanism. The resultant copolymer is soluble in common organic solvents like chloroform, methylene chloride, THF, NMP and benzene. The copolymer shows red electro luminescence with a maxima at 698 nm at a onset voltage of ~10 volts. Copolymer has been characterized using spectroscopic and thermo gravimetric techniques.

Organic Light Emitting Diodes

We have studied the current-voltage (*J-V*) characteristics at different temperatures in hole only devices of poly (2-methoxy 5-(2-ethylhexyloxy) 1, 4-phenylene vinylene) (MEH-PPV), which is very important luminescent material for OLEDs applications. The *J-V* characteristic of MEH-PPV at 98 K on log-log scale is shown in Fig. 3.10. The curve shows ohmic conduction at low voltages, trap limited conduction at intermediate voltages and trap filled conduction at higher voltages. From these experiments we calculated hole mobility to be $0.2 \acute{} 10^{-5}$ $cm^2V^{-1}s^{-1}$ and the hole trap density of $1x10^{18}$ cm^{-3} in MEH-PPV.

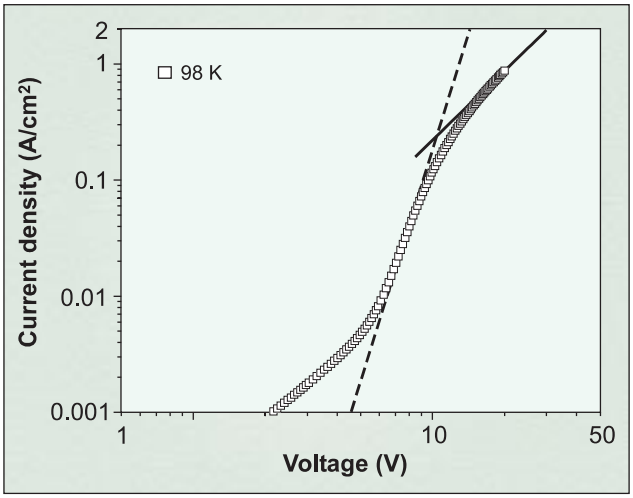


Fig. 3.10. *J-V* characteristic of conducting organic polymer MEH-PPV at 98 K. The symbols represent the experimental data, dotted line shows calculated curve, while solid line represents the trap filled V^2 region.

Bimolecular and Sensor Electronics

Development of DNA biosensor

Double stranded calf thymus deoxyribonucleic acid (DNA) was physisorbed on to polypyrrole-polyvinyl sulphonate (PPy-PVS) films electrochemically deposited onto ITO coated glass plates. These DNA immobilized films have been optimized using various conditions and characterized using FTIR, AFM and cyclic voltammetric techniques. The amperometric response studies were carried out as function of 2-aminoanthracene (2-AA) and *o*-chlorophenol (OCP). It has been reveled that 10 ppm of 2-AA and 25 ppm of OCP is capable of reducing the guanine oxidation current to zero.

Development of Conducting Polymer based Cholesterol Biosensor

Cholesterol oxidase, cholesterol esterase and peroxidase have been co-immobilized onto electrochemically prepared polyaniline films. These polyaniline enzymes films have been characterized using spectroscopic techniques and have been used to fabricate a cholesterol biosensor. Polyaniline based cholesterol biosensor have a response time of 240 sec, Km values as 75 mg/dl and can be used to estimate cholesterol concentration upto 500 mg/dl (Fig 3.11).

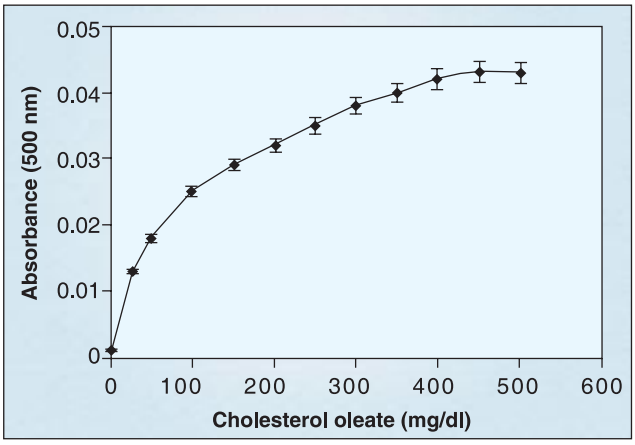


Fig. 3.11 Response of PANI/ChEt/ChOx/POD films as a function of cholesterol oleate concentration (mg/dl) at pH 7.0, phosphate buffer (50mM), phenol and 4-aminoantipyrine.

Organic Insulating Polymers for Device Application

To find suitability of organic insulating polymers in various device applications such as photoreceptors, light emitting diodes and polymer solar cells the role of polymer as interface barrier layer was studied in photoreceptor mode. To be precise effect of poly (styrene-acrylonitrile) [P(S:AN)]copolymer interface layer was studied on x-ray sensitivity of amorphous selenium using the potential decay technique. Dark and x-ray decay characteristics of amorphous selenium (a-Se) films (~100mm) were studied (Fig.3.12) as a function of P(S:AN) interface barrier layer film thickness (0 - 10000Å). Based on these investigations it was found that x-ray sensitivity of a-Se films increased from $6.3R^{-1}$ (without interface layer) to ~ 22.9 R^{-1} (with interface layer thickness of ~ 10000Å). This enhancement in x-ray sensitivity was attributed to the mechanism of blocking, trapping and field enhanced mobility role of P(S:AN) interface barrier layer. A typical curve showing potential decay characteristics of a-Se films with and without P(S:AN) interface layer. Curve A corresponds to without interface layer and curve B with P(S{AN) interface layer of thickness ~10000Å.

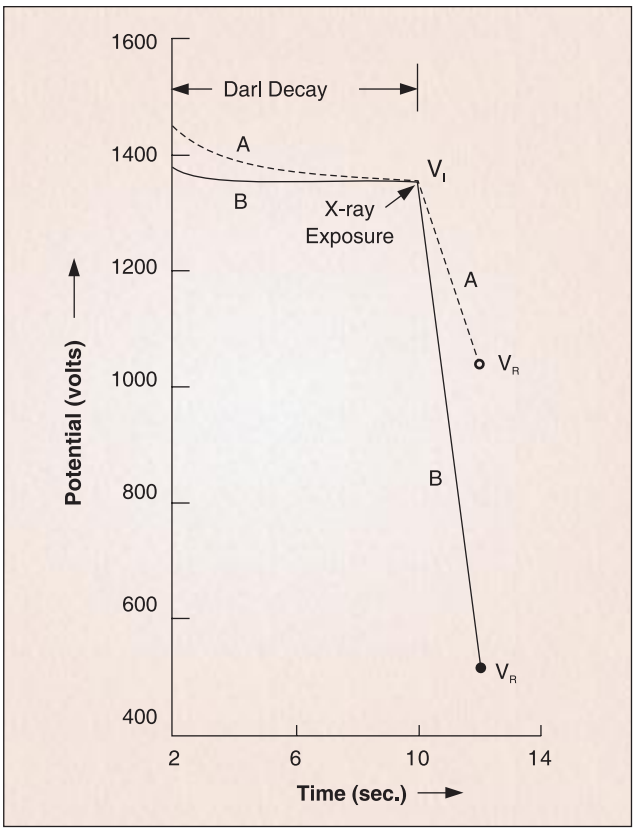


Fig. 3. 12 Dark and x-ray decay characteristics of Al/P(S:AN)/a-Se films. Curve A with no interface layer and Curve B with P(S{AN) interface layer of thickness ~ 10000Å.

Organic Solar Cells

The electrical conduction and morphology are important properties for organic solar cell applications. At NPL we have studied the surface morphology and electrical conductivity of poly(3-otylthiophene) [P3OT] films in both their pristine and doped states using the scanning electron microscopy and dc conductivity variation in the temperature range 10-300 K. Pristine P3OT film exhibits a mat-type structure whereas ferric chloride doped P3OT film shows conducting domains in the range 40–80 nm. The room temperature dc conductivities of pristine and doped P3OT films are $\sim 1\times 10\text{-}8$ S cm^{-1} and 8.2×10^{-4} S cm^{-1}, respectively. The temperature dependence of dc conductivity in the region 77–300 K, where hopping conduction dominates, is well described by Mott's three-dimensional variable range hopping transport.

Automation Group

Computerized R-T measurement Setup, I-V-T measurement Setup in the range 20K to 300K for Cryogenics. I-V measurement Setup, Light intensity vs Voltage measurement Setups (for two different Light Intensity measuring instruments) for OLED lab.

Developed the electronic circuitry for automatic controlling of the coloration of back view mirror in case of light falling on it, electronic circuitry for taking data from 16 different BOD sensors, for I-V measurements of Solar Cells, for 0-100V 100mA power supply.

Documented in detail the control cum data analysis program used for controlling the Solid Density Standard Setup.

D. LIQUID CRYSTAL MATERIALS AND DEVICES

Fabrication of micro patterned structures with contrasting physical properties

Soft lithography (micro contact printing) offers exciting prospects to create micro patterned structures on various solid surfaces with contrasting physical, chemical and surface charge properties for variety of application in the fields of biotechnology, biosensors and fundamental cell and culture studies. Micro contact printing (mCP) of alkane thiols $SH(CH_2)_nX$ with different functional groups where X could be methyl, alcohol, amide, imine, COOH, etc. has been utilized to create patterns structures on metal surfaces with contrasting hydrophilic and hydrophobic regions with dimensions going down to a few microns. In the first place, a monolayer coating of hexadecanethiol is done on selected regions of metal film by utilizing (mCP). Subsequently the substrate is dipped in 1mM ethanolic solution of mercepta hexadecanol to cover the remaining regions of the substrate. The sequential deposition of two S AM monolayers with different functional groups (CH3 and COOH) attached at their ends results in strongly hydrophobic and hydrophilic regions, respectively. When such a substrate is exposed to water vapor, the water wets only selected regions coated with polar group and repels from regions coated methyl groups.

Substrates showing such contrasting properties are being explored to selectively deposit biomolecules such as proteins and cells. Some initial results have been obtained and detailed investigations are being carried out to create pattern structures of biomolecules.

Control of the surface properties of Polydimethyl Siloxane (PDMS) rendering them hydrophilic

Polydimethyl Siloxane (PDMS) is widely used for μCP technique and for fabrication of microfluidic networks and devices. But μCP by PDMS has some drawbacks because it is strongly hydrophobic (contact angle (CA) of water on its surface is nearly 110°). If the ink is of a polar nature it does not spontaneously wet the PDMS stamp, drying inked stamps leads to inhomogeneous patterns; Surface hydrophilization of PDMS stamp is consequently needed for micro contact printing of polar inks.

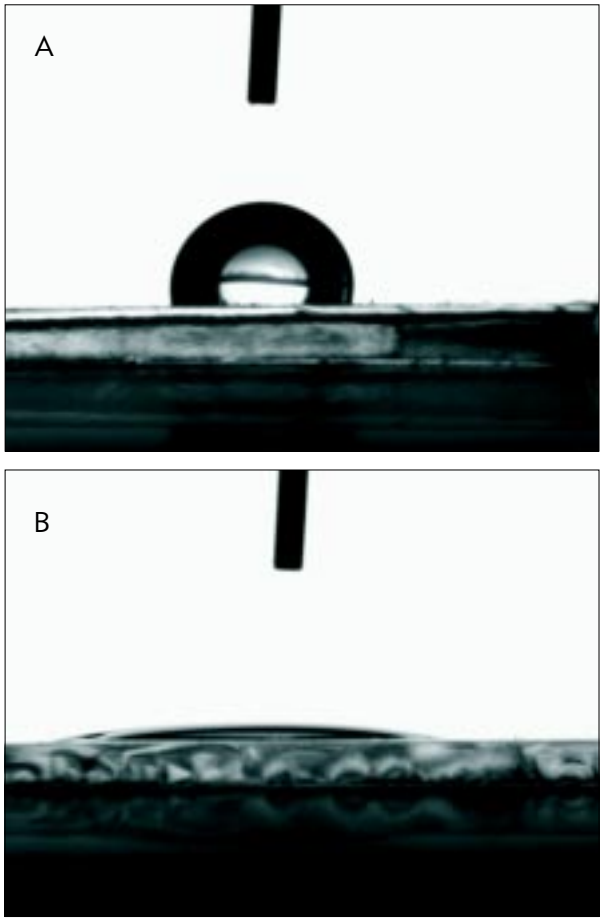


Fig. 3.13 (a, b) show the strongly hydrophobic and hydrophilic character of the PDMS surface with and without plasma oxidation.

The plasma oxidation is one of the best tool for the cleaning and waste removal from the surface. We used the plasma oxidation treatment on the PDMS for surface modification. It has been observed

that the surface properties of PDMS can be selectively rendered hydrophilic (showing water contact angle < 10°) and hydrophobic (showing water contact angle > 100°) with spatial resolution of a few microns as shown in Fig. 3.13

Fig. 3.13 (a, b) show the strongly hydrophobic and hydrophilic character of the PDMS surface with and without plasma oxidation.

However the surface quickly (with in less than a hour) regains its hydrophobic character if left in the air. It has been found that that the recovery time

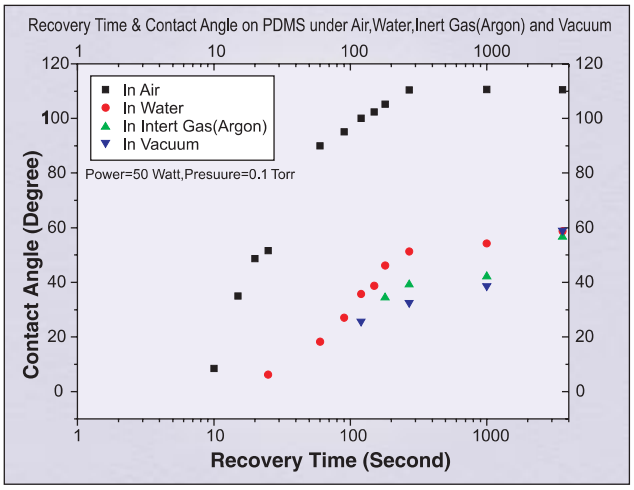


Fig. 3.14 Recovery time and contact angle of PDMS under different procurement conditons.

could be increased to a few weeks if the treated surfaces were preserved under proper environmental conditions. A detailed systematic investigations has been carried to evaluate the role of various experimental parameters such as the time of oxidation and partial pressure of oxygen in the plasma chamber, the power of the rf coil, composition of PDMS substrate on the change in the surface properties of PDMS. We have also studied in detail the time of hydrophobic recovery on the conditions of storage of the plasma treated PDMS stamps. Fig. 3.14 shows the time of recovery (change in the contact angle of PDMS) under various storage conditions. It can be clearly seen that the hydrophobic recovery is greatly influenced by storage conditions. However the PDMS surface could not be rendered permanently hydrophilic by plasma oxidation alone. We are presently working on grafting of suitable PEG based polymer to render the PDMS surface permanently hydrophilic.

Preparation of PDMS membrane with desired perforation

A new technique has been developed to create perforation in polymer membranes. In the first place, a desired pattern is created on the glass plate or silicon wafer using the SU-8 negative photo resist of appropriate thickness using standard photolithography. Subsequently PDMS prepolymer solution is spun on the patterned sample such that the thickness of spun PDMS film is less than the thickness of the photo resist film. The baking of the substrate is done at 50-60°C for one hour & the polymer membrane is peeled off from the substrate. We get the PDMS membrane with desired perforations as shown in Fig. 3.15. We can use these perforated PDMS membranes for the patterning of bio-molecular and for other applications.

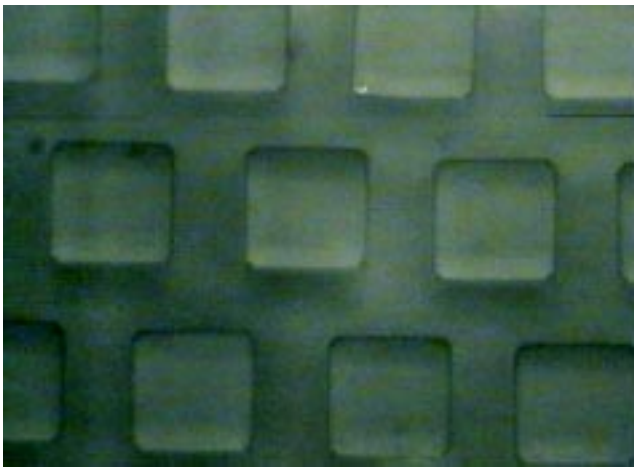
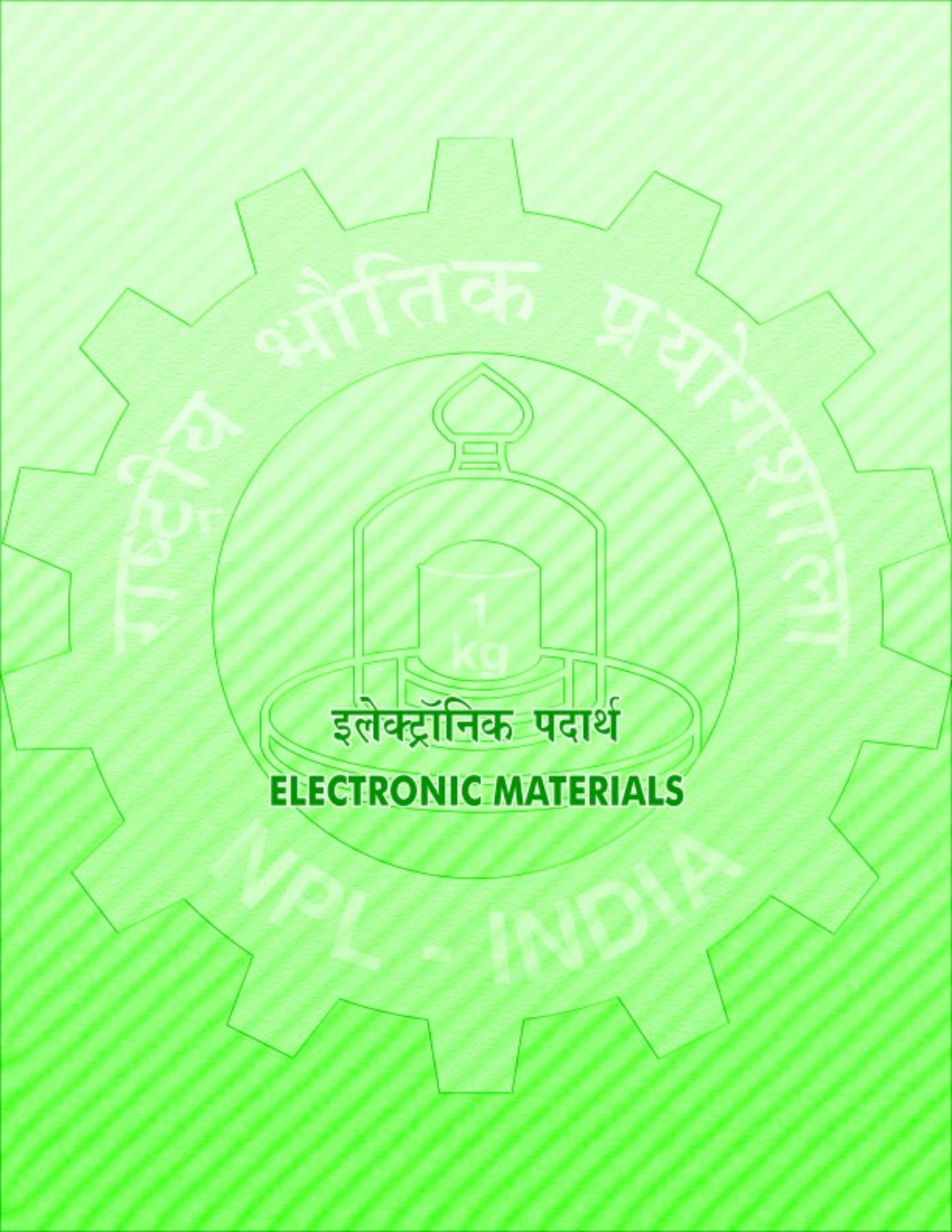


Fig.3.15 Perforations in PDMS with perforations of size ~80microns



इलेक्ट्रॉनिक पदार्थ

ELECTRONIC MATERIALS

इलेक्ट्रॉनिक पदार्थ

इलेक्ट्रॉनिक सामग्री प्रभाग सरकारी तथा निजी संस्थाओं की रूचि के विभिन्न प्रकार के अनुप्रयोगों के सम्बन्ध में सामग्रियों, साधनों तथा प्रणालियों की व्यापक विविधता पर अनुंसधान और विकास कार्य को आगे बढ़ाने में सक्रिय रूप से कार्यरत रहा है। प्रभाग में अनेक समूह विभिन्न प्रकार के कार्यकलापों में कार्यरत हैं जिनका विवेचन नीचे किया गया है :

संदीप्तिशील सामग्री तथा साधन समूह अग्रणी सरकारी तथा निजी संगठनों की महत्वपूर्ण मांगों को पूरा करने के लिए विभिन्न प्रकार के अकार्बनिक फॉस्फोरस तथा संबंधित साधनों के विकास से संबंधित अनुसंधान और विकास कार्यों में रत है, ये महत्वपूर्ण मांगें हैं - टी वी की पिक्चर ट्यूबों के लिए सल्फाइड फॉस्फोरस, अधिक ऊर्जा (1-15 एम ई वी) एक्सरे इमेजिंग के लिए प्रतिदीप्त स्क्रीनों के लिए दुर्लभ मृदा ऑक्सीसल्फाइड, संवर्धित स्फुरदीप्ति विशेषताओं सहित विशेष फॉस्फोरस के लिए रंगीन टी वी फॉस्फोरस तथा क्षारीय मृदा ऐलुमिनेट्स उपलब्ध करवाना। इस समूह ने विद्युत संदीप्तिशील फॉस्फोरस और पैनल विकसित किए हैं जो पाउडर और तनु फिल्म दोनों रूप में हैं। इसने नैनो फॉस्फोरस और औद्योगिक अनुप्रयोगों के लिए साधनों का विकास करने के लिए भी एक व्यापक योजना तैयार की है ।

सामग्री समूह का प्लाज़्मा प्रोसेसिंग समूह हाल ही में संस्थापित लेज़र आधारित दाब माप व्यवस्था का प्रयोग करके एम ई एम एस तथा सेंसर अनुप्रयोगों के लिए मोटी (SiO_2) फिल्मों में दबावों के अध्ययन में कार्यरत है। आर एफ प्लाज़्मा संवर्धित रासायनिक वाष्प निक्षेपण द्वारा माइक्रो तथा नैनो क्रिस्टलीय सिलिकॉन फिल्मों का निक्षेपण तथा तनु फिल्म सौर सेलों और सफेद लेड में अनुप्रयोग के लिए इनका अन्वेषण अनुसंधान और विकास का एक निरन्तर अनुधवन क्षेत्र था। हाइड्रोजन, नाइट्रोजन और बोरॉन समावेशन सहित चतुष्फलकीय अक्रिस्टलीय कार्बन के विकास और विशेषताओं पर अन्वेषण कार्य जारी रहा।

सिलिकॉन और सिलिकॉन साधन, एम ई एम एस (MEMS) तथा सेंसर ग्रुप पृष्ठ गठित तथा परिष्कृत क्रिस्टलीय सिलिकॉन सेलों के विकास और अभिलक्षण निर्देशन में कार्यरत है। बायोप्रोसेस अनुवीक्षण के लिए सूसख्म प्रणलियां विकसित करने के लिए सिलिकॉन में निक्षारित माइक्रो चैनलों में संरंध्र सिलिकॉन तैयार किया गया है।

नैनो संरचित, प्रकाशीय वैद्युतक्रोमिक तथा बहुलक सामग्री विकास समूह ने निम्नलिखित क्षेत्रों में विभिन्न प्रकार के कार्य आरंभ किए हैं -

- नैनोक्रिस्टलीय कोबाल्ट फेराइट पाउडरों और तनु फिल्मों का अन्वेषण।
- गैस संवेदकों में प्रयोग के लिए जलतापीय पाउडर संश्लेषण द्वारा तैयार नैनो संरचित सामग्री।
- संकीर्ण बैंड पारक तनु फिल्म फिल्टरों का विकास।
- प्लाज्मा बहुलकीकरण निक्षेपण प्रणालियों तथा विभिन्न प्रकार की बहुलक फिल्मों के निक्षेपण की प्रक्रियाओं का विकास।
- नैनो संरचित मध्यरंध्र टंगस्टेन ऑक्साइड फिल्मों, जो द्रुत गतियुक्त हैं, का वैद्युत क्रोमिक स्मार्ट विंडोज में प्रयोग के लिए विकास।
- अनेक प्रकार के घोल - प्रक्रमणीय सयुग्मित बहुलकों और सम्मिश्रों का बहुलक सौर सेलों के विकास में प्रयोग के लिए संश्लेषण और अभिलक्षण निर्देशन ।

उच्च तापमान वाले अतिचालक पदार्थ तथा उन्नत मृतिका शिल्प समूह उच्च धारा परिवहन के लिए Bi2223 तथा Bi2212 ट्यूब/छड़ चालकों, HTSC चुम्बकीय फिरकियों तथा तारों के लिए Bi2223 प्रदीर्घ लम्बाई वाली एकल/बहु तंतु टपों और धारा तारों के विकास, ट्यूबों को जोड़ने की एक नई पद्धति के विकास, (Bi,PB) एक डी-बैंड होस्ट के लिए पिन बंधन केन्द्रों की सभावनाएं तलाशने आदि के कार्य में संलग्न है। इसके अलावा, बीटा ऐलुमिना का सूक्ष्म तरप तापपुंजन और मृतिका आधारित एल पी जी संवेदकों का विकास कार्य प्रगति पर है। जल प्रदूषण अनुवीक्षण के लिए सॉल जेल से प्राप्त प्रकाशीय जैव संवेदक पर कार्य का प्रस्ताव रखा गया है ।

पृष्ठ भौतिकी तथा नैनो संरचना समूह ठोस पृष्ठों पर पृष्ठ घटना जैसे उच्च सूचकांक Si (5512) एम आई (5512) पर उप एकल परत प्रावस्थाओं का निर्माण अनावृत्त, गैडोलिनियम नैनो कणों की स्थिरता और हाइड्रोजनीकरण, SiO_2 फिल्मों में परिक्षेपित क्यूबिक तथा षटकोणीय CdTe सूक्ष्म कणों की सिंटरिंग के दौरान ऑक्सीजन की भूमिका और XPS गहराई परिच्छेदिका तथा प्रकाशीय मापनों द्वारा अन्वेषित टोपो (TOPO) आच्छादित CdSe नैनो क्रिस्टलों पर अल्प ऊर्जा आयन प्रेरित प्रभावों के अध्ययन में कार्यरत था ।

ELECTRONIC MATERIALS

MANDATE AND MAJOR ACHIEVEMENTS

The Division of Electronic Materials has been actively engaged in pursuing R & D work on a large variety of materials, devices and systems, for multifarious applications of interest to government and private institutions. Several groups in the Division are involved in a host of different activities, enumerated below:

Luminescent Materials and Devices Group is engaged in R & D activities related to the development of variety of inorganic phosphors and related devices, to meet the strategic demands of leading government and private organizations — sulfide phosphors for TV picture tubes, rare earth oxysulfides for fluorescent screens for high energy (1-15 MeV) X-ray imaging, colour TV phosphors and alkaline earth aluminates for special phosphors with enhanced phosphorescence characteristics. The group has developed electroluminescent phosphors and panels both in powder and in thin film form. It has also drawn up an extensive plan for development of nanophosphors and devices for industrial applications.

Plasma Processing of Materials Group has been engaged in studying the stresses in thick SiO_2 films for MEMS and sensors applications, using a recently installed laser based stress measurement set-up. The deposition of micro and nano crystalline silicon films by RF plasma enhanced chemical vapour deposition and their investigation for applications in thin film solar cells and white LED's was an ongoing area of R & D. Investigations on the growth and characteristics of tetrahedral amorphous carbon with hydrogen, nitrogen and boron incorporation continued.

Silicon and Silicon Devices, MEMS and Sensors group has been engaged in the development and characterisation of surface-textured and improved crystalline silicon solar cells. Porous silicon has been grown in microchannels etched in silicon to develop microsystems for bioprocess monitoring. Growth of nano- and micro-structured porous silicon has also been undertaken.

Development of Nanostructured, Optical, Electrochromic and Polymeric Materials group has undertaken multifarious activities in

- Investigations of nanocrystalline cobalt ferrite powders and thin films
- Nanostructured materials prepared by hydrothermal powder synthesis for use in gas sensors
- Development of narrow bandpass thin film filters
- Development of plasma polymerization deposition systems and processes for the deposition of a variety of polymeric films
- Development of nanostructured mesoporous tungsten oxide films with fast kinetics for applications in electrochromic smart windows
- Synthesis and characterization of a variety of solution-processable conjugated polymers and composites for application in the development of polymer solar cells

High Temperature Superconducting Materials and Advanced Ceramics group is engaged in the development of Bi-2223 and Bi-2212 tube/rod conductors for high current transport, Bi-2223 long length mono/multifilamentary tapes and current leads for HTSC magnetic spools and cables, development of a novel method of joining (Bi, Pb) – 2223 tubes, exploring the possibilities of pinning centers for a d-band host, etc. Moreover, the microwave sintering of beta alumina and the development of a ceramic-based LPG sensor are in progress. Work on sol-gel derived optical biosensor for water pollution monitoring has been proposed.

Surface Physics and Nanostructures Group was engaged in several studies regarding surface phenomena on solid surfaces, such as formation of Sb submonolayer phases on high index Si (5 5 12) surface, stability and hydrogenation of "bare" Gadolinium nanoparticles, role of Oxygen during sintering of cubic and hexagonal CdTe nanoparticles dispersed in SiO_2 films and low energy ion induced effects on TOPO capped CdSe nanocrystals probed by XPS depth profiling and optical measurements.

R & D ACTIVITIES

Advanced Luminescent Materials and Related Devices

Luminescent materials known as phosphors are able to convert absorbed (invisible) energy in the form of moving particles or quanta of radiation into visible light. The major and important applications of phosphors are in light sources, display devices and detection system. The Luminescent Materials and Devices group continued its work towards developing phosphors, with special emphasis to nanophosphors, for applications such as solid-state lighting using blue LED, field emission and other display devices.

Nanophosphors have been synthesized during the last few years by many processes and techniques as these have demonstrated their application potential for various novel and efficient displays and devices. A brief review of different synthesis techniques employed all over the world for the development of industrially important nanophosphors was prepared and published for the benefit of the R & D community.

The field of solid-state white lighting has become very active globally as better energy efficiency can be achieved compared to present day light sources. YAG:Ce phosphor in nanophase has been synthesized for this purpose and studied. Fig. 4.1 shows excitation and emission spectra of the synthesized phosphor. Other phosphors with excitation in the range of 450-470 nm are being explored for use with blue light emitting LED for generation of white light. A Japanese company showed interest in developing this category of phosphors.

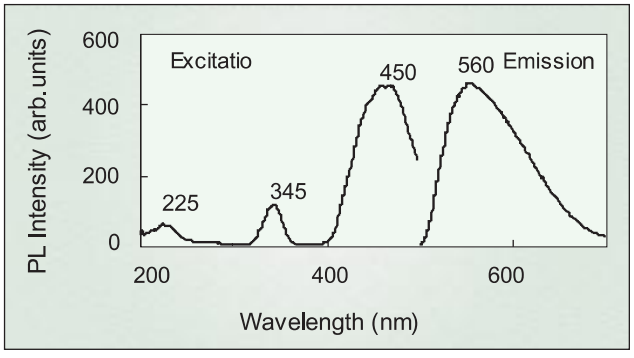


Fig. 4.1. Excitation and emission spectra of YAG: Ce nanophosphor

Development of long persistence phosphors is another important activity. These phosphors find applications in emergency escape route markings and for locating important objects in the dark. Green emitting phosphor is the most common, but to get full colours in the dark, phosphors emitting in blue and red are also needed. A process to prepare blue light emitting long decay/persistence phosphor excitable with ambient light has been developed, with a persistence time of 6-8 hrs (Fig. 4.2).

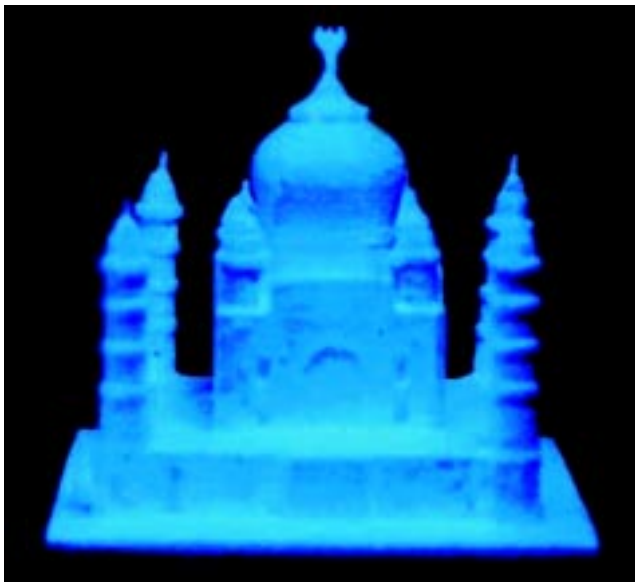


Fig. 4.2. Model of Taj Mahal coated with blue- emitting long decay phosphor, viewed in the dark

To achieve the goal of developing nanophosphor based devices, a simple methodology has been developed for dispersing the silica-capped ZnS:Mn nanophosphors with controlled particle density as two-dimensional (2D) layers. Size-controlled ZnS:Mn nanoparticles were capped with silica for their surface passivation, growth retardation, and stabilization against environmental attacks. Controlled particle density, uniform particle distribution, good room temperature photoluminescence, etc. were important achievements.

Plasma Processed Materials, Devices and Systems

A CSIR Network project on MEMS and sensors is being undertaken, whose major objective is to study the stress in thick SiO_2 films. A laser based stress measurement set-up has been installed and thick silica films were analysed for stress.

A physical vapor deposition technique known as "Filtered cathodic vacuum arc" (FCVA) for the deposition of tetrahedral amorphous carbon (ta-C) films has been set up and a reactor for the same custom designed and indigenously developed, perhaps for the first time in India. Fig. 4.3 is a photograph of the system developed under a DST sponsored project. The system consists of (a) water cooled cathode and anode (b) S bend magnetic filter on 6 inch duct to remove the macro particles and neutrals generated in the arc and (c) an 8 inch S.S. Cross deposition chamber with a provision of biasing the substrate. The system is evacuated by two turbo pumps backed by two rotary pumps and a base pressure of $\sim 1x10^{-6}$ mbar is achieved in the system. The magnetic filters are energized by using three different D.C. power supplies. A mechanical striker initiates the arc. The film is deposited by condensation of highly ionized plasma on any substrate including low melting point plastic at room temperature. The cathodic vacuum arc offers the opportunity of growing various forms of carbon ranging from highly diamond-like to graphite- like and various intermediate materials like tetrahedral amorphous carbon (ta-C), hydrogen and nitrogen incorporated tetrahedral amorphous carbon, nanoclustered carbon , nanocomposite and carbon nano tubes.

The system developed has been used so far to grow (i) ta-C films, (ii) hydrogen and nitrogen incorporated ta-C films and (iii) boron and phosphorous incorporated ta-C films. The investigations on undoped and doped ta-C films involving electrical conductivity, activation energy, stress, hardness, optical band gap, space charge limited conduction, electron paramagnetic resonance, spectroscopic ellipsometry, X-ray photoelectron spectroscopy, X-ray Auger electron spectroscopy, photoluminescence, SEM, AFM and field-emission measurements etc, have been carried out. The effect of varying substrate bias on the properties of as grown (undoped) ta-C films, varying amounts of hydrogen and nitrogen incorporation and the effect of varying the amount of boron and phosphorous dopants on the properties of ta-C have been studied.

Tetrahedral amorphous carbon (ta-C), relatively a new semiconductor, which is somewhat analogue to a-Si and a-Ge is of great technological importance due to its possible applications in displays and vacuum microelectronics etc. The system so developed will be used to grow a new form of amorphous carbon thin films having nanoparticle inclusions and nano tubes using novel modified arc based techniques in future and its application for field-emission type of display devices and tribological coatings will be explored.

Fig. 4.3. A custom designed and indigenously developed S bend FCVA process equipment

Silicon Devices, Mems and Sensors

A silicon solar cell usually consists of a diffused p-n junction made in a thin silicon wafer. Texturization is one of integral parts of fabrication of crystalline silicon solar cell to enhance absorption of light in the cell. To achieve this, the reflectance of the solar cell has to be reduced as much as possible so that the weak incident light can be trapped on surface to get the maximum output. Anisotropic etching is a well-known technique in the field of silicon micro-machining or V-groove etching on <100> oriented silicon wafers to produce three dimensional structures. The texturization of the mc-Si for solar cell with alkaline or acidic solution has been investigated. It has been found that the reflectance of a mc-untextured silicon surface is reduced marginally by alkaline or acidic textured mc surface and so are not good enough. Hence a $\lambda/4$ coating of silicon nitride (λ about 600nm) can reduce the reflectivity to about 5%. Silicon nitride also serves as a surface and grain boundary passivator. This silicon nitrite coating also serves as a surface as well as grain boundary passivation to increase the efficiency of mc-Si solar cell. The SEMmicrographs of both alkaline textured and acidic textured mc-Si

are nearly same and a representative micrograph is shown in Fig. 4.4.

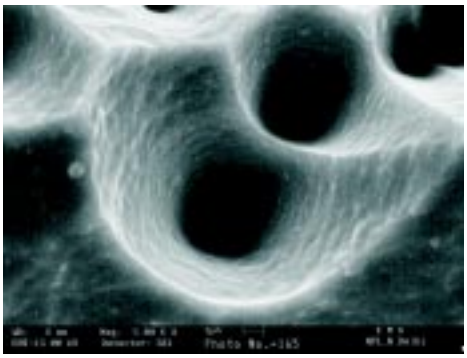


Fig. 4.4. SEM micrograph of textured mc-Si

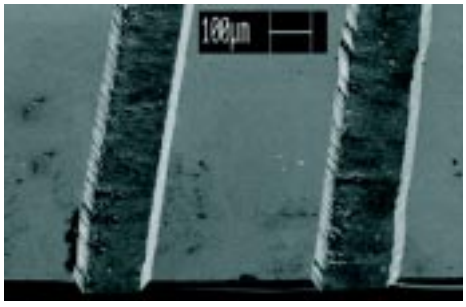


Fig. 4.5. SEM micrograph of typical microchannel

In the development of microsystems for bioprocess monitoring, enzymes are commonly used to obtain biospecific detection. The enzyme is immobilized on the high surface area porous matrix. As the sample passes through the packed bed the substrate is covered by the enzyme, giving rise to reaction products that can be detected optically or electrochemically. Silicon surface when covered with PS provides a large enhancement in surface area ($\sim$200m^2 cm^{-3}) as compared to non-PS samples. The surface area could be enhanced further if the PS layer is grown on micro channels. In order to fabricate microchannels on crystalline silicon (c-Si) alkaline anisotropic wet etchants are used to have V (flat bottom) and U- grooves on <100> and <110> oriented wafers respectively. This is useful to make microelectromechanical systems (MEMS) in general and PS sensors in particular. The depth of the channels was measured and came out to be 100$\pm$10 μm. A representative micrograph is shown in Fig. 4.5. PS was grown in an electrochemical bath with Si was the anode while the counter electrode consisted of a Pt wire mesh that was positioned in the electrolyte at a distance of 2 cm from the anode. The resulting thickness of the PS layer was measured and found to be 250$\pm$15 nm.

NANOSTRUTURE DEVICES, OPTICAL THIN FILMS, ELECTROCHROMIC DEVICES, POLYMER DEVICES

Thin Film Optical Coatings

The Leybold L-560 vacuum coating plant was restored to operation and multilayer coatings of 35 layers were deposited, to serve as narrow bandpass filters in the 800 - 900 nm range. Narrowband filters had typical characteristics : Peak transmittance 68- 83%, halfwidth about 16 nm, center wavelengths in 800-900 nm range, stopband range about 100 nm on either sides of the centre wavelength (Fig. 4.6). A glass block holder and calotte mount, monitor plate holder and test plate holder were designed and fabricated. A 17 layer high reflectance coating of TiO_2 and SiO_2 $\lambda/4$ layers at 850 nm was deposited on one face of a glass block for the fabrication of a WDM device.

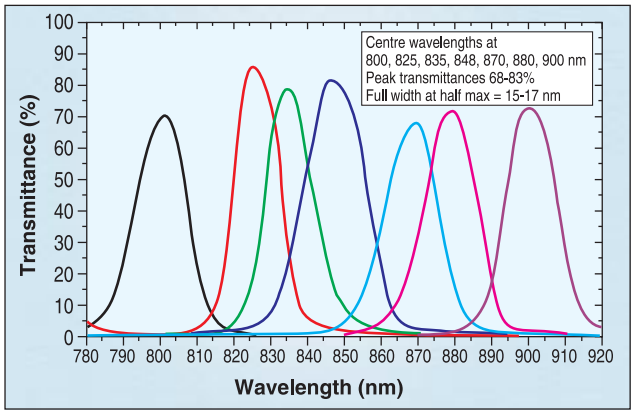


Fig. 4.6. Spectral characteristics of fabricated narrowband filters

Development of Plasma Polymerisation Systems and Thin Film Coatings

Total integration of the plasma polymerisation deposition system for ***polymeric dielectric films*** has been completed with incorporation of the in-house designed and fabricated cold trap and the procured automatic pressure controller and mass flow controllers, along with the required couplings, adapters, valves, etc. A second deposition system for ***polymeric conducting films***, consisting of deposition chamber with parallel plate electrodes, gas manifold, liquid vapour delivery system, rotary, roots and diffusion (turbo) pumps, has also been fabricated and assembled. Both systems are

operational (Fig. 4.7).

Good quality TiO2-like and SiO2-like polymeric films have been deposited and characterized for incorporation in antireflection coatings on polycarbonate substrates. Transparent conducting films of ITO with sheet resistances of about 40Ω/□ with visible transparency of about 85% have been achieved. Efforts to optimize the deposition parameters for best film quality continue.

Fig. 4.7. Plasma polymerization deposition systems

Polymeric Materials and Devices

Solution processable conjugated polymers and their composites have been synthesized and characterized for application in the development of polymer solar cell. The important polymers of polythiophenes family such as poly(3-octylthiophene) (P3OT), poly(3-hexylthiophene) (P3HT) have been synthesized by chemical polymerization at low temperatures using ferric chloride (FeCl3) as an oxidant in an inert atmosphere. Development of composites of P3HT, P3OT with carbon nanotubes and fullerene and its derivatives is in progress.

In a related study an unusual morphology in solution processable P3OT synthesized in our laboratory has been observed. The P3OT is comparable with high quality regio regular poly (3 - alkyl thiophene), rr-P3ATs. Upon thermal annealing a rare well arranged corrugated-rod-type (CRT) morphology has been observed for the first time by SEM, supported by photoluminescence quenching, red shift of l_{max} (π-π^* absorption) in UV–vis spectra and increase in conductivity. These improvements in physical properties are perhaps due to the increase in the planarity and 3D-π-π stacking of polymer chains by gradual soft-thermal annealing. The improvement in the quality of P3OT may induce self-assembly due to increased π-π interactions. The surface morphology and electrical properties of P3OT films, in both their pristine and doped states, were studied by SEM and the variation of conductivity with temperature in the range 10–300 K. Pristine P3OT film exhibits a mat-type structure whereas ferric chloride doped P3OT film shows conducting domains in the range 40–80 nm (Fig. 4.8). The room temperature dc conductivities of pristine and doped P3OT films are $\sim 1\times10^{-8}$ S cm^{-1} and 8.2×10^{-4} S cm^{-1}, respectively. The temperature dependence of dc conductivity in the region 77–300 K, where hopping

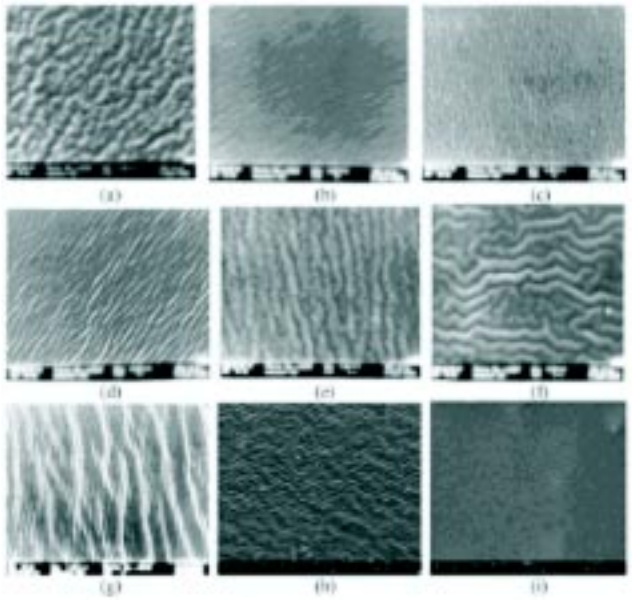


Fig. 4.8. SEM micrographs of pristine P3OT films annealed at 373 K for different interval of time (a) unannealed—303 K (b) 1 h, (c) 5 h, (d) 12 h, (e) 24 h, (f) 48 h, (g) 72 h, (h) annealed for 5 h at 423 K, and (i) annealed for 5 h at 473 K.

conduction dominates, is well described by Mott's three-dimensional variable range hopping transport. A new mechanism of chemical doping of p-conjugated polymer has been proposed.

Nanocrystalline Cobalt Ferrite Powders and Thin Films

Cobalt ferrite, $CoFe_2O_4$, is unique among cubic spinel ferrites with a cubic magnetocrystalline anisotropy as high as that of hexagonal barium ferrite and has been well studied for possible magnetic recording applications. Nanoparticles prepared by low temperature chemical methods and thin films often show magnetic properties and cation distributions that are different from bulk. Stoichiometric cobalt ferrite nanoparticles in the 5-20 nm size range were prepared from a citrate precursor by a self-ignition reaction initiated at near dryness, to form fine brown flakes of ferrite. XRD pattern of the self-ignited powder shows typical inverse spinel structure with broad lines characteristic of nanoparticles. Particles in the of 5-20 nm size range were observed at different stages of nucleation and growth by TEM. The hysteresis loop shows a relatively low magnetization of 30 emu/g and a coercivity of 800 Oe. The magnetization does not saturate in 10 kOe. Thin films (100 nm thick) were deposited by a spray pyrolysis method. Films annealed at 700°C and above showed single spinel phase and coercivity of 1000 Oe. Improvements have been made in the deposition procedure and conditions to grow more than 10 microns thick films of barium ferrite, for applications in microwave circulators.

Nanostructured Mesoporous Tungsten Oxide Films With Fast Kinetics for Electrochromic Smart Windows

A potential driven self-assembly of sodium dodecyl sulfate/ tungsten oxide aggregates at the electrolyte-electrode interface followed by template extraction and annealing yielded mesoporous thin films of electrochromic tungsten oxide (WO_3). SEM images revealed a hitherto unreported hybrid structure comprising nanoparticles and nanorods, with a tetragonal crystalline phase of WO_3. This resulted in coloration efficiency and switching kinetics higher and faster than previously reported. Repetitive cycling between the clear and blue states has no deleterious effect on the electrochromic performance of the film, indicating its potential as cathode in practical electrochromic windows. A simple and inexpensive strategy has been employed to synthesize mesoporous tungsten oxide films with a hybrid structure comprising nanoparticles and nanorods with a tetragonal crystalline phase, not been reported so far. Such a microstructure aided ion-movement resulted in coloration efficiency and color-bleach kinetics higher and faster than previously reported for mesoporous nanostructured WO_3. The films also sustain 1000 color-bleach cycles without any degradation, which hints at their suitability for smart electrochromic windows.

As-deposited sol-gel derived amorphous tungsten oxide films transform into nanostructured films with an interconnected framework of grains and pores and a dominant triclinic crystalline phase upon annealing at 250°C. Microstructural changes on annealing were studied by TEM, SEM, XRD, etc. The effect of lithium ion intercalation on the chemical composition of the WO_3 films was studied in detail using X-ray Photoelectron Spectroscopy for the first time. Typical mesoporous WO_3 films in blue and clear states are shown in Fig. 4.9.

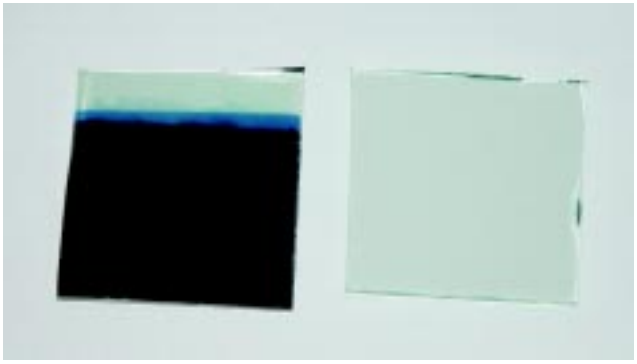


Fig. 4.9. Mesoporous WO_3 films in blue and clear states

Nanostructured Materials for Gas Sensors

Hydrothermal powder synthesis has been known as a powerful technique for the preparation of fine, high purity and homogeneous powders of various single component and multi-component powders. Hydrothermal reactions are usually performed in moderate conditions, do not require expensive precursors or equipments. The temperature, pH, dilution can be controlled to obtain powders of required size. The synthesis of SnO_2, ZnO and ZnS

powder using the hydrothermal synthesis route under a variety of synthesis conditions was carried out. The solvents, additives and dopants were varied. Powders were characterized using XRD, TEM for their particle size and morphology. The optical properties of synthesized powders were investigated by optical absorption and photoluminescence studies. Nanocrystalline powders of various sizes and morphologies obtained depended on the synthesis conditions.

HIGH TEMPERATURE SUPERCONDUCTING MATERIALS/DEVICES & ADVANCED CERAMICS

High Temperature Superconducting (HTS) Materials/ Devices

The core component for majority of the high energy applications of HTS are HTS tube/rod conductors and long length wires/tapes, which can transport very high electrical current (>KA), can provide high fields and can withstand very high fields. This is the main object of applied work on Bi-2223 & Bi-2212 HTS.

Applied Research Studies

- HTS (Bi, Pb)-2223 tube current leads of large size (43 cm long, 4.8 cm diameter, 3 mm wall thickness) have been developed (Fig. 10). Work on joining of a pair of such tubes is in progress.
- A patent on a novel method for joining of a pair of tubes of (Bi, Pb)-2223 HTS of lower dimensions has been submitted. The joint is not only superconducting but also stable for carrying critical currents. *There are no reports so far on joining of superconducting tubes.*
- Seven monofilamentary Ag clad (Bi, Pb)-2223 tapes (Fig. 4.10) of length varying from 30 m to 35 m, which all are superconducting end to end and can carry critical transport current of 50 A at 4.2 K have been developed. A small magnet has been assembled by stacking two pancakes in series made by wind & react method and has been tested. The optimization of wind & react parameters and another magnet assembled by stacking four pancakes in series is under testing.

Basic Research Studies

The only parameter at HTS compounds which limits their use at 77 K in their low upper critical field and which can be improved upon by a proper understanding of the nature and mechanism of electron/hole pairing and pinning of flux lines as microscopic and macroscopic aspects of the HTS compounds are highly interwoven and this is the focal point of basic research.

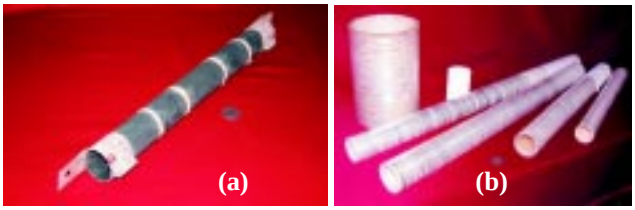


Fig. 4.10. (a) High temperature superconducting (Bi, Pb)-2223 tube current lead
(b) monofilamentary long length tapes.

Ionic Conductors

Work on microwave sintering of beta alumina was initiated. Initial studies reveal microwave sintering is superior to conventional sintering methods, which was substantiated by microstructural studies. Scanning Electron Micrograph of beta alumina processed at 1300 - 1600°C shows gradual grain size variations. As a part of LPG sensor development the effect of Pb incorporation, operating temperature, morphology, and sensitivity were studied. Out of various sensor compositions, sintered Pb doped SnO_2 has shown high sensitivity towards LPG.

Surface Physics And Nanostructures

- **Formation of Sb submonolayer phases on high index Si(5 5 12) surface**

  Sub-monolayer antimony nanostructures using the highly trenched high index (5 5 12) surface have been formed as templates for the growth of single atom nano-wires for the first time. Temperature treatment relaxes this one-dimensional structure to form a zig-zig chain due to strain relaxation. Chemical and structural aspects are probed by surface sensitive electron spectroscopies & Low Energy Electron Diffraction.

- **Synthesis of cubic and hexagonal CdTe nanoparticles dispersed in SiO2 films: Role of oxygen during sintering**

  CdTe nanoparticles formed by co-sputtering

the constituent elements are sequestered in a SiO2 matrix. It has been observed that annealing this film in oxygen ambient leads to formation of hexagonal core due to formation of oxide and defects in the shell structure. Vacuum annealed films resulted in defect-free cubic CdTe core, demonstrating the influence of the nature of the shell on the properties of the core in the nanoparticle form.

- **Stability and hydrogenation of 'bare' gadolinium nanoparticles**

  Gadolinium formed by Activated Reactive Evaporation in the nanoparticle form (5 nm) has been observed to show very high stability towards oxidation by x-ray photoelectron spectroscopy. Since Gd can be used in this form for hydrogen sensing and storage without the Pd cap layer, the sensitivity of such devices can be greatly enhanced and can be used for applications such as optical-mirrors with hydrogen sensing switches.

SPECIAL ACHIEVEMENTS

- **Low energy ion induced effects on TOPO capped CdSe nanocrystals probed by XPS depth profiling and optical measurements**

  CdSe nanoparticles were formed by using tri-octo-phosphonic oxide (TOPO) organic molecules to limit the size during synthesis by the chemical route. The pre-cursor ratio was optimized to obtain monodisperse and well-defined CdSe nanoparticles of various sizes showing size-induced optical property variations. X-ray photoelectron spectroscopy in conjunction with Argon ion sputtering was used to reveal the core-shell structure formed. From this study it was observed that a 2:1 Cd:Se precursor ration provided optimal conditions for the formation of high quality CdSe nanoparticles of 5 nm. The depth profile also showed the compositional changes from the optimal conditions when ratios in the range (0.5:1 to 3:1) were used. The study enabled the derivation of a structural model for the various compositional regimes that can be classified as a) selenium rich, 2) stoichiometric and 3) cadmium rich. The study graphically demonstrates the dynamics of CdSe synthesis by the chemical route and also the role of the organic cap layers.

पदार्थ अभिलक्षणन

MATERIALS CHARACTERIZATION

पदार्थ अभिलक्षणन

विभिन्न प्रकार की नई और उन्नत सामग्री का विकास स्थूलता, तनु फिल्मों और विभिन्न प्रकार की प्रक्रियाओं द्वारा संश्लेषित सूक्ष्म ट्यूबों तारों, सूक्ष्म कणों और सूक्ष्मरेशों जैसी सूक्ष्म सामग्री के रूप में प्रतिदिन हो रहा है। पदार्थ अभिलक्षणन प्रभाग इन सामग्रियों का अभिलक्षण निर्देशन करने के लिए उत्तरदायी है ताकि शुद्धता, तात्विक संरचना, अशुद्धता अन्वेषण संबंधी अनुमानों संरचनात्मक विश्लेषण, क्रिस्टलीय प्रावस्थाओं की पहचान, पृष्ठ तथा अंतरापृष्ठ अभिलक्षण निर्देशन और क्रिस्टल दोषों संबंधी जानकारी का अभिनिश्चयन किया जा सके। यह प्रभाग विभिन्न अनुप्रयोगों के लिए लगभग पूर्ण एकल क्रिस्टलों के विकास में भी कार्यरत है। एक अंतर प्रयोगशाला सहयोगी कार्यक्रम के अन्तर्गत प्रमाणित संदर्भ सामग्री का नियोजन, निर्माण और प्रसार इस प्रभाग का एक अन्य महत्वपूर्ण कार्य है। एन पी एल के विभिन्न अनुसंधान और विकास समूहों तथा अन्य अनुसंधान संगठनों/उद्योगों को सामग्री अभिलक्षण निर्देशन सुविधाएं उपलब्ध करायी गयी। यह प्रभाग वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद् की विभिन्न नेटवर्क परियोजनाओं जैसे 'कस्टम टेलर्ड स्पे ाल मैटीरियल्स' सी एम एम (022) तथा प्रमाणित सन्दर्भ सामग्री का निर्माण और प्रसार (सम एम एम 024) में भी सक्रिय रूप से कार्यरत है। इस अवधि के दौरान जिन कुछ महत्वपूर्ण अनुसंधान और विकास कार्यों को आगे बढ़ाया गया वे इस प्रकार हैं : -

(1) वायु विलय आकार तथा द्रव्यमान वितरण के अलावा निलंबित कण द्रव्य (एस पी एम) तथा इसकी रासायनिक संरचना के लिए दिल्ली के कोहरे पर मानवोद्भवी प्रभाव का अध्ययन। एशिया प्रशांत नेटवर्क (APN) स्वास्थ्य परियोजना और ISRO-GBP परियोजना के अन्तर्गत जैव भार ज्वलन पर अनुरेखण गैसों तथा वायु विलय भौतिक रासायनिक अध्ययन भी किए गए।

(2) क्षार जर्मनोबोरेट तथा सीसे के बिस्मथ बोरेट कांच के सम्बन्ध में विभिन्न ऑक्साइड कांचों पर EPR अध्ययनों ने अनेक प्रकार की महत्वपूर्ण जानकारी प्रदान की है। सूक्ष्म क्रिस्टलीय कोबाल्ट फेराइट पर किए गए अध्ययनों से अतापानुशीतत नमूनों में $CoFe_2O_4$ और कणों के अति अनुचम्बकीय स्वरूप का पता चला जबकि कण आकार में वृद्धि के कारण तापानुशीतत नमूने इस प्रकार का व्यवहार नहीं दर्शाते। अन्य संस्थान के साथ सहयोगी कार्य के अन्तर्गत विभिन्न संक्रमण धातु आयन डोपित एकल क्रिस्टलों का भी अध्ययन किया गया।

(3) एन पी एल तथा अन्य संस्थाओं/उद्योगों के विभिन्न समूहों से प्राप्त अत्यधिक विविधता वाली उन्नत सामग्री को भी एक्स आर डी, एस ई एम तथा टी ई एम तकनीकों का प्रयोग करके अभिलक्षण निर्देशित किया गया है। इनमें से कुछ सामग्री है कार्बन की सूक्ष्म ट्यूबें, WO_3 तथा InSb फिल्में, उच्च टी सी अतिचालक, α-Al_2O_3 जैसी संदीप्त सामग्री तथा प्रबलित तरल बहुलक सम्मिश्र आदि।

(4) उच्च ग्रेड स्वर्ण भू रासायनिक संदर्भ सामग्री (बी एन डी 3401.01) का एक नया सी आर एम, एन पी एल, एन जी आर आई तथा मैसर्स हाट्टी गोल्ड माइंस कम्पनी लिमिटेड, कर्नाटक राज्य के सहयोग से तैयार किया गया है। नए क्षेत्रों जैसे स्पेक्ट्रमी, ए-ऐलूमिना, पेट्रोलियम, प्राकृतिक जल, पेस्टनाशी तथा एकल अवयी घोलों में सी आर एम तैयार करने का कार्य भी आरंभ किया जा चुका है ।

(5) मद वाष्पन घोल विकास तकनीक (SEST) द्वारा उच्च गुणवत्ता वाले कार्बनिक अरैखिक प्रकाशिक (NLO) एकल क्रिस्टल तैयार किए गए हैं। HRXRD अध्ययन सरंध्र सिलिकॉन परतों Fe डोपित $LiNbO_3$ तथा हि पूरिक अम्ल के घोल में विकसित क्रिस्टल आदि पर किए गए थे ताकि क्रिस्टलीय पूर्णता का मूल्यांकन किया जा सके।

(6) Si पटलिका पर Si/Co/Si, Si/V/Si & Si/Fe/Si की अनेक परत वाली संरचना के अंतरापृष्ठ मिश्रण के व्यवहार का दो पूरक तकनीकों SIMS और RBS का प्रयोग करके अध्ययन किया गया था। सभी तीनों प्रणालियों के लिए मिश्रण दरें आकलित की गयी थी और यह पता चला है कि SHI अविकिरण के अंतर्गत V, Fe तथा Co की Si के साथ मिश्रण दर की ह्रासमान प्रवृत्ति है।

MATERIALS CHARACTERIZATION

Development of various types of new and advanced materials is taking place every day in the form of bulk, thin films and nano materials such as nanotubes, nanowires, nanoparticles and nanofibres synthesized by different processes. Materials Characterization Division is responsible to characterize these materials to ascertain the purity, elemental composition, estimation of trace impurities, structural analysis, identification of crystalline phases, surface and interface characterization and information on crystal defects. This division is also engaged in the growth of nearly perfect single crystals for the various applications. Planning, preparation and dissemination of certified reference materials under an inter laboratory collaborative programme is another important activity of this division. Materials characterization facilities were provided to various R&D groups of NPL as well as to other research organizations/industries. This division also actively engaged in the various CSIR network projects such "Custom Tailored Special Materials" CMM(022) and Preparation and Dissemination of certified reference materials (CMM024). Some of the important R&D activities pursued during this period are:

(i) Studies on Anthropogenic influence on Delhi fog has been carried out for suspended particle matter (SPM) and its chemical composition apart from aerosol size and mass distribution. Trace gases and aerosol physico-chemical studies were also carried out under Asia Pacific Network (APN) health project and ISRO-GBP project in collaboration with NRSA Hydrabad on biomass burning.

(ii) EPR studies on different oxide glasses has provided many useful information for alkali germanoborate and lead bismuth borate glasses. Studies on nanocrystalline coablt ferrite revealed the superparamagnetic nature of $CoFe_2O_4$ particles in unannealed samples while annealed samples do not exhibit this behaviour due to increase in particle size. Different transition metal ion doped single crystals were also studied under the collaborative work with the other institute.

(iii) A large variety of advanced materials received from different groups of NPL as well as other institutes/ industries have been characterized using XRD, SEM and TEM techniques. Some of the materials are, carbon nanotubes, WO_3 and InSb films, high Tc superconductors, luminescent materials like, ZnS nano particles embedded in SiO_2, α-Al_2O_3 and ferrofluid polymer composites etc.

(iv) A new CRM of high grade gold geochemical reference material (BND3401.01) has been prepared in collaboration with NPL, NGRI and M/s Hatti Gold Mines Co. Ltd, Karnatka state. Work on preparation of CRM's in new sectors namely spectroscopic, α-alumina, petroleum, nature water, pesticides and monoelemental solutions have also been initiated.

(v) High quality organic nonlinear optical (NLO) single crystals have been grown by slow evaporation solution growth technique (SEST). HRXRD studies were carried out on porous silicon layers, Fe doped $LiNbO_3$ and solution grown crystal of hippuric acid etc to assess the crystalline perfection.

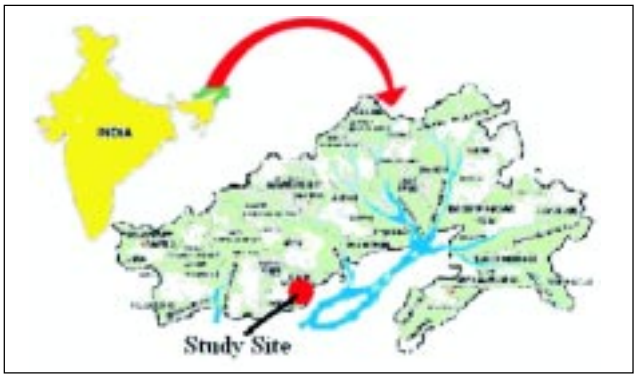
(vi) The behavior of interface mixing of multi layered structure Si/Co/Si, Si/V/Si and Si/Fe/Si on Si wafer was studied using two complimentary techniques, viz, SIMS and RBS. Mixing rates were estimated for all three systems and it is revealed that the mixing rate of V, Fe, and Co with Si has a decreasing tendency under SHI irradiation.

Analytical Chemistry

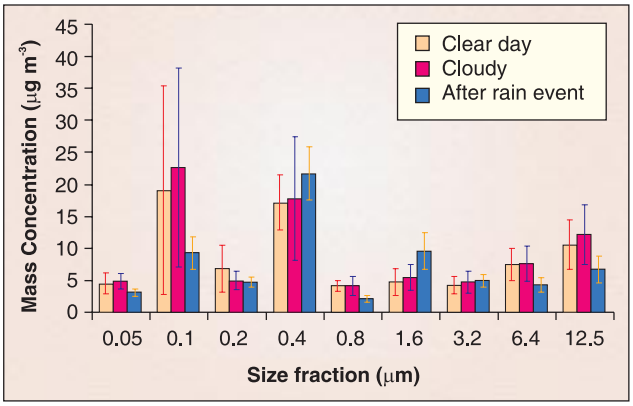
Analytical chemistry section has carried out work related to metrology in chemistry, apart from characterization of materials for ascertaining purity, chemical composition and environmental species analysis for various areas viz. environment & health, chemicals, metals & alloys, and ores. It catered the need of industries, government agencies and institutions for characterization of a large variety of materials e.g. poly aluminum chloride and alumina ferric used for treatment of water by Delhi Jal Board; indelible ink for election purpose from Election Commission of India; gas mixtures; water; metal & alloys and graphite brushes. The Gas Chromatographic techniques have been utilized for evaluation of gaseous samples from different sources for Greenhouse Gases (GHGs), and pollutants viz. CO, NO-NO_2-NO_x, CO_2 using respective online gas analyzers. In organometallic synthesis, two symmetrical organotellurium(IV) compounds and one new unsymmetrical telluroxides, have been synthesized and FTIR, UV-Vis. & photo-luminescent spectroscopic measurements studies have been made.

During November 2005, the section has completed three sponsored projects from MoEF/UNDP of GHG uncertainties reduction & their inventories under National Communication (NATCOM) in agriculture sub-sectors viz. Rice Cultivation, Livestock and Agricultural Residue Burning, apart from one project of Agriculture sector inventory. Under the CPCB & NPL collaborative work for anthropogenic influence on Delhi Fog, studies by the group have been done for Suspended particulate matter (SPM) and its chemical composition apart from aerosol size and mass distribution by Anderson and quartz crystal microbalance (QCM). Methane emission measurements have been carried out in Karnal, Haryana during July-October 2005 with integration of GIS/ RS tools for up scaling. New projects in collaborations with Tezpur univ. Assam (Prof. K.K. Baruah)/ DST, TIET Patiala (Dr. R. Agarwal)/ DST, APN-health (Dr. Mitra)/ APN, Biomass burning EF (TK Mandal)/ DST, and dry/wet acid deposition under Swedish CAD project (Prof. H. Rodhe) have been initiated.

The group has carried out trace gases & aerosol physico-chemical studies at NPL Delhi under the Asia Pacific Network (APN) health project during 2005-06 winter period. Under the ISRO-GBP project on biomass burning in collaboration with NRSA Hyderabad, a field campaign from January 29 to March 20, 2005 in Arunachal Pradesh was carried. Another project of ISRO-GBP period for integrated campaign on aerosols and radiation budget (ICARB) on observational platforms viz. land fixed sites, mobile sea cruises (SK-222 BoB area & SK-223 arabian sea area) on ORV Sagar Kanya and aircraft, during the period Feb.15 to May 12, 2006, has been carried out and group has participated in land (Delhi, and Darjeeling) observation & synchronous to above sea cruises period. These simultaneous measurements are first of its kind. It will provide extensive data-base for understanding the role of aerosols and trace gases for their radiative forcing over northern Indian region and would be very useful for climate modeling.



Itanagar, Arunachal Pradesh



Aerosol mass-size concentration at Itanagar

EPR & IR Spectroscopy

EPR study has been made to determine the microstructure of different ternary oxide glasses depending upon composition for alkali germanoborate and lead bismuth borate glasses.

Glasses with composition $xGeO_2$ (0.30-x) $M_2O.0.70B_2O_3$(M=Li, K) and xBi_2O_3 (0.30 - x) $PbO.0.70B_2O_3$ were prepared (O < x < 0.15 mole%) containing 2.0 mol % of V_2O_5 by normal melt quenching technique in collaboration at Physics Department, M.D. University, Rohtak.

In GeO_2. $Li_2O.B_2O_3$ glass system, EPR parameter g_{11} /g do not show any variation on increasing GeO_2 content which reveals no change in tetragonal nature of V_4+O_6 complex ion and the size of 3dxy orbital of unpaired electron in VO^2+ion. While in $GeO_2.K_2O.B_2O_3$ glass system, the variation in EPR parameter, $\Delta g_{II}/\Delta g_{\perp}$ has been observed and it increases with the increase in GeO_2 content. The octahedral symmetry of V_4+O_6 is reduced which may leads to the increase in tetragonal nature of V_4+O_6 complex ion and expansion of 3 d_{xy} orbital. The dc conductivity increases on increasing temperature from 373 to 523K and the contribution of germanium ions in electrical conduction is not observed in both glass systems. The electrical conductivity is induced by the mobile alkali metal ion (Li^+ and K^+) and depends upon their concentration. Hence it is concluded that germanium ions are present as network former and not as network modifier in both these glass series. In another heavy metal based oxide glass $xBi_2O_3.(0.30- x)PbO.0.70B_2O_3$, EPR studies showed the increase in tetragonal nature of V_4+O_6 complex ion with increasing Bi_2O_3 content and contraction of 3dxy orbital. The dc conductivity at first decreases on increasing Bi_2O_3 content upto 0.8% then increases with a maxima at x = 0.1% and further decrases upto x = 0.15 mol% of Bi_2O_3. The first decrease in dc conductivity was attributed to the decrease in charge carrier (Pb^{2+}) concentration and increase in dc conductivity was discussed in terms of the expansion in glass structure.

Different transition metal ion doped single crystals were studies under the collaborative work with Physics Department, University of Allahabad, Allahabad. Single crystals of Mn^{2+} doped zinc ammonium phosphate hexahydrate, Cr^{3+} doped tetramethyl ammonium cadmium chloride and Cr^{3+} doped diammonium hexaqua magnesium sulphate grown by slow evaporation process were characterized by EPR and optical spectroscopic techniques. Optical spectra of these single crystals were measured in 1100-200 nm range to estimate orbital energies of transition metal ions. These studies showed that transition metal ion (Mn^{2+} and Cr^{3+}) substitutes in crystal lattice by replacing zinc, cadmium and magnesium ions with distorted octahedron structure and revealed the existence of covalent bonding between transition metal ion and ligand.

Study of superparamagnetic behaviour in nanocrystalline cobalt ferrite ($CoFe_2O_4$) was carried out in collaboration with X-ray group of our division. Nano crystalline $CoFe_2O_4$ superparamagnetic particles were prepared by chemical co-precipitation method. The particles have spherical shape with 5-10 nm size. The crystallize size can be increased from 5-28 nm by changing the annealing temperature. This increase in crystallite size has also increased the saturation magnetization from 18 emu g^{-1} to 74 emu g^{-1} and coercivity from 0 Oe to 1200 Oe. The electron paramagnetic resonance studies revealed the superparamagnetic nature of these particles in unannealed samples while in annealed samples due to increase in particle size this behaviour is not exhibited.

FT-IR spectroscopic studies have been continued on single crystals of ZnSe, ZnS, CaF_2, KBr and Quartz. The results of investigations reveal that there is no predominant absorption peaks in the IR transmittance and specular reflectance spectra of ZnSe. ZnS, CaF_2 and KBr and their respective average values are complementary to each other. FT-IR and FT-Raman spectra of a number of samples related to development projects of various divisions of NPL were characterized.

Calibration of polystyrene films, pyroelectric detector and IR thermometer from various organizations such as Sipra Lab. Ltd, Hydrabad, Choski Lab. Ltd., Indore, Maruti Udyog Ltd., Gurgaon, Manisha Analytical Lab. Pvt. Ltd., Mumbai, Trading Corporation (regd) India, Delhi and Northern Lab. Pvt. Ltd., Mumbai were also undertaken.

X-ray Analysis

Characterization of materials by XRD & XRF techniques

Characterization of materials by X-ray diffraction and X-ray fluorescence method were carried out for samples from various groups of NPL and out side institutions. These materials includes carbon -carbon

composites, carbon nano tubes, Zr and Silicates compounds, Mg alloy, WO_3, TiO_2 , PbTe, , AlSb, SnO_2 bulk and thin films, InSb, C-BN and hBN, Magnetic materials like Ba-hexaferrite, Fe_3O_4, $MnZnFe_2O_4$, $CoFe_2O_4$. Thin film samples of TiO_2, B_4C composites, ZnO, CO/Cu multiplayer thin films, carbon nanotubes, high Tc superconductor, SiC, Ceramic lik ZrO_2, ZrNi ZrCu, orthoferrites like $PrCaFeO_3$, MnO_3, luminescence materials like ZnS nano particles embedded in SiO_2, Conducting polymers like PANI and their composites etc.

Bonding of silicon onto glass is gaining attraction due to its versatile applications in modern technology. It is going to play a key role in the development of gen-next solid-state sensors and actuators. Proton and phosphorous implantation in single crystal silicon wafer and ion-cutting were carried at SSPL , New Delhi. High resolution X-ray diffraction rocking curves and topographs were recorded using a double crystal X-ray diffractometer attached with a 12 kW rotating anode X-ray generator (Rigaku, Japan make). A (001) monochromator of 100 mm diameter was aligned for 400 relp with $CuK\alpha_1$ radiation. The specimen was used as a second crystal in (+, -) configuration. High resolution X-ray diffraction (HRXRD) curves for (400) reflection of silicon wafer, un-implanted and P-implanted ion cut silicon layer transferred onto glass were recorded. A very sharp diffraction curve was obtained with (400) diffracting planes of silicon wafer. The half width of this curve was found to be only 6 arc sec.

This indicate that crystalline perfection of the silicon wafer is very good since this experimental value is very close to the theoretical value i.e. 3.8 arc sec. The rocking curves for (400) reflections of unimplanted silicon layer transferred onto glass were recorded at different positions of the thin layer.The average half width of the diffraction curve was nearly 32 arc sec. These indicate that defects were introduced during the anodic bonding of SOG. However the rocking curves for P- implanted layer shows varying half width from 90-220 arc sec. at different places of the specimens which show the P-implanted SOG is more defective.

In the IRM activity under the project of planning, preparation and dissemination of certified reference materials, 5 gm of α–Al_2O_3 samples were sent to 20 laboratories, for analyzing the material using their equipments on given prescribed experimental parameters for round robin test. Data received has been analyzed for the certification and dissemination of certified reference materials. Repeatability of the powder data result was verified by conducting different experiments over a period of time. The material is now ready for the for the certification.

Nano-crystalline $CoFe_2O_4$ particles were synthesized under the research activity of ferrofluid. The crystallite size of the powder varied from 5-28 nm on changing the annealing temperature from 373 K to 1173K. On heating, the crystallite size increases with a increase of saturation magnetization(Ms) from 18 emu g^{-1} to 74 emu g^{-1}. The coercivity (Hc) also changes from 0 Oe to 1200 Oe on increasing the crystallite size. X-ray diffraction pattern of the sample shows the single crystalline phase of $CoFe_2O_4$ at all the annealing temperatures. The electron paramagnetic resonance study shows the super-paramagnetic nature of the particles.

The electromagnetic interference effect of super-paramagnetic particles (Fe_3O_4, $MnZnFe_2O_4$, $CoFe_2O_4$) of ferrofluid in polymer matrix in relation to conductivity of the composites were studied. The measurement of shielding effectiveness (SE) was carried out in X and K band of microwave region and it is observed that the shielding effectiveness increases with the increase of doping and graphite filler loading level. Samples were characterized by XRD, EPR, SEM and TEM techniques. The correlation of shielding effectiveness and electrical conductivity is investigated.

X-ray powder diffraction data on $CuZnGa_3Te_6$, has now been included in the Powder Diffraction File (PDF) of the International Center for Diffraction Data, the pattern number is 56-1258 (2006). Also X-ray powder diffraction data on CuInSeTe and $ZnGa_2Te_4$ were included in the PDF file vide No 53-0457 and 55-0260 (2005).

Electron Microscopy

Electron Microscopy plays a very important role in the characterization of materials for their microstructure, chemical composition and phase identification. NPL has Scanning and Transmission electron microscope facility. The group is involved in

the characterization of various type of materials developed by different divisions. The microscopy group also carries out research in the area of growth and characterization of materials such as doped InSb, BiTe, SnO_2 and ZnO. We have a LEO 440 SEM with EDS attachment. The facility is extensively used by the groups in the laboratory working on the development of advanced materials for different applications. This facility has also been used by various industries located in and around Delhi for the characterization of their samples for particle size, shape analysis, surface microstructure, failure analysis, chemical composition of their products etc. SiC incorporated Al alloys, Al-Mg alloys, SiC nanofibres, SiC, SiC + B4C Composites, CNT's with Ni and Co as catalysts, CNT Composites, Pure carbon graphite, Carbon fibres made from different pitch with different concentrations of polymers, fibres and reinforced glass fibres, Vapour grown Carbon fibres with and without polymers, SiC Oxidised and carbonised, Ferrofluid composites and thin films, ZnO, SnO_2 and CdS powders, ZnS nano particles with Mn as dopant, ZnO and SiN films on Si, Ce-Ti films on Tin oxide coated glass, ZnO and TiO_2 deposited on Nb substrate have been characterized, TiO_2 films grown on different substrates, WO_3 thin films, Porous Silicon grown in micro channels /Si, Metal doped PS+PANI Composites etc. High Tc Superconducting Bi2223, Y123, La-Sr-MnO3, Pb-Ca-FeO3 CMR materials C-BN films/Si by PECVD and C-BN Composites were also analyzed.

The SEM and EDS facility has also been used by the industry for carrying out different type of testing and analysis work. The service was provided to M/s. Delphi Automotive systems, Noida ; Ranbaxy Chemical Manufacturing, SAS Nagar Mohali and Gurgaon; Maruti Udyog Ltd, Gurgaon , Garware Polyester Ltd., Aurangabad; Subros Ltd, Noida, Samtel Color Ltd, Ghazibad ;.Minipore Microproducts, Ghaziabad and GKN Drive Line (India) Ltd, Faridabad.

Microstructural characterization of variety of materials has been done using the TEM (model JEOL JEM 200 CX) facility. This system has been used for NPL and outside R&D organizations. The process for the procurement and installation of a new Tecnai G^2 F30 S-TWIN TEM with excellent and versatile capabilities for high resolution imaging as well as extremely good analytical performance is under process.

Ultra-fine objects of oxide semiconductors like zinc oxide (ZnO) and cadmium oxide (CdO) are unique materials possessing novel electrical, mechanical, chemical and optical properties. The present work envisages the preparation of these materials employing a vapor-solid mechanism by a simple thermal evaporation technique. In this process the growth is governed via vapor-solid, in which the metal vapor evaporated from the starting material at a high temperature reacts with the oxygen and directly deposits on a substrate.

Fig. 5.1 exhibits the growth of very high yield tetrapod morphologies of ZnO with a hexagonal wurtzite crystal structure (a=0.33 nm, c = 0.52 nm). CdO has been grown with a hybrid shapes of faceted cuboids (Fig. 5.2a) and long smooth surfaced rods (Fig. 5.2b) of NaCl-cubic structure (a=0.47 nm) with a preferred direction along 002. These ultra-fine nanostructured oxides with large surface area and inherent physical, mechanical & thermodynamic

Fig. 5.1

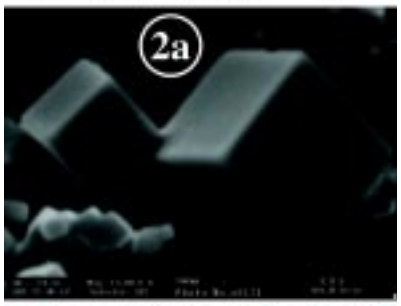


Fig. 5.2a

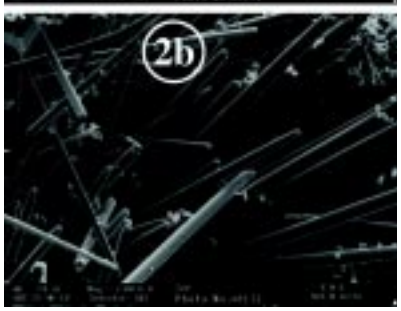


Fig. 5.2b

properties are futuristic materials for many usages. Several papers have been presented and a patent has also been filed on the growth of nanostructured ZnO.

Indian Reference Materials

Preparation and Dissemination of Certified Reference Materials and Chemical Metrology

National Physical Laboratory is coordinating a CSIR Network project on "Up gradation of SI Base Units, National Standards of Measurements & Apex Calibration Facilities and Creation of High Quality Network of Testing and Calibration Laboratories and Preparation & Dissemination of Certified Reference Materials (CMM 0024)". Work on preparation and dissemination of certified reference materials has been included as Task 4 in this project. Thirty-five reputed laboratories of the country are the partners in this project. This year a new CRM of High Grade Gold Geochemical Reference Material (BND 3401.01) had been prepared in collaboration with NPL, New Delhi, NGRI, Hyderabad and M/s Hatti Gold Mines Co. Ltd. (HGML), Hatti, Dist. Raichur, Karnataka State. It is a first CRM, which was prepared under a collaborative programme with any industry. It was sent to the fifteen laboratories in India, Canada, China and Tanzania to measure the concentration of gold and other major, minor, trace and REE elements after homogenization and homogeneity test. Thirteen laboratories reported the values and the concentration of gold have been certified to be 12.12 + 0.68 g/g at a confidence level of 95% (coverage factor k=2) on the basis of inter-comparison results. Uncertified concentration of other major, minor and 56 trace elements including all rare earth elements (REE) had also been given for the information to the user.

This CRM was released on January 24, 2006 by Prof. Paul De Bievre, Member, ISO Council on Reference Materials; Member, Consultative Committee on Amount of Substance and Editor-in-Chief, Journal Accreditation and Quality Assurance ("ACQUAL") SPRINGER.

Work on the preparation of following new CRMs in different areas had also been initiated:

i) Spectroscopic (Metals & Alloys) Reference Materials. Six heats of Plain Carbon steel (200 kg each)

Containing elements responsible for their quality and grade have been prepared at NML, Jamshedpur. The concentration of these elements in different heats varied to get the desired property of the steel. As an typical example the concentration of carbon is in the range of 0.003-1% C. All the heats are under homogenisation. The other elements to be certified are:S, Si, Mn, P and Cr.

ii) α-Alumina

A new XRD standard of α-alumina particle size 25 micron is prepared from commercially available high purity material by grounding and annealing at NPL. The material is under round robin testing at 12 laboratories for its certification.

iii) Petroleum Standard

This material has been prepared at IIP, Dehradun. Five elements namely Na, Ca, Mg, Fe and V in known concentration have been doped in the materials. After stability studies material has been sent to 20 participating laboratories for round robin testing.

iv) Mono Elemental Solutions

CRMs of new elemental solutions **(a) BND 105.01: Lead, (b) BND 205.01: Cadmium (c) BND 1205.01: Zinc, (d) BND 1305.01: Iron, (e) BND 1405.01: Copper ,(f) BND 2101.01: Strontium, (g) BND 2201.01: Cobalt, (h) BND 2301.01: Magnesium, (i) BND 2401.01: Bariun , (j) BND 2501.01: Chloride and (k) BND 2601.01: Sulphate Solution: with nominal concentration 5 mg/L** have been prepared and send to 20 participating laboratories for round robin testing.

v) Nature Water

For preparation of CRM of multi elements (cations and anions) in nature water raw water has been collected from granite hard rock area of Vairapalli near Hyderabad for certification of cations and anions. The sample was divided in two parts and cations and anions were stabilized separately by the addition of stabilizing agents. Both the materials are under round robin testing at 18 participating laboratories.

vi) Pesticides

Four pesticides **Chlorpyriphos, Isoproturon, Fenvalerate** and **Cypermethrin** had been prepared and purified at IICT, Hyderabad. These materials have been sent to 13 participating laboratories

to measure their concentration under round robin testing.

vii) Gas Standard

Certified reference material of Carbon dioxide in nitrogen has been prepared at NPL. Its stability has also been studied. The sample is ready for dispatch for round robin testing.

Dr. Paul Bievre, Member, ISO Council on Reference Materials; Member, Consultative Committee on Amount of Substance and Editor-in-Chief, Journal Accreditation and Quality Assurance ("ACQUAL") SPRINGER releasing a new Certified Reference Materials High Grade Gold Geochemical Reference Material (BND 3401.01) on January 24, 2006. Other dignitaries on the dais from his left are Dr. Vikram Kumar, Director NPL; Dr. S.K. Gupta, Head Materials Characterization Division and right Dr. A.K. Agrawal, Coordinator, Certified Reference Material Programme; Dr.V.P.Dimri, Director, NGRI; Mr.Ashok V. David, IAS, Managing Director, HGML, Bangalore and Dr. V. Balaram, Scientist NGRI.

Some of the important users belong to Defence, Power, Petroleum, Bureau of Indian Standards, National Test House, State Pollution Control Boards and Public Health sectors. Nepal Bureau of Standards and Metrology is also using these CRMs.

Crystal Growth & Characterization

A new activity of growing nonlinear optical (NLO) organic and semi organic single crystals by slow evaporation growth technique (SEST) has been started first time at NPL. Some of the successfully grown crystals are benzimidazole (BMZ), hippuric acid (HA), 8-hydroxy quinoline (8-HQ), L- alaninium maleate (LAM), methyl p-hydroxybenzoate (p-MHB) etc. These crystals have been characterized by various instrumentation methods with the help of some collaborators namely , (i) High-resolution X-ray diffractometry (HRXRD) to evaluate crystalline perfection., (ii) Powder XRD to confirm their structure, (iii) FTIR and NMR to confirm functional groups, (iv) DT/TGA to assess thermal behaviour, (v) UV-Vis. and PL spectroscopic studies to characterize their optical properties, (vi) Kurtz Powder test to determine the second harmonic generation (SHG) conversion efficiency using Nd:YAG Laser source, (vii) Laser damage threshold to see their strength needed for device applications and (viii) Vickers micro hardness test, to assess the mechanical strength. Enhancement of crystalline perfection and other physical properties due to thermal annealing in BMZ crystals was observed.

After designing and fabrication of suitable glassware apparatus a sample benzimiazole single crystal in a predetermined unidirection by using a suitable seed crystal has been grown first time by a unidirectional slow evaporation solution technique (USEST) similar to the recently invented SR method and its crystalline perfection was found to be excellent as evaluated by HRXRD.

We have carried out HRXRD studies for the samples grown by our collaborators like acenaphthene, sulphamic acid, doped KDP/ADP, Benzophenone, Phthalic Anhydride, L-Lysine monohydrochloride dihydrate (L-LMHCl), L-Asparaginium Picrate (LASP), zinc thiourea sulphate (ZTS) etc. to assess the crystalline perfection. In doped ZTS crystals we have found some interesting facts by HRXRD. Some organic dopants form complexation with impurities in the solution in the form of an epilayer and restrict the entry of imputies inside the crystal, which results a better quality of the crystal and at the same time, enhance the growth rate. We also characterized the effect of irradiation on the crystalline perfection.

Point defects in as-grown and annealed bismuth germanate (BGO) single crystals have been characterized by high-resolution diffuse X-ray scattering measurement technique. These studies could explain the rarely observed colours along certain facets and also revealed the changes in volume and density of point defect clusters due to thermal annealing.

Enhancement in crystalline, piezoelectric and optical quality of undoped and Fe-doped LiNbO3

single crystals by post-growth annealing and poling has been studied by HRXRD, XRT, FTIR, UV-Vis. and piezoelectric measurement techniques. These studies are pertaining to CSIR network project (CMM-0022/1G).

Porous silicon (PS) layers formed by anodization on polished and textured substrates of (100)Si at different current densities have been characterized by HRXRD, topography, radius of curvature, strain measurements etc. These studies indicate that the structural, mechanical and optical properties of thick PS formed on textured Si are superior to those formed on polished Si substrates.

Secondary Ion mass spectrometry

Mixing behaviour of buried transition metal layer in silicon due to swift heavy ion irradiation

Different transition metals have already been tried to form silicides, which are widely used in microelectronics and other applications. Amongst the different synthesis techniques adopted to grow such metal silicides, swift heavy ion beam mixing (SHIBM) with post annealing is becoming more attractive in term of its spatial selectivity, precise control and low temperature process.

Apart from being technologically important the behavioural changes that take place when energetic ions lose their energy also requires to be thoroughly investigated. We, in the present work, have undertaken similar transition metals, V, Fe & Co, to study the Si/V/Si, Si/Fe/Si and Si/Co/Si systems, which might give us an overall trend in mixing behaviour of similar transition metals with Si due to SHI. For this experiment the thin film samples were prepared by depositing the transition metal (Me = V, Fe or Co) on Si wafer using electron beam evaporation technique under UHV condition at a base pressure of $1.5x10^{-8}$ torr. 120 MeV Au ions were used to irradiate the Si/Me/Si (Me=V, Fe, Co) samples using 15 UD Pelletron at NSC, Delhi. The fluences used were varied between $1x10^{13}$ and $1x10^{14}$ ions/cm^2.

The behaviour of interface mixing was studied using two complementary techniques, viz, RBS and SIMS. The RBS experiments were performed on both the un-irradiated and irradiated samples using 1.0 MeV He beam. A quadrupole type Secondary ion mass spectrometry (SIMS) was used for studying the interface profile of Si/V/Si and Si/Fe/Si. In case of Si/Co/Si a dual beam of (Ar+ and Ga+) TOF-SIMS was used. The depth profiling of the Si/V and Si/Fe samples were carried out with oxygen primary ions of energy and the +ve secondary ions were collected for analysis. In case of Si/Co/Si, Ar+ ions of energy 1.0 keV with 13nA beam current were used for sputtering and Ga+ions of 11.0keV with 1pA was used for analysis. The layer thicknesses of the metal layers were measured from the RBS data. These were further used to normalize the depth scale of SIMS data for the measurement of mixing layer width.

Mixing rates were estimated for all the three systems. Mixing rate, k, is defined as $k = \ddot{A}\grave{U}^2/\ddot{O}$ where $\ddot{A}\grave{U}^2$ is the spatial mixing width and $\ddot{A}\grave{U}^2 = \ddot{A}\grave{U}_t^{\,2} - \ddot{A}\grave{U}_0^{\,2}$, $\ddot{O}$ = maximum fluence. The k values are calculated from the slope of the $\ddot{A}\grave{U}^2$ vs $\ddot{O}$ graph. Mixing rate in case of V is $kv \simeq 600\ nm^4$, where as in case of Fe and Co, mixing rates are $kFe \simeq 225\ nm^4$, $kCo \simeq 125\ nm^4$ respectively. This shows that the mixing rate of V, Fe, and Co with Si has a decreasing tendency under SHI irradiation. From the above data it is clear that as we increase the atomic number (or mass) in the transition metal series, the mixing rate decreases suggesting a direct correlation between the atomic number and the mixing behaviour.

Considering the properties of transition metals, the energy required for the bond breakage of the transition metal atoms increases suggesting a decrease in the mixing rate since the ion fluence or the energy supplied due to SHI irradiation remained same. Higher mixing rate in case of V can also be attributed to its lower heat of formation as compared to Fe and Co. The diffusion co-efficient for Si/V/Si was found to be $Dv \sim 10^{-6} m^2 s^{-1}$, which is characteristics of the liquid phase. Similar calculations for Fe and Co in Si show almost same order of values i.e. D_{Fe} or $D_{Co} \sim 10^{-5}$-$10^{-6} m^2/s$. Considering the fact that liquid phase diffusivity is almost five orders of magnitude higher than solid phase diffusivity at high temperatures, it is clear that mixing has taken place in transient melt phase, which suggests that thermal spike model is responsible for mixing.

रेडियो तथा वायुमण्डलीय विज्ञान

RADIO AND ATMOSPHERIC SCIENCES

रेडियो तथा वायुमण्डलीय विज्ञान

राष्ट्रीय भौतिक प्रयोगशाला कई वर्षों से रेडियो के प्रसार तथा माध्यम (मीडिया) के अभिलक्षणों के साथ वायुमण्डलीय विज्ञान पर व्यापक अनुसंधान एवं विकास कार्यक्रम चला रहा है जिसमें विश्वभर में वायुमण्डल में हो रहे परिवर्तनों के अनुसंधान कार्य पर विशेष ध्यान दिया जा रहा है। इस वर्ष के कार्यकलापों को दो प्रमुख प्रयोगशाला परियोजनाओं (एम एल पी) के अन्तर्गत नए ढंग से शुरू किया गया है - परिवर्तनशील वायुमण्डलीय वातावरण इसकी प्रक्रियाएं एवं प्रभाव और रेडियो भौतिकी और अनुप्रयोग। इन दोनों परियोजनाओं के उद्देश्य को निम्नलिखित पैराग्राफों में संक्षेप में वर्णन किया गया है।

परिवर्तनशील वायुमण्डलीय वातावरण, इसकी प्रक्रियाएं और प्रभाव : वायुमण्डलीय वातावरण भूमि-महासागर वायुमण्डल ढांचे का योग है जो इसकी जटिल प्रक्रियाओं और पुनर्निवेशन के द्वारा परिवर्तनों के प्रति अतिसंवेदनशील है। हाल ही में, विश्व में व्यापक परिवर्तन के सन्दर्भ में इसके प्रभाव को बहुत अधिक महत्व प्राप्त हुआ है। इसलिए वर्तमान में परिवर्तनशील वायुमण्डलीय वातावरण, इसकी प्रक्रियाओं और प्रभावों की विशिष्टताओं के बारे में गहन प्रयास किए जा रहे हैं। वायुमण्डल के अवयवों का पता लगाने, ग्रीन हाउस गैसों और पुरोगामी, वायुधुंध और सूर्य के विकिरण के सम्बन्ध में विशेष महत्व दिया जा रहा है। इस अध्ययन में सांसारिक और आकाशीय माप (जिसमें भूमि और महासागर पर योजनाबद्ध प्रणाली प्रयोग, अंटार्कटिका में स्थायी भूमि स्टेशन पर लम्बे समय तक माप और प्रेक्षण शामिल है), मॉडलिंग, सम्बन्धित माध्यम रेफरल प्रयोगशाला की स्थापना और विविध आंकड़ों का सृजन शामिल है।

रेडियो भौतिक और अनुप्रयोग - सही अर्थों में रेडियो तरंग के प्रसार के लिए वायुमण्डलीय वातावरण 'मुक्त अंतरिक्ष' नहीं है। वायुमण्डल का निचला भाग निष्क्रिय होता है, जबकि इसका ऊपरी भाग आवेशित होता है। निचले भाग को 'ट्रोपोस्फेअर' और ऊपरी भाग को आइनोस्फेअर के नाम से जाना जाता है। ये दोनों ही माध्यम आश्चर्यजनक तथ्यों के साथ रेडियो संकेत के प्रसार के लिए उपयोगी हैं। ऐसा तथ्य जिसे इस क्षेत्र में प्रगति का मार्ग प्रशस्त करने के लिए लगातार खोज करने की आवश्यकता है, आश्चर्य को कम करने के लिए माध्यम का अवश्य ही विशिष्टीकरण किया जाना चाहिए और उसे समझा जाना चाहिए। इसी कारण से प्रभाग माध्यम विशिष्टताओं का कार्यक्रम चला रहा है ताकि भूभौतिकीय (जिओफिजिकल) में अंतर्निहित विविध प्रक्रियाओं को समझकर रडार और संचार (मोबाइल, लाइन ऑफ साइट आदि सहित) में इसके उन्नत अनुप्रयोगों के लिए इसे बेहतर बनाया जा सके। मॉडल विकसित करने के लिए पर्याप्त आंकड़ों का सृजन और भौतिकी को समझना बहुत आवश्यक है। प्रभाग उपग्रह प्रणाली, रडार और लाइन ऑफ साइट लिंक (जो वर्ष भर चलता रहता है) का उपयोग कर आइनोस्फेअर और ट्रोपोस्फेअर दोनों माध्यम की सीमाओं पर नियंत्रण रख रहा है। इन आंकड़ों का विश्लेषण कर माध्यम को अच्छी तरह समझा गया और शुद्धता को निर्धारित किया गया। इसके अतिरिक्त, भारत के माननीय राष्ट्रपति द्वारा वैज्ञानिकों से भूकम्प के सम्भव अग्रसूचना का पता लगाने की संभावनाओं के आह्वान का अनुसरण करते हुए प्रभाग ने संभव अग्रसूचना के रूप में आइनोस्फेअर में होने वाले कुछ असाधारण परिवर्तनों के निरीक्षण के अध्ययन का कार्य शुरू किया है।

RADIO AND ATMOSPHERIC SCIENCES

Radio and Atmospheric Sciences Division (RASD) at the National Physical Laboratory has been pursuing comprehensive Research & Development programs on Radio Propagation and media characterization as well as Atmospheric Sciences with a special focus on Global Change Research for many years. This year activities have been reorganized under two Major Laboratory Projects (MLPs) - Changing Atmospheric Environment, its Processes and Impacts and Radio Physics and Applications. Objectives of these two projects are described briefly in the following paragraphs.

Changing Atmospheric Environment, its Processes and Impacts: The Atmospheric environment is a coupled land-ocean-atmosphere system susceptible to changes through its complex processes and feedbacks. Its impact on geosphere-biosphere has gained greater importance recently in the context of Global Change. An intense effort is therefore on presently to characterize the changing atmospheric environment, processes and its impacts. Particular emphasis is being put in respect of atmospheric trace constituents, green house gases and precursors, aerosols and solar radiation. The study involves temporal as well as spatial measurements (which includes campaign mode experiments over land and ocean, long term measurements over permanent land stations and observations at Antarctica), modeling, related instrumentation, setting up of referral laboratory and creation of various databases.

Radio Physics and Applications: The atmospheric environment for radio wave propagation, in true sense, is not "Free Space". Lower part of the atmosphere is neutral while upper part of it is charged. The lower part is known as "troposphere" and the upper one is known as "Ionosphere". Both of these media are useful for propagation of radio signals with elements of surprises – the fact that require continuous research leading to developments in the field. To minimize the surprises the media must be characterized & understood. It is for this reason that the division has been pursuing media characterization programmes, understand the various underlying geophysical processes leading to improvements for advanced applications in radar and communication (includes mobile, line-of-sight etc.). Generation of data base to develop models and understanding of physics is a must. The division has been monitoring both ionospheric / tropospheric media parameters by using satellite systems, radars and line-of-sight links which continued during the year. Analysis of these data led to better understanding of the media & estimation of corrections. Further, following the President of India's call to scientists to look at the possibilities of finding possible precursors of earthquake the division initiated studies to examine some unusual changes foF2 in ionosphere as possible precursors.

Atmospheric Environment and Global Change Studies

Features of Temperature Inversion During FOG

The atmospheric boundary layer from very close to ground to 35 m altitude has been characterised in terms of temperature variations, especially during post sunset hours in winter months. Vertical temperature gradients, as recorded by the fast response, matched-bead-thermisters, have shown the onset of a strong temperature inversion layer very close to ground within 35m height following sunset. Temperature gradients of 3 to 8 deg C within 30m altitude have been recorded on different days. Maximum temperature change is normally seen between 6m and 30m sensors and temperature minima may be seen any where between 2m and close to earth surface. Inversion starts building around sunset with much faster decrease of temperature of layers closer to ground, and matures thereafter within 1 to 2 hours. It normally persists through out the night and vanishes soon after sunrise. On many days, however, it is found to persist even after sunrise for several hours and sometime even through out the day in continuation of the next day inversion occurrence. On some nights inversion vanishes suddenly bringing the temperatures at all heights to the same value and following this the onset of strong radiative fog occurs.

Trace Gases and Aerosol Studies

Seasonal variations of aerosol number size distribution at NPL, New Delhi during 2004-2006

Seasonally, aerosol number concentration (Fig. 6.1) in sub-micron size regime has been found highest in winter season than summer and monsoon seasons.

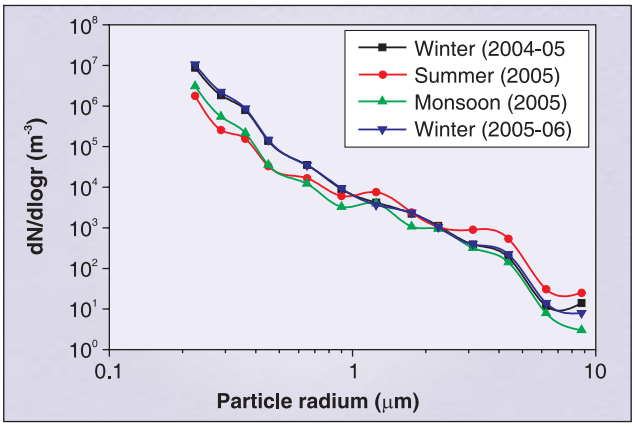


Fig: 6.1: Atmospheric aerosol number size distribution at NPL, New Delhi during 2004-2006

In the sub-micron mode, wintertime aerosol number concentration is approximately 8 & 4.5 times higher than summer and monsoon values, respectively.

Where as in super micron mode, wintertime values are approximately 1.4 times higher than monsoon values. But in this size regime the summer values are approximately 3 & 7 times higher than winter and monsoon values, respectively and it may be due to the coagulation of smaller size particles and became bigger size particles or wind blown dust during summer.

The number-size distribution at NPL has been found to be bimodal with dominant sub micron mode particles. Keen observation of the data reveals that fine mode particles ($r \leq 0.5$m) are dominant and their percentage share to total number of particles is approximately 85.

Aerosol and Radiation Studies

During this period the major emphasis of the aerosol and radiation research group had been to study the aerosol-radiation interaction and to estimate the radiation forcing using the ground based observations, satellite remote sensing data and aerosol and radiation models like OPAC (Optical Properties of Aerosol and Cloud), SBDART (Santa Barbara DISORT Atmospheric Radiative Transfer) and TUV (Tropospheric Ultraviolet Visible). The observations cover the northern and central Indian region, the coastal and deep-sea regions onboard Sagar Kanya ship and NPL Delhi. A few results are highlighted below:

Aerosol forcing over Delhi

Intense aerosol loading during pre-monsoon period over Delhi is found to be responsible for a very low and some time negative Angstrom exponent and high average AOD at 500nm (1.17± 0.65). The surface fluxes in the wavelength range 280-2800 nm were measured during the pre-monsoon period, April-June 2003 along with the spectral distribution of aerosol optical depth (AOD) in the visible and near infrared wavelengths. The Angstrom exponent alpha retrieved from the data

showed abundance of desert aerosols over Delhi during this period. The aerosol composition constructed using the OPAC model indicated a typical mixture of two aerosol types: Urban and Desert. Due to this the aerosol mixture had a very low value of single scattering albedo ~0.67. The average total radiative forcing efficiency observed at the surface in the broad wavelength band (280-2800 nm) was estimated and compared with the SBDART model calculated values. The observed short-wave forcing efficiency was of the order of 13.6 $\pm$1.4 Wm^{-2} and the SBDART model estimate value was in the range 16.1 $\pm$ 1.2 Wm^{-2}.

Column AOD & Size distribution in Central India

Studies were carried out on the ground-based, clear sky daytime measurements of column aerosol optical depths at different wavelengths and the mixing height of atmospheric boundary layers at various locations, conducted during ISRO-GBP aerosol-radiation-trace gases measurements campaign in the Central Indian region (17.3° N to 28.6° N and 77.2° - 78.2° E) from Delhi to Hyderabad and back, in the month of February 2004. The measurements show AOD variation at 500nm in the range of 0.2 to 0.5 and Angstrom exponent in the range of 1.0 to 1.4 throughout the region. The entire experimental region was classified into four categories depending upon their locations and surroundings, viz., forest, rural, semi-urban, and rural-dusty. The volume size distribution of the aerosol particles at all these categories showed a bi-modal distribution with fine mode dominating around 0.23 μm effective radius and the coarse mode dominating around 1 micron. The forest site near Jabalpur showed minimum AOD and α values with an equal contribution of aerosol particles in the fine and coarse mode. As the fine mode particle concentration relatively increased at other regions, the α value also went on increasing, along with the increase in AOD. The AOD also showed a latitudinal variation with a minimum occurring at about 23.5° N. During the whole campaign the average mixing height of planetary boundary layer (PBL) during the daytime was found to be between 650-950 m.

UV Irradiance in Lower Himalayas

The observations at Nainital during December 2004 showed that the diurnal maximum irradiance at 305.5, 312.5 and 320.0 nm in a 2.4 nm bandwidth varied between 0.015-0.020, 0.15-0.20 and 0.29-0.37 Wm^{-2} respectively with average AOD ~0.06. The measured UV irradiances are compared with the Tropospheric Ultraviolet Visible (TUV) radiation model and show a good agreement. The backwards trajectory analysis using Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) backward trajectory model suggest that AOD increases due to winds from populated north Indian plains and decreases when winds are from pristine Himalayan ranges in the west.

Trace gases and aerosol over Indian Ocean during monsoon and transition period

Flow of pollutants is expected from south and south-east Asia during the monsoonal transition period due to the wind flow patterns different from monsoon period. This is the first detailed report on aerosols and trace gases during the sampled period as the earlier Bay of Bengal Experiment (BOBMEX), Arabian Sea Monsoon Experiment (ARMEX) and Indian Ocean Experiments (INDOEX) are during monsoon seasons. Characteristics of trace gases (O_3, CO, CO_2, CH_4 and N_2O) and aerosols (particle size of 2.5 micron) were studied on board Sagar Kanya over the Arabian Sea, Equatorial Indian Ocean and southwest part of the Bay-of-Bengal during the monsoon transition period (October-November, 2004). The significant results are obtained as follows:

(i) The wind flow patterns during monsoon transition period are different from the period of monsoon as observed in NCEP/NACR reanalysis and on board measurement meteorological parameters. The 10-days backward trajectories suggest that origin of air parcel over Arabian Sea is mostly over the ocean, whereas, origin of air mass along the equator and return journey is either from south and south east Asia.

(ii) Surface ozone concentration is maximum near coastal region and minimum near equator. Along longitude, no substantial changes are observed in Ozone concentration. Carbon monoxide concentration shows similar feature with maximum value near the coast and lowest value near the equator. The observed trend is consistent with the earlier reported results. The

role of long range transport from south Asia and southeast Asia, which are region of biomass burning as seen MOPITT and MODIS data, are assessed.

(iii) Arabian Sea, North Indian Ocean and Bay of Bengal are important regions in terms of sea-to-air exchange of biogenic gases. No atmospheric observation of CH_4, CO_2 and N_2O is available during monsoon transition period; therefore, comparative study is not possible at this stage. Large variation of CH_4, CO_2 and N_2O concentration over short time scale is however unexpected.

(iv) During onward journey from 15°N to equator, CH_4 and N_2O show prominent negative gradients, and CO_2 shows positive gradient, whereas, on return leg CH_4 and CO_2 shows positive latitudinal gradients, whereas, N_2O concentration does not shows such trend. Since Arabian Sea is normally known as a region of CO_2 and N_2O emitter, the enhanced concentration of atmospheric CH_4 and N_2O over Arabian Sea might be due to emission from ocean, whereas, the enhanced value over Bay of Bengal and along the equator may be linked to biomass burning over East Asia and South East Asia.

(v) The mass concentration of PM2.5 is to be varied within 5-20 $\mu g/m^3$ except during the journey along the equator, where, the value has reached as high as 37 $\mu g/m^3$. Relative humidity and wind speed is strongly correlated with high concentration of PM 2.5. Chemical composition analysis of these samples may give more insight into enhanced concentration.

Budget estimation of Carbonaceous Aerosol Emissions from Rural India

Budget estimate for carbonaceous aerosols including black carbon and organic carbon, emitted from the combustion of various fuels, is very important for regional climate studies. Emission factors for carbonaceous aerosols from bio-fuels and soft coke were determined in a controlled combustion study. The emission factors thus obtained along with those available for other fossil fuels consumed in different sectors, have been applied to assess the budget for carbonaceous aerosols from India. The emission factors were determined for OC and BC for fuelwood (OC: 3.5±1.9 g/kg, BC: 1.1±0.5 g/kg), dungcake (OC: 12.6±4.5 g/kg, BC: 4.4±2.2 g/kg), agricultural residue (OC: 3.9±3.4 g/kg, BC: 1.3±1.1g/kg), charcoal (OC: 0.9±0.6 g/kg, BC: 0.4±0.2 g/kg) and softcoke (OC: 1.2±0.6 g/kg, BC: 0.8±0.4 g/kg).

Based on the consumption of fuels in different sectors in India, the emissions of carbonaceous aerosols consisting of organic carbon and black carbon are 2.8 Tg. The residential sector has maximum contribution of OC (1.1-3.2 Tg) and BC (0.3-1.0 Tg); out of which dung cakes show the highest emissions in spite of its lower consumption as compared to fuel wood. Major (~80%) portion of carbonaceous aerosols emitted from India are found to originate from the use of biomass for energy as 70-80 percent of energy requirement in rural India is met by combustion of traditional bio-fuels.

Tropopause Studies over Indian Tropical Region

Extremely low Tropopause Temperature Over Indian Tropical Region During Monsoon and Post Monsoon Period: Possible Implications

Many years ago, Newell and Gould-Stewart pointed out the significance of Bay of Bengal and Indian tropical region in Stratosphere-troposphere exchange (STE) processes. The 'freeze and dry effect' is generally believed to occur when the tropopause temperature is lower than 191K. So far, there are observational evidences to support the role of 'freeze dry mechanism' over the western Pacific region, in particular, over Indonesia. The observations from four intensive radiosonde /GPS sonde campaigns during summer monsoon and post monsoon seasons from number of stations in tropical Indian region provide clear evidence of the existence of tropopause temperature lower than 191K. Analysis suggests that cold tropopause occurs over a wide area of 5°x5° in latitude and longitude and more often around local midnight hours. Occurrence of cold tropopause temperature appears to occur more often over the ocean as compared to the coastal stations. The observations, at the coastal stations show that on the days of low temperature, the tropopause is cooler by ~8K than the climatological temperature for the Indian equatorial region and ~ 3.5K from mean of all observations. It is noted that on the days of observed cold tropopause, the lapse rate just below

the tropopause, is closer to the dry adiabatic lapse rate. This indicates a rapid cooling in a narrow height range. The present observations thus provide evidence that 'freeze dry mechanism' could be operating over a wide area, which includes the Indian tropical region.

Present observations show that Indian tropical region, including Bay of Bengal, actively participates in STE process and contributes to the dehydration of the stratosphere during monsoon and post monsoon seasons. It appears that both i.e. convection and the wave activity have a role in the occurrence of low tropopause temperature. Since the convection may not be right overhead, the horizontal advection is transporting air through the cold tropopause region and subsequently into the stratosphere. Long series of high range resolution radiosonde measurements of winds, temperature and water vapour are required in the upper troposphere and the lower stratosphere region to link the occurrence of low tropopause temperature to the water vapour in lower stratosphere and to better understand the complex processes, taking place in the vicinity of the tropical tropopause, that determine the stratospheric water vapour and its long-term trend.

Antarctica studies

One complete year data taken at Maitri, Antarctica were analyzed to study the annual variation of carbon mono-oxide. The diurnal variability in CO concentration has been observed with hourly ratios ranging from 30ppb to 90ppb at Maitri. It has been observed that on clear sunny days CO concentration increases in daytime with sunlight intensity. The Figure 6.2 below depicts the annual variation of Monthly mean CO concentration at Maitri Antarctica in 2004. Higher concentrations were found in the months of June, July , September and October and lower concentration in February and January.

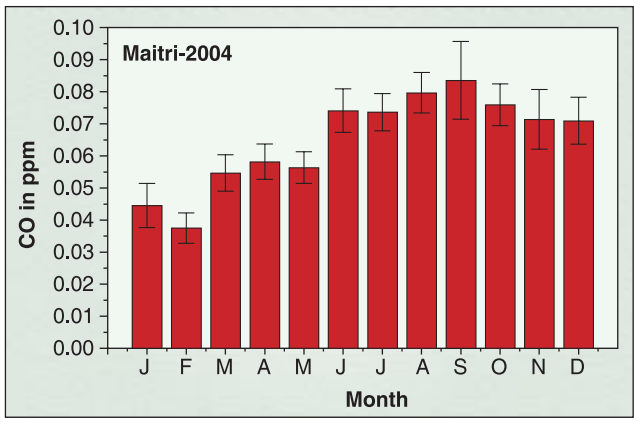


Fig. 6.2 Monthly mean CO concentration at Maitri Antarctica

RADIO PHYSICS AND SPACE APPLICATIONS

Upper atmospheric Studies

Ionospheric perturbations over Delhi caused by the December 26, 2004 Sumatra Earthquake

The death and destruction caused by the Sumatra earthquake on 26 December 2004 has once again jolted the seismologists to find a reliable precursor of an impending major earthquake. The F-region ionospheric parameters probed remotely by a digital ionosonde over Delhi (28.6^0 N, 77.2^0 E) have shown precursory signatures in the form of anomalous increases in foF2, few days before the occurrence of 26 December 2004 Sumatra earthquake (see Fig. 6.3) of 26 December 2004 Sumatra earthquake. Results indicate severe perturbations in foF2 and hmF several hours before the deadly earthquake. The

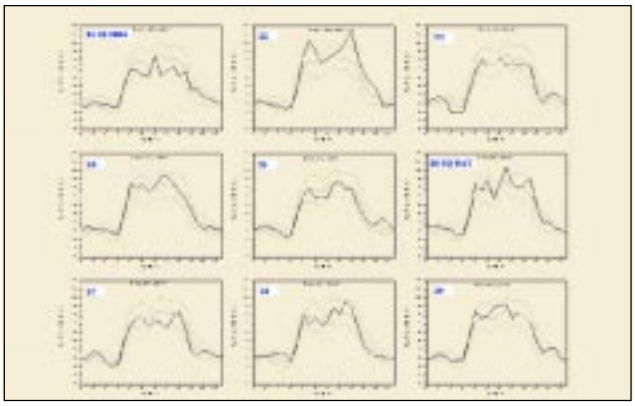


Fig. 6.3 Dashed gray line shows upper quartile and lower quartile values. Solid gray line shows monthly median value and black solid line show observed foF2 values.

wavelike perturbations in foF2 continued for several days even after the event. It is important to note that this earthquake struck at a time when there were no solar or geomagnetic disturbances for days together to cause any anomalous ionospheric changes.

Prediction of Solar Cycle 24 using modified precursor method

For predicting the maximum amplitude of forthcoming solar cycle number 24, precursor method is used. Precursor technique is based on the correlation of geomagnetic indices (disturbances) prior to the minimum or in the falling part of the sunspot cycle with the magnitude of the ensuing solar cycle maximum. In the present study, twelve monthly running average sunspot number (R12) and the number of geomagnetic disturbed days in a month (with Ap $\geq$ 25) for the periods corresponding to last seven solar cycles number 17 to 23 are considered. Geomagnetic disturbance index (DI) is determined using 12 month moving average of the monthly geomagnetic disturbed days. The linear correlations analysis is obtained between DI at ten selected times (defines as variate 1, 2 etc) during the decline part of a solar cycle with the R12 maximum (R12M) of the ensuing solar cycle. It is noted that the DI values near to the minimum of the declining part of a cycle i.e. variates 8 to 10, gives the best correlations with correlation coefficient (CC) equal to about 0.9 or more with the R12M of the ensuing solar cycle. These correlations are used to predict back the observed R12 peak values for cycles 17-23 and the results agree within about 10%. Instead, in each cycle if DI average of the best two cases with highest correlation coefficients are taken and again determine their correlation with peak R12M values of the ensuing solar cycle then the correlation results further improves drastically getting CC=0.98 and predicted values reaches within 5% of the observed R12 peaks for cycles 17-23. This modified technique predict a maximum amplitude of about R12M =139.6 $\pm$ 6.7 for the forthcoming solar cycle number 24 which is expected to occur about 50.5 $\pm$ 0.4 months after the minimum of cycle 23. The predicted cycle no. 24 is shown in figure 6.4.

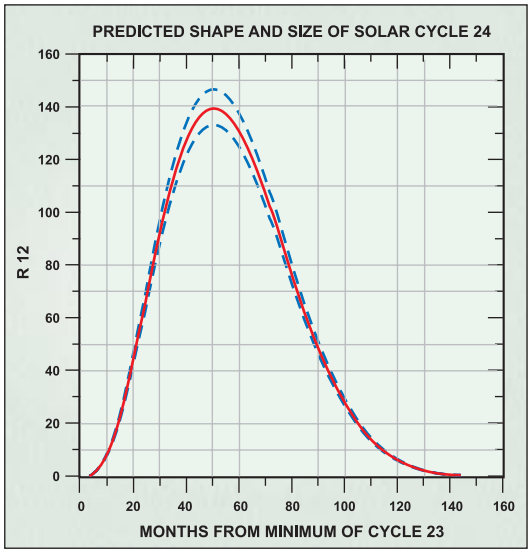


Fig. 6.4 Predicted maximum and shape of the forthcoming Solar Cycle 24

Response of Low Latitude Ionosphere to magnetic storms : Observations from SROSS C2 data

Observations made by the Retarding Potential Analyzer (RPA) payload onboard the Indian satellite SROSS-C2 are examined for four prominent geomagnetic storm events that occurred during the high solar activity period of 1997-2000. The daytime passes of SROSS-C2 have been selected to examine the redistribution of ionization in the equatorial ionization anomaly (EIA) region. Results from two prominent storms of 15 November 1998 and 7 April 2000 show that the contribution of disturbance dynamo related electric field is to modulate the daytime eastward electric field by westward electric field, which results in the weakening of EIA at the low and equatorial latitudes.

It is also noted that, though E X B drifts contribute significantly to redistribution of ionization at these latitudes, to explain the observed distribution of ionization at these latitudes, it is necessary to invoke other mechanisms. The changes in E X B drifts combined with meridional winds

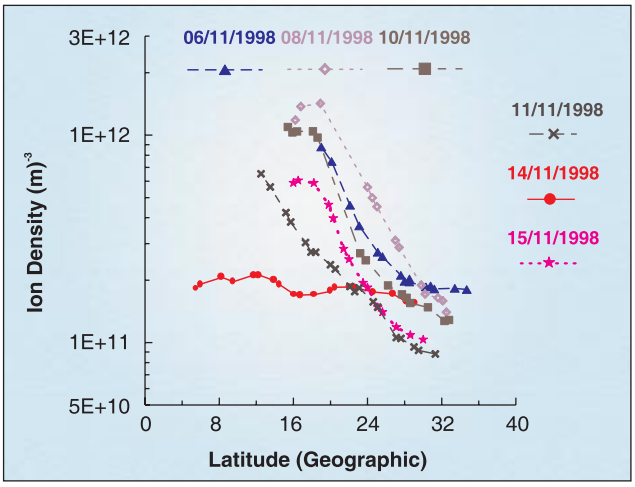


Fig. 6.5 Negative ionospheric storm

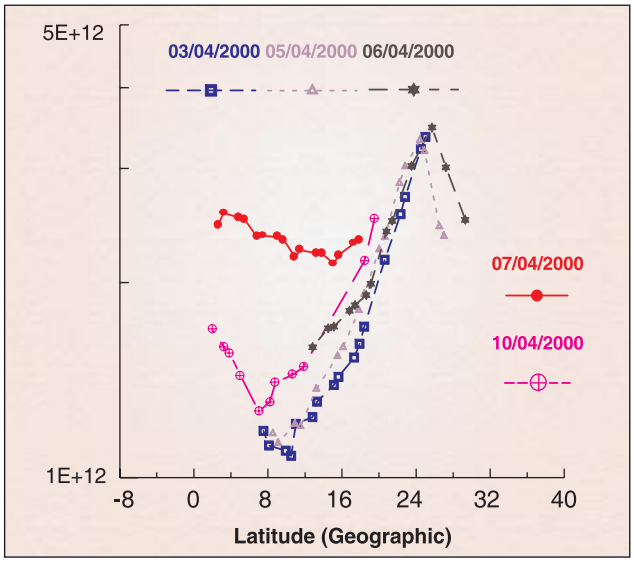


Fig. 6.6 Positive ionospheric storm

appear, to a large extent, explain the present observations. Figs. 6.5 and 6.6 show two different ways, the low latitude ionization distribution gets affected by the modulation effects of E X B drifts together with storm time neutral winds resulting in negative and positive ionospheric storms.

TROPOSPHERIC COMMUNICATIONS

Urban mobile radio wave propagation characteristics in the UHF band

A comparative study of urban mobile radio wave propagation characteristics in the UHF band has been carried out based on the field strength measurements conducted inside a moving train in two widely varying urban environments. The major fall out of this study is the modification of Xia's model which gave better agreement with observed results. The field strength measurements conducted with Chennai TV and FM were analysed and path loss exponents were deduced from observed results. These were compared with existing models. The variability of path loss as a function of distance for seven radial directions had been studied. This has been done to identify simpler and easy models to design future communication and broadcasting circuits. Coverage and capacity issues in CDMA for universal mobile telecommunication system networks have been studied in different propagation environments.

Studies of evaporation ducts for radio communication over the Indian ocean region at 10.5 GHz

To study both the duct formation processes and its variability and the extended range propagation of radar and communication signals required establishing microwave link at 10.5 GHz over an ocean path of 10 km. The transmitter and the antenna system is under development. A Dielectric Resonator based transmitter at 10.5 GHz is being developed. Also an antenna system at 10.5 GHz with a high performance feed is under development.

Validation of International Reference Ionosphere model (IRI) using Digital Ionosonde measurements at NPL, New Delhi

Bottomside electron density profiles

Using digital ionosonde measurements at NPL, New Delhi , noontime bottomside electron density profiles below the F2-peak, using in-built POLAN program for moderate solar activity period (2003) are obtained. These profiles are then normalized to peak height and density of the F2-region and are used to assess the predictability of the latest IRI-2001 model. Our analysis shows that IRI model using B0 Tab. option shows a good agreement with the observations, while IRI with Gulyaeva option overestimates bottomside electron density distribution.

Bottomside profile shape parameters

In the IRI model the electron density distribution below the F2-peak is described by analytical function involving profile shape parameters (B0,B1), where B0 represents bottomside thickness and B1 determines the profile shape. The best B0,B1 are derived by fitting each observed profile measured from digital ionosonde to the bottomside IRI profile function. These derived B0,B1 values are then compared with those obtained from IRI model. The data from 2001 to 2002 ($82 \leq R12 \leq 114$), a period of high solar activity (HSA) and 2003 ($52 \leq R12 \leq 80$), a moderate solar activity (MSA) are analyzed for this study. (R12 is 12 month running average sunspot number).

Comparison of median B0 values with those predicted by the IRI model (B0 Tab.) during HSA for all the seasons, show in general good agreement during daytime, while the IRI (Gulyaeva) option

reveals better agreement during nighttime. While for the B1 parameter, the IRI (Gulyaeva) option overestimates during all the seasons, and IRI (B0 Tab.) predictions show good agreement with observed median B1 values. Diurnal variation of B0,B1 parameters derived from digital ionosonde measurements over New Delhi along with the IRI model values are shown in the Fig. 6.7 and 6.8 respectively.

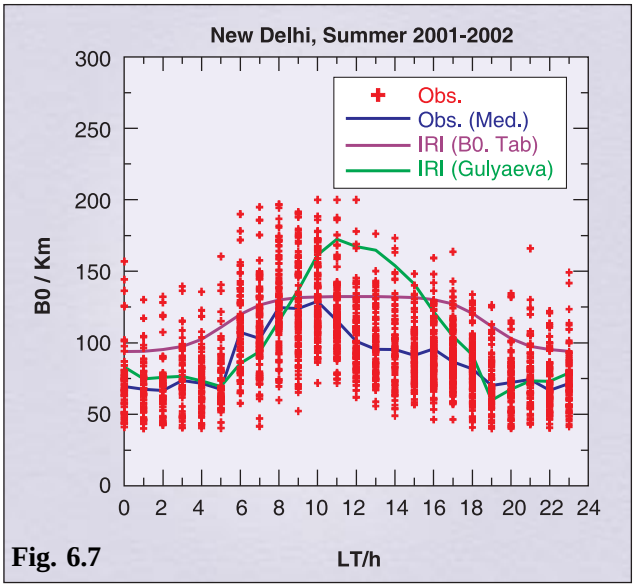


Fig. 6.7

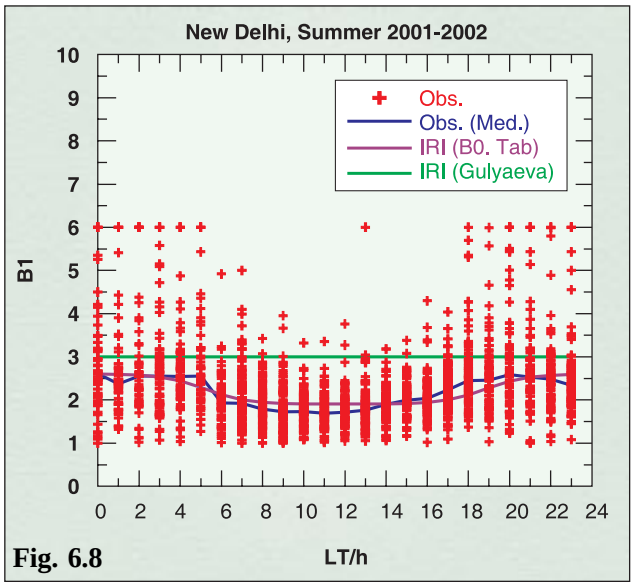


Fig. 6.8

Fig. 6.7 and 6.8 show mass plot of the parameters B0 and B1 along with their median values and the IRI model values respectively.

Instruments and Facility Development Activities

Application of LabView Facility to Sunspot Activity

A powerful time-series analysis tool has been developed using LabVIEW virtual instruments platform for the analysis of "chaos" in sunspot numbers and to enhance the predictability of solar activity (Fig.9). This is based on a generalised scheme (algorithm) for observing and studying chaotic systems. The following scheme is adopted.

Time series Analysis to study chaos in sunspot activity

Evaluation of standard Correlation Function

The sunspot values are embedded in a n-dimensional phase space so that a point in the space is given by

$X(t) = \{x(t),x(t+\tau),.....x(t+(n-1)\tau)\}$, τ is the scaling-delay

The correlation function is given by

$$C(r,n) = \lim \{1/N \sum H(r - IIX(i)-X(j)II)$$

N is the no. of points on the attractor of long time series, n is dimension of the attractor and H is the heaviside function IIX(i)-X(j)II is the Euclidean distance between points in n-dim.

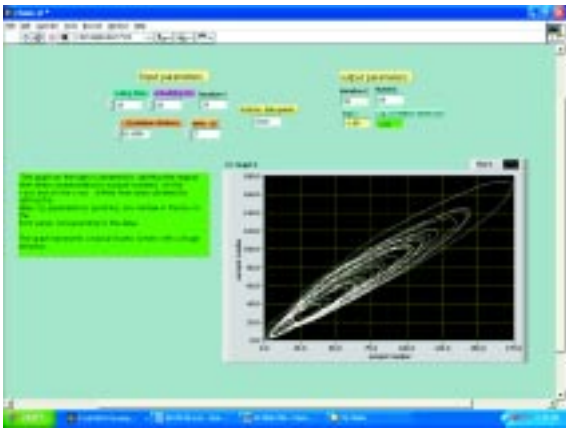


Fig. 6.9 : The front panel of a program developed in LabVIEW for studying chaos in sunspot numbers. The graph represents a typical chaotic system with a strange attractor

Surface Ozone calibration facility

Mass flow calibrator (Model: 700) of Advanced Pollution Instruments, USA has been installed and made operational since January, 2005. The M700 calibrator can generate diluted calibration gas including ozone, gas phase titration from gas cylinders, or from a permeation tube source gas. Each

concentration is generated precisely by mixing the gas with diluent zero air in which the mixing ratio is controlled by the mass flow controller. Typically, ozone is generated by the photolysis of purified air using radiation at 185 nm. The purified zero air is assumed to contain no significant impurities, have less than 1000 ppbv total hydrocarbons, and contain 20-21% oxygen. Zero air adequate for this application is obtainable with Zero Air Module (Model: 701) of Advanced Pollution Instruments, USA, which gives zero air with a maximum delivery pressure of 35 psig. Using the above facility, Ozone analyzers available with NPL have been calibrated regularly.

On request from different institutes like J.C. Bose Institute, Darjeeling, Delhi University, Delhi and Indian Institute of Tropical Meteorology, Pune etc., we have calibrated their ozone analyzers with our ozone calibrator.

अतिचालकता तथा निम्नतापिकी

SUPERCONDUCTIVITY AND CRYOGENICS

अतिचालकता तथा निम्नतापिकी

प्रभाग का फोकस (केन्द्र बिन्दु) प्रतिस्थायी उच्च ताप अतिचालक और अन्य संबद्ध पदार्थों का मूल दृष्टिकोण रहा है। पोलीक्रिस्टेलाइन नमूनो की विभिन्न श्रेणियों के विद्युत, चुंबकीय, थर्मल और अवसंरचनात्मक तकनीकों द्वारा संश्लेषित और अभिलाक्षणिक (Characterized) किया गया था। उनमें से कुछ निम्न है जैसे :- 0, 2, 4 और 6% सहित Bulk MgB_2 नमूने जिसमें नैनो-Co_3O_4 को जोड़ा गया है, को संश्लेषित किया गया था जिससे कि नैनो-डोपिंग द्वारा विवेचनात्मक करंट सघनता की वृद्धि का अध्ययन किया जा सके । Mo (doped) Ruthenocuprates $Ru_{1-x}Mo_xSr_2Eu_{1.5}Ce_{0.5}Cu_2O_{10-\delta}$ (for x = 0.0, 0.2, 0.4, 0.6, 0.8 और 1.0) में चुंबकत्व और अतिचालकता के सह अस्तित्व की खोज की गयी थी। Mn-प्रतिस्थायी $REBa_2(Cu_{1-x}Mn_x)_3O_y$ (RE=Y,Gd); 0<x<2%) और $Y_{0.95}Pr_{0.05}Ba_2(Cu_{1-x}Mn_x)_3O_y$ (o < x < 2%) के थर्मल व्यवहार (Behaviour) की तुलना की गयी थी। $Pr_{1-x}Ba_xMnO_3$ और Sb-doped (सामान्यतः Mn Sites तक) $Pr_{2/3}Ba_{1/3}MnO_3$ पैरावेस्काइट मैग्नाइट्स के सूक्ष्म अवसंरचनात्मक आकार सहित विद्युत और चुंबकीय गुण धर्मों के सम्बन्ध की खोज की गयी थी ।

SUPERCONDUCTIVITY AND CRYOGENICS

The focus of the division has been on the basic aspects of substituted high temperature superconductors and other related materials. Various series of polycrystalline samples were synthesized and characterized by electrical, magnetic, thermal and structural techniques. Some of them are as follows. Bulk MgB_2 samples with 0, 2, 4 and 6% added nano-Co_3O_4 were synthesized to study enhancement of critical current densities by nano-doping. Coexistence of magnetism and superconductivity in Mo doped ruthenocuprates $Ru_{1-x}Mo_xSr_2Eu_{1.5}Ce_{0.5}Cu_2O_{10-\delta}$ (for x = 0.0, 0.2, 0.4, 0.6, 0.8 and 1.0) was investigated. Thermal behaviour of Mn-substituted $REBa_2(Cu_{1-x}Mn_x)_3O_y$ (RE=Y,Gd); $0<x<2\%$) and $Y_{0.95}Pr_{0.05}Ba_2(Cu_{1-x}Mn_x)_3O_y$ ($0 \leq x \leq 2\%$) was compared. Relation of electrical and magnetic properties with micro-structural features of the $Pr_{1-x}Ba_xMnO_3$ and Sb-doped (nominally at Mn sites) $Pr_{2/3}Ba_{1/3}MnO_3$ perovskite manganites were investigated.

SUPERCONDUCTIVITY STUDIES

- **"Fluxiod jumps coupled high critical current density of nano-Co_3O_4 doped MgB_2"**

Polycrystalline MgB_2 samples with 0, 2, 4 and 6% added nano-Co_3O_4 being synthesized by vacuum (10^{-5} Torr) annealing at 750 ^{0}C for two and half hours each are found to be nearly single phase with presence of only a small quantity of Mg/MgO in pristine sample and in addition the Co_2O_3 in doped compounds. All the samples exhibited clear and sharp diamagnetic transitions at around 38 K, in Zero-field-cooled (*ZFC*) magnetic susceptibility measurements with sizeable signal. The Field cooled (*FC*) measurements though having sharp transitions, but showed a very small signal, indicating high level of pinning centers in these samples. Further some of the doped samples exhibited Paramagnetic-Meissner-Effect (*PME*) in applied field of 5 Oe. The critical current density (J_c), being estimated by invoking Bean's model for the pristine compound increase by nearly an order of magnitude for 2% and 4% nano-Co_3O_4 doping and later the same decreases sharply for 6% sample at nearly all studied temperatures and applied fields. Further the increased J_c ($\sim 10^8$ A/cm^2) is coupled with fluxoid jumps (T = 20 K and H = 1 T). Fluxoid jumps are not seen in relatively low J_c pristine or 6% sample (Fig. 7.1). This means the fluxoid-jumps are intrinsic only to the high J_c samples.

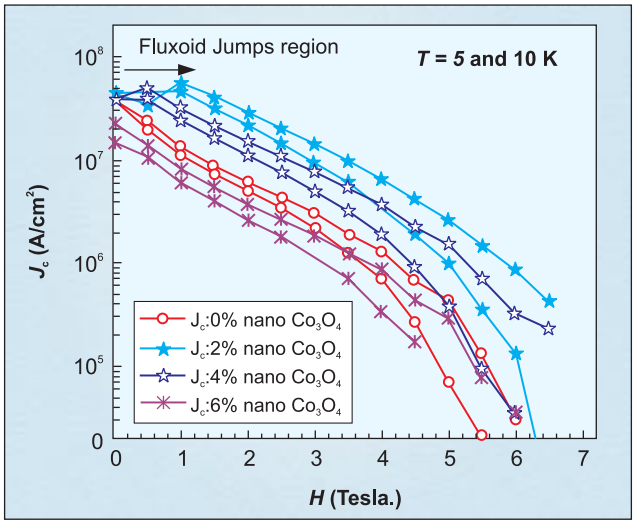


Fig. 7.1 J_c versus H plots for various n-Co_3O_4 doped MgB_2 samples.

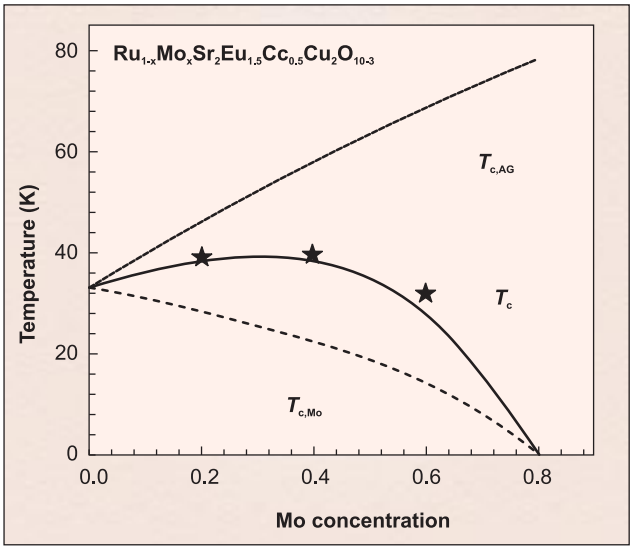


Fig.7.2 Transition temperature versus x plot for the $Ru_{1-x}Mo_xSr_2Eu_{1.5}Ce_{0.5}Cu_2O_{10}$ system

- **Experimental study of magneto-superconductor $RuSr_2Eu_{1.5}Ce_{0.5}Cu_2O_{10-\delta}$: Effect of Mo doping on magnetic behaviour and Tc variation"**

Mo doped ruthenocuprates $Ru_{1-x}Mo_xSr_2Eu_{1.5}Ce_{0.5}Cu_2O_{10-\delta}$ are synthesized for x = 0.0, 0.2, 0.4, 0.6, 0.8 and 1.0, and their magnetic and superconducting properties are studied. It has been found that the magnetic transition temperature T_{ZFC}^{peak}, which corresponds to the appearance of weak ferromagnetic effect, decreases from its value of 75 K for x = 0.0 to 22 K, 25 K and 18 K, respectively for the x = 0.2, 0.4 and 0.6 samples. Another finding is that the magnetic susceptibility reduces at T_{ZFC}^{peak} by a factor of about 6, 85 and 413 for x = 0.2, 0.4, and 0.6 respectively. The samples of x = 0.8 and 1.0 are found to have no magnetic or superconducting effects. The values of the superconducting transition temperature are obtained from the resistivity versus temperature data. An important result is that *Tc* increases by 4.5 K and 7.0 K for x = 0.2 and 0.4 respectively, and then decreases by 17 K for x = 0.6. The observed variation of T_c with x has been explained in terms of a theory which combines the effects of weakening magnetic behavior and reducing carrier concentration in a phenomenological manner (Fig. 7.2). The resulting theory is found to provide a good agreement with the observed value of T_c.

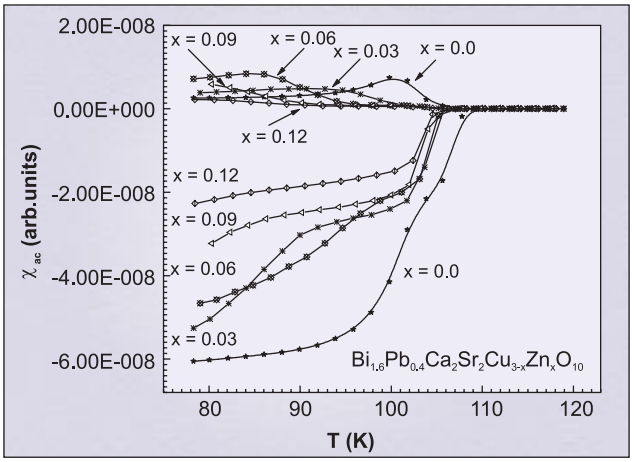


Fig.7.3 Magnetic susceptibility versus T plots for $Bi_{1.6}Pb_{0.4}Sr_2Ca_2Cu_{3-x}Zn_xO_{10}$ system.

- **Impact of Zn substitution on phase formation and superconductivity of $Bi_{1.6}Pb_{0.4}Sr_2Ca_2Cu_{3-x}Zn_xO_{10-\delta}$ with x = 0.0, 0.03, 0.06, 0.09 and 0.12"**

Samples of series $Bi_{1.6}Pb_{0.4}Sr_2Ca_2Cu_{3-x}Zn_xO_{10-\delta}$ with x = 0.0, 0.015, 0.03, 0.06, 0.09 and 0.12 are synthesized by solid-state reaction route. All the samples crystallize in tetragonal structure with majority (>90%) of Bi-2223 ($Bi_2Sr_2Ca_2Cu_3O_{10}$) phase (c-lattice parameter ~36 Å). The proportion of Bi-2223 phase decreases slightly with an increase in x. The lattice parameters a and c of main phase (Bi-2223) do not change significantly with increasing x. Superconducting critical transition temperature (T_c) decreases with x as evidenced by both resistivity [ρ(T)] and AC magnetic susceptibility [χ(T), Fig.7.3] measurements. Interestingly the decrement of T_c is not monotonic and the same saturates at around 96 K for x >0.06. In fact *Tc* decreases fast (~10K/at%) for x = 0.015 and 0.03 samples and later nearly saturates for higher x values. Present results of Zn doping in Bi-2223 system are compared with Zn doped other HTSC (High temperature superconducting) systems, namely the RE-123 ($REBa_2Cu_3O_7$) and La-214.

- **Electrical and Thermal Investigations on $RBa_2(Cu_{1-x}Mn_x)_3O_{7-\ddot{a}}$ (R=Gd,Y)**

Thermal behaviour (Specific heat, thermoelectric power and thermal conductivity) of superconducting samples $GdBa_2(Cu_{1-x}Mn_x)_3O_{7-\ddot{a}}$ ($x \leq 0.02$) has been investigated. Experimental data obtained are analyzed by using a narrow band model for the thermoelectric power and a phonon model for the thermal conductivity. It has been found that while the specific heat shows a jump at the superconducting transition temperature T_c for $x \leq 0.0075$ only, the thermal conductivity supports the presence of a superconducting energy gap at zero temperature for all values of x. Comparison of the parameters obtained from the analysis of the thermoelectric power and resistivity indicates a crossover of the role of Mn at $x = 0.0075$. Based on the thermoelectric power and thermal conductivity results of the $GdBa_2(Cu_{1-x}Mn_x)_3O_{7-\ddot{a}}$ and $YBa_2(Cu_{1-x}Mn_x)_3O_{7-\ddot{a}}$ systems with $x = 0.0$ and 0.005, it is suggested that Gd^{+3} ions also affect the considered thermal behavior.

Thermal conductivity (k) and thermoelectric power (S) on the Mn-substituted $YBa_2(Cu_{1-x}Mn_x)_3O_y$ (0<x<2%) using a DC pulse technique and specific heat on $Y_{0.95}Pr_{0.05}Ba_2(Cu_{1-x}Mn_x)_3O_y$ ($0 \leq x \leq 2\%$) by semi-adiabatic heat pulse technique were investigated. Results indicate the normal state S(T) shows a concave behaviour for pure and low dopant concentrations; however, a convex behaviour is observed for samples with Mn concentrations of 1% and above. Significantly, replacing 1% Cu by Mn has little effect on the transition temperature; however, the change in S(T) is about a factor of eight. Specific heat jump of 3.8J/mol K, was observed only for pure Y-123 sample. However, no jump was observed in the doped samples. Detailed specific heat measurements carried out on pure and Mn-doped YBaCuO and GdBaCuO systems show that T_c remains practically unchanged for YBaCuMnO with respect to Mn substitution but in contrast, a noticeable reduction in T_c is observed in the GdBaCuO case. Prestine systems exhibit a clear jump in the specific heat at T_c. However, a small Mn substitution caused a strong suppression in C_p jump, suggesting that Mn is being incorporated into REBaCuO sytem as a whole and not in the form of a local cluster.

- **Magneto-transport and morphological studies of $Pr_{1-x}Ba_xMnO_3$ and Sb-doped $Pr_{2/3}Ba_{1/3}MnO_3$ Perovskites**

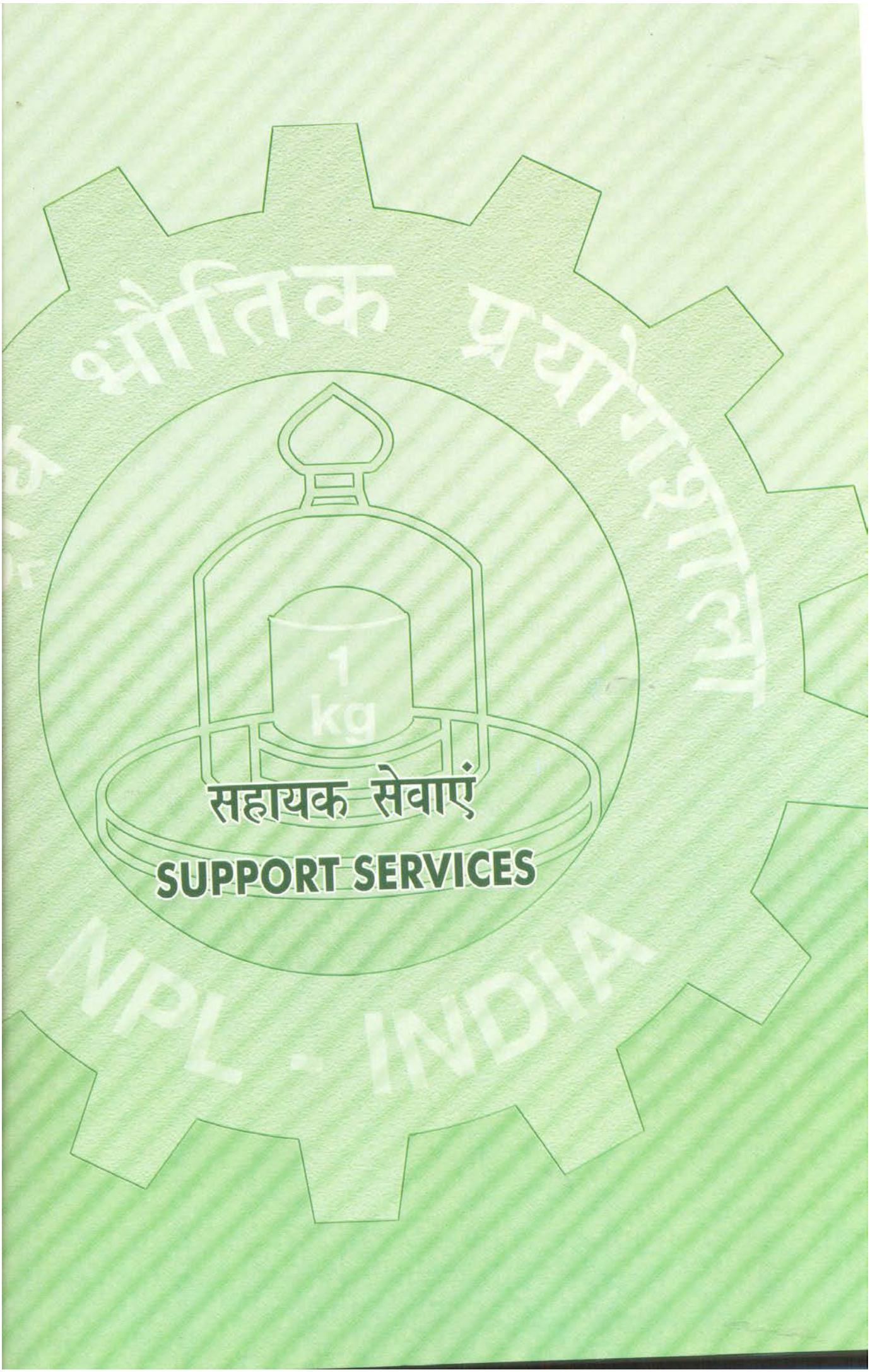
Electrical, magnetic and micro-structural features

of the $Pr_{1-x}Ba_xMnO_3$ and Sb-doped (nominally at Mn sites) $Pr_{2/3}Ba_{1/3}MnO_3$ perovskite manganites were also investigated. Pristine material shows two insulator-metal (I-M) like transitions in the resistivity-temperature behavior. While the higher temperature transition (T_{P1}) at ~195K is reminiscent of the usual metal-insulator transition, the lower temperature transition (T_{P2}) at ~160K has been ascribed to the grain boundary (GB) effects arising out of the ionic size mismatch between the ions present at the rare-earth site (Pr and Ba). LFMR results (at 0.15T) also substantiate the observed data. MR peaks near T_{P1} and increases further at lower temperatures, reflecting the grain boundary contribution. Susceptibility measurements show Curie transition (T_c) to be close to T_{P1} of the ñ-T data. Results are found to be consistent with other systems like $(NdBa)MnO_3$. Resistivity data on $Pr_{0.67}Sr_{0.33}MnO_3$ system, where the transition at T_{P2} is not seen due to smaller ionic size difference of (Pr^{+3}- Sr^{+2}) than (Pr^{+3}- Ba^{+2}), also corroborate these results. The resistivity upturn observed at low temperatures is considered in terms of the ensuing localization of carriers due to varying degree of ionic size mismatch in these systems.

With Sb doping at the Mn-site, both the resistivity peaks are seen to shift to lower temperatures. Room temperature resistivity and the peak values are also successively increasing with Sb doping. Scanning micrographs of the samples indicate a gradual increase in their grain sizes with Sb which indicates a gradual decrease in the GB density. The higher temperature insulator-metal transition (T_{P1}) shift is explained on the basis of a competition between double-exchange and super-exchange mechanisms. The observed overall resistivity increase and the shift in the resistivity hump (T_{P2}) with Sb are found related to the gradually decreasing GB density and the ensuing lattice strain increase at the grain boundaries. The intrinsic MR gets suppressed and extrinsic MR gets enhanced with Sb doping. The observed low temperature resistivity upturn related to the localization of carriers, is also seen to increase with Sb.

Dielectric, Electrical and Microstructural Studies of W-doped $SrBi_2Ta_2O_9$ ferroelectric Ceramics

Crystal structure, surface morphology, dielectric and electrical properties of tungsten doped $SrBi_2(W_xTa_{1-x})_2O_9$ ($0.0 \leq x \leq 0.2$) ferroelectric ceramics were investigated. Dielectric measurements performed as a function of temperature at 1 kHz, 10 kHz and 100 kHz show an increase in Curie temperature (T_c) over the composition range of $x=0.05$ to 0.20. W^{6+} substitution in perovskite-like units results in a sharp dielectric transition at the ferroelectric Curie temperature with the dielectric constant at their respective Curie temperature increasing with tungsten doping. The dielectric loss reduces significantly with tungsten addition. The temperature dependence of ac and dc conductivity vis-à-vis tungsten content shows a decrease in conductivity that is attributed to the suppression of oxygen vacancies. The activation energy calculated from the Arrhenius plots is found to increase with tungsten content.



सहायक सेवाएं

SUPPORT SERVICES

Planning, Monitoring and Evaluation Croup

Contract R & D Projects, as Sponsored, Collaborative and Grant-in-Aid Projects are undertaken by the Laboratory with funding from External Agencies. Before submission of the project proposals to the outside agencies they are evaluated by the Group based on various criteria and guidelines. Monitoring and developing of complete database for report generation on projects are done and project files are created and maintained. Similarly Major Laboratory Projects and other In-house Projects funded by CSIR & NPL undertaken in NPL are also monitored. Fund allocation and processing of indents is an important activity. The report on completed projects and refund of unspent balance to the funding agencies at the end of project are made by the group

PME prepares Annual Plan and Five Year Plan for NPL. It organizes Research Council meetings and coordinates with Management Council meetings organized by administration. Time to time PME disseminates information on projects, performance reports and ECF reports to CSIR. PME is also involved in monitoring of Networking Projects. PME developed manpower data and maintains staff positions and disseminates the information to various authorities. The group also maintains and regulates the appointments of project staff under various externally funded projects.

Industrial Liaison Group

This group handles two major areas viz. Marketing of developed technologies and Consultancy projects. Besides this ILG is responsible for all matter connected with business development, open days function, where few thousand schools and college students with their teachers are invited to see the various activities at NPL. Students are shown a film on NPL activities too. A technology day function is also observed where all licenceses are invited to delibrate with concerned PI of the technology for any suggestions. This group is also responsible for the dissemination of information, publication in CSIR news and in CSIR annual report. This group also takes care in the Management of S & T outputs with other funding agencies viz. DST, CSIR, NRDC etc.

Human Resource Management Group

This group arranges training programmes for the benefit of NPL staff and also organizes NPL sponsored training courses for the benefit of industries in various areas of core competency. It also supports organization of 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 graduates and summer training on reciprocal basis. In processes induction of JRF's. SRF's, Research Associates for NPL programmes. The group also pursues other schemes of CSIR on EMR and HRD activities.

International Science and Technology Affairs Group

International visits play an important part of scientific R & D Processing of application of the laboratory scientists pertaining to international visits, bilateral exchange programmes, sabbatical study period and deputations abroad are handled by this group. It also arranges important lectures and invited talks. Arranging training programmes for international candidates is also the job of this group.

Library and Technical Information Services

NPL Library has been providing library and information support to scientist for R&D pursuits. Over the years it has developed a rich collection of scholarly books and journals for the purpose specifically in the filed of physics and related sciences.

During the current year library subscribed to 112 scholarly journals (93 foreign journals and 19 Indian journals) and added 98 S&T books, 53 Hindi books and 2222 bound volumes of journals. The library uses library management package developed in house, to perform its entire house keeping functions. Library provides library services such as photocopying service, electronic document delivery service, inter library loan service, reference service and literature search.

The library offers online access to more than 4500+ full text journals under the e-consortium project of CSIR. It facilitate access to journals from various publishers i.e. Science Direct (elsevier), Blackwell, Springer, AIP, APS (American Physical

Society), Wiley Inter science, John Wiley and sons, Oxford University Press, Royal Society of Chemistry, American Chemical Society as well as to their archives going back to 1995 in case of elsevier science and 2000 onwards in the case of other publisher.

This Service was made operational in NPL on 31st July 2002 with the access to Science Direct (Elsevier) group of journals and other w.e.f. February 2005 onwards.

The Library has a KSK Library site on the NPL internet providing latest information on its activities such as additions to its collection, current subscribed journals, new journals received during the week, links to electronic libraries, publishing houses, library catalogue, and papers published by NPL scientists. The library continued to Update this site during the year.

The Library also maintains NPL website (www.nplindia.org) on Internet. It is providing latest information on activities of NPL such as its role; thrust areas of research, facilities, services and achievements. The library continued to update this site.

Central Workshop

Different types of machining facilities have been established in NPL's Central workshop to extend support to laboratory's R&D needs and to undertake external contract jobs. In addition to normal milling, lathe and welding machines etc. for normal fabrication jobs, work-shop is also under-taking a wide varieties of jobs of die making, sheet metals, plating and polishing jobs, high quality carpentry works etc. The NPL workshop also has CNC milling facilities backed up by a CAD / CAM facility comprising a high precision German 'DECKAL FP4A' universal milling machine, with CNC rotary table and a GLIDEMESTER CT-200 CNC lathe machine capable of producing turned components. The workshop is also having a Auto CAD based drawing and tracing facilities. During the year the central workshop has completed- more than 1095 jobs of in- house machining and fulfilled most of the requirements of high precision jobs of various Divisions/Sections. Total cost of work done during the year at Workshop was approx. Rs.One crore thirty eight lacs thirty six thousand two hundred eighty eight only).

In addition to design, development and fabrication jobs, work-shop also undertakes a large number of maintenance jobs comprising different precision machines, pumps, compressors, gear boxes, machines of the Glass Technology Unit etc.

Glass Technology Unit

This unit is having excellent facilities and expertise for design,development, fabrication and repair of scientific glass and quartz glass apparatus and equipments. It undertakes scientific glass instrumentation work for in-house as well as other institutions,industries and organisations.During the year Glass Technology Unit completed 176 jobs for NPL and 15 jobs for outside agencies and earned Rs 97898/- (Rs. Ninety seven thousand eight hundred and ninety eight only) as ECF. GTU has also provided a comprehensive technical training for various skills to one Technical Officer from Sri Lanka, University of MORATOWA for two months and charged a sum of US $ 2000/-

राजभाषा कार्यान्वयन

हिन्दी पखवाड़ा

राष्ट्रीय भौतिक प्रयोगशाला में तारीख 1.9.2005 से 14.9.2005 तक हिन्दी पखवाड़े का आयोजन किया गया। पखवाड़े के दौरान विभिन्न प्रतियोगिताएं आयोजित की गयीं। तारीख 14.9.2005 को प्रयोगशाला के सभा–भवन में समापन समारोह आयोजित किया गया। प्रयोगशाला के निदेशक डा. विक्रम कुमार ने कार्यक्रम की अध्यक्षता की तथा उपस्थित सभी स्टॉफ सदस्यों को इस अवसर पर संदेश दिया। अपने संदेश में उन्होंने प्रयोगशाला में हो रही हिन्दी सम्बन्धी विभिन्न गतिविधियों के बारे में बताते हुए उन प्रतिभागियों की प्रशंसा की जिन्होंने विभिन्न प्रतियोगिताओं में उत्साहपूर्वक भाग लिया और उपस्थित सभी स्टॉफ सदस्यों को अपना कार्य हिन्दी में करने के लिए प्रेरित किया।

निदेशक महोदय के स्वागत भाषण के पश्चात् प्रयोगशाला के वैज्ञानिक डा. जी भगवन्नारायण ने अपने निजी अनुभवों के बारे में बताया। प्रयोगशाला में प्रतिवर्ष कविता प्रतियोगिता का आयोजन किया जाता है। प्रतियोगिता में प्रथम पुरस्कार विजेताओं (दो) की कविताएं सुनायी गयी। इसके उपरान्त विभिन्न प्रतियोगिताओं में भाग लेने वाले विजेताओं को पुरस्कार प्रदान किए गए। इस वर्ष प्रतिभागियों की संख्या काफी अच्छी रही। कुल 67 पुरस्कार दिए गए। इस वर्ष से एक अन्य प्रतियोगिता, साइंस क्विज प्रतियोगिता का आयोजन किया गया जिसमें अधिकारियों/कर्मचारियों की अच्छी भागीदारी रही इस प्रतियोगिता में कर्मचारियों ने अच्छा रूझान दिखाया। कविता पाठ प्रतियोगिता, क्विज प्रतियोगिता के साथ–साथ निबन्ध प्रतियोगता, टंकण प्रतियोगिता में भी प्रतिभागियों ने उत्साहपूर्वक भाग लिया।

प्रशासनिक कार्यशाला

प्रयोगशाला में प्रशासन विभाग से सम्बन्धित विभिन्न पहलुओं पर प्रत्येक तिमाही में कार्यशालाओं का आयोजन किया जाता है। दिनांक 17 मार्च, 2005 को प्रयोगशाला के अधिकारियों/कर्मचारियों के लिए 'राजभाषा कार्यान्वयन' से सम्बन्धित एक दिवसीय कार्यशाला का आयोजन किया गया। इस कार्यशाला का मुख्य उद्देश्य प्रशासन के सभी अधिकारियों/कर्मचारियों को हिन्दी में किए गए कार्य से सम्बन्धित तिमाही प्रगति रिपोर्ट को प्रपत्र में भरने के सम्बन्ध में जानकरी उपलब्ध कराना था। इसके अतिरिक्त 1963 की धारा 3(3) के नियम अधिनियमों से अवगत कराना, सी.एस.आई.आर. की क्रय प्रक्रिया, भण्डारण व्यवस्था व रिकार्ड मैनेजमेंट एवं सी सी एस नियमों से संबंधित विस्तृत जानकारी उपलब्ध कराना था।

कार्यशाला का शुभारंभ करते हुए निदेशक महोदय ने अपने संदेश में कहा कि प्रयोगशाला में हिन्दी के कार्य में निरंतर प्रगति हो रही है परन्तु इसमें और अधिक गति लाने के उददेश्य से प्रशासन में कार्यरत सभी सदस्यों के साथ–साथ वैज्ञानिक/तकनीकी दोनों में भी कार्यरत सभी सदस्यों को अपना सर्वश्रेष्ठ प्रदर्शन व योगदान देना होगा तभी हिन्दी का सर्वांगीण विकास हो सकेगा।

कार्यशाला को तीन सत्रों में विभक्त किया गया था जिसमें क्रमशः प्रथम सत्र में डा. पूरनपाल ने तिमाही प्रगति रिपोर्ट भरने व धारा 3(3) से सम्बन्धित विषय पर चर्चा की। उसके पश्चात् दूसरे सत्र में श्री कुलदीप कौशिक ने सी.एस.आई. आर. की क्रय प्रक्रिया व भण्डारण व्यवस्था पर विस्तार से बताया और अंत में तृतीय सत्र में श्री आर.पी. शर्मा ने रिकार्ड मैनेजमेंट एवं सी सी एस नियमों के बारे में बताया। इस कार्यशाला में कुल 58 प्रतिभागियों ने भाग लिया। कार्यशाला में भाग लेने वाले प्रतिभागियों को बहुत सी ऐसी जानकारियां प्राप्त हुई जिनसे वे अनभिज्ञ थे। यह कार्यशाला अत्यंत सफल रही।

राष्ट्रीय कार्यशाला

राष्ट्रीय भौतिक प्रयोगशाला में पिछले चार–पांच वर्षों से विज्ञान विषय पर हिन्दी में राष्ट्रीय कार्यशालाओं का आयोजन किया जा रहा है। आमतौर पर लोगों की अवधारणा है कि वैज्ञानिक कार्यों में हिन्दी का प्रयोग कठिन है लेकिन यदि किसी कार्य को करने की दृढ़ इच्छा शक्ति हो और निष्ठापूर्वक प्रयत्न किया जाए तो कुछ भी असंभव नहीं है। इसी विचार को केन्द्र में रखकर राष्ट्रीय भौतिक प्रयोगशाला ने प्रतिवर्ष हिन्दी माध्यम से पूर्णरूप से वैज्ञानिक कार्यशालाओं का आयोजन आरंभ किया है। इसके लिए प्रयोगशाला के कार्य क्षेत्र को तीन भागों में विभक्त किया गया है – मानक, पदार्थ विज्ञान तथा रेडियो एवं वायुमण्डलीय विज्ञान। प्रत्येक वर्ष इनमें से एक क्षेत्र में क्रमशः राष्ट्रीय स्तर की कार्यशाला आयोजित की जाती है। इस वर्ष दिनांक 3–4 मई, 2005 को पदार्थ विज्ञान एवं अनुप्रयोगों की प्रगति पर कार्यशाला आयोजित की गयी है। इस कार्यशाला में राष्ट्रीय स्तर पर वैज्ञानिकों व युवा शोध छात्रों को अपनी–2 वार्ताएं प्रस्तुत करने के लिए आमंत्रित किया गया जिससे कि सभी एक ही प्लेटफार्म पर एकत्र होकर विचारों का आदान–प्रदान कर सकें।

इस कार्यशाला में लगभग 55 प्रतिभागियों ने अपने–2 क्षेत्र से सम्बन्धित

पेपर प्रस्तुत किए जो पूर्णतः वैज्ञानिक थे, केवल उनकी भाषा हिन्दी थी। इस कार्यशाला का मुख्य उद्देश्य विज्ञान सम्बन्धी कठिन तथ्यों एवं विचारों को सरल सुबोध हिन्दी में प्रस्तुत करना रहा जिससे कि वैज्ञानिक शोधों एवं विकास से जुड़ी गतिविधियों को प्रौद्योगिकीय विकास की ओर ले जाकर भारत का सर्वांगीण विकास सुनिश्चित किया जा सके।

इस कार्यशाला में इस वर्ष से एक नई पहल की गयी है। इसमें 35 वर्ष या

उससे कम आयु के वैज्ञानिकों/शोध छात्रों द्वारा प्रस्तुत पेपर्स में से दो श्रेष्ठ पेपर्स का चयन करके उन्हें पुरस्कृत किया गया। इस वर्ष दो शोध छात्रों का चयन किया गया। राष्ट्रीय कार्यशाला के समापन समारोह में निदेशक, एन.पी.एल. ने नकद पुरस्कार प्रदान किए।

विशिष्ट व्याख्यान

राजभाषा हिन्दी के प्रभावी कार्यान्वयन, इसके व्यापक प्रचार-प्रसार तथा वैज्ञानिक, तकनीकी व प्रशासनिक क्षेत्रों में अधिक से अधिक बढ़ावा देने के उद्देश्य से कुछ वर्ष पूर्व से राष्ट्रीय भौतिक प्रयोगशाला में व्याख्यान श्रृंखला को आरम्भ किया गया था। इसी संदर्भ में समय समय पर विशिष्ट व्यक्तियों द्वारा महत्त्वपूर्ण एवं प्रेरणात्मक विषयों पर व्याख्यान आयोजित किए जाते हैं। इसी श्रृंखला के अन्तर्गत दिनांक 8 जून, 2005 को प्रो. रमेश पाण्ड्या, विभागाध्यक्ष, स्टेटिस्टिकल विभाग, रतलाम (मध्यप्रदेश) ने 'ग्रहों का मानव जीवन पर असर : केवल आंकड़ों का समन्वय या यथार्थ ?' नामक विषय पर व्याख्यान दिया। इसमें प्रो. पाण्ड्या ने ग्रहों की पूर्ण रूप से जानकारी दी व उन ग्रहों का मानव शरीर पर किस तरह से प्रभाव पड़ता है इस पर विस्तार से बताया। प्रयोगशाला के सदस्यों ने इसमें अत्यधिक रूचि व जिज्ञासा प्रदर्शित की व अनेक प्रश्न पूछकर उनका समाधान प्राप्त किया।

संलग्न

APPENDICES

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157. Subrahmanyam P., Jain A. R., Garg, S.C., Sethi N. K., Chopra P., Bahl M., Maini H. K., John T., "Singh Vishram & Singh Dhan, Validation of ion density measurement using RPA payload onboard Indian satellite SROSS - C2", XXXVIII General Assembly of International Union of Radio Science (URSI), New Delhi, India, October 23- 29, 2005.

158. Tanwar R. S., Bano Tarannum, Khan A. F., Singh Sachchidanand, Garg S. C. & Singh Risal, "Study of relative variation in attenuation of visible solar radiation reaching the earth surface", XVIII URSI General Assembly – 2005, New Delhi, India, during 23-29 October, 2005.

159. Titus S.S.K., Tiwari Arvind and Jain K.K., "Development of Torque Transducer of 1000 N.m Capacity", Presented at NSI-30, Cochin, Nov. 30 – Dec.2, 2005.

160. Vasudevan V., Arivanandan M., Vijayan N., Bhagavannarayana G. and Sanakaranarayanan K., "Growth of vannilin single crystals by Cz technique for frequency devices", Fifth DAE-BRNS National Laser Symposium (NLS-5), held at Vellore Institute of Technology, Vellore, Tamil Nadu, during Dec. 7-10, 2005.

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162. Vijayan N., Bhagavannarayana G., Maurya K.K., Gopalakrishnan R. and Ramasamy P., "Growth and Characterization of hippuric acid single crystal: Organic NLO material", International workshop on Physics of Semiconductor Devices (IWPSD) held at National Physical Laboratory, New Delhi during December 13-17, 2005.

163. Vijayan N., Bhagavannarayana G., Maurya K.K., Gopalakrishnan R. and Ramasamy P., "Growth and characterization of organic nonlinear optical single crystal of methyl p-hydroxybenzoate (p-MHB)", 35th National seminar on Crystallography (NSC-2006) held at National Physical Laboratory during 22-24, February 2006.

164. Vijayan N., Bhagavannarayana G., Maurya K.K., Gopalakrishnan R. and Ramasamy P., "Studies on the growth, structural and thermal behavior of L-alaninium maleate single crystals", 35th National seminar on Crystallography (NSC-2006) held at National Physical Laboratory during 22-24, February 2006.

165. Vijayan N., Bhagavannarayana G., Maurya K.K., Gopalakrishnan R. and Ramasamy P., "Structural, optical and thermal behaviour of some nonlinear optical single crystals", Second National Symposium on Crystal Growth of Laser related materials held at SSN College of Engineering, Kalapakkam, Chennai during 19-20th December 2005.

166. Vijayan N., Bhagavannarayana G., Maurya K.K., Gopalakrishnan R. and Ramasamy P., "Studies on the growth and characterization of some nonlinear optical and alkali halide single crystals", National Conference on Materials Science held at Periyar University, Salem during February 16-17 2006.

167. Vinod kumar, Pant R.P., Halder S.K., Gupta S.K., "Preparation and investigations of super-paramagnetic particles of $CoFe_2O_4$", Int. Conference on nanoscience and technology, held at IIT Delhi, 16-18 March, 2006.

168. Yadav Sanjay and Bandyopadhyay A.K., "Proficiency testing (PT) program under NABL in the pressure range 7- 70 MPa using a dead weight tester", Presented during 4th CCM International Conference on Pressure Metrology, Institute of Physics, London, April 19-21, 2005.

169. Yadav Sanjay and Bandyopadhyay A.K., "Proficiency testing (PT) program under NABL in the pressure range 7-70 MPa using digital pressure calibrator (DPC)", NCSL International Workshop and Symposium on Serving the World of Measurement, Washington DC, USA, August 4-8, 2005.

170. Yadav Sanjay and Bandyopadhyay A.K., "Traceability chain and metrological infrastructure of national hydraulic pressure standards", Presented during National Symposium on Instrumentation (NSI-30), Cochin, Nov. 30 - Dec. 2, 2005.

171. Yadav Sanjay, Singh Manju, Prakash Om, Bandyopadhyay A.K. and Singh V.R., "Ultrasonic studies in high pressure working fluids for the hydrostatic pressure measurements up to 1.0 GPa", Presented during National Symposium on Ultrasonics (NSU-XIV), New Delhi, Feb. 16-18, 2006.

PATENTS

Patents filed in India

Sr No	Title	Application No	Filing Date	Inventors
1.	A process for the preparation of nano material	1984DEL2005	26.07.2005	Harish Chander
2.	A novel Iron-Poly [3-Octylthiophenel] (Fe-P3OT) nano composite material and a process for the preparation thereof	2845DEL2005	25.10.2005	Ramadhar Singh and Jitendra Kumar
3.	Monoclinic $CeTi_2O_6$ thin film and a Sol-Gel process for the preparation thereof	0392DEL2006	13.02.2006	Amita Verma, Suhasini Avinash Agnihotry and Ashok Kumar Bakshi
4.	Improved process for the preparation of high temperature superconducting bulk current leads with improved properties and superconducting bulk current leads made thereby	0640DEL2006	10.03.2006	Shrikant Narayan Ekbote, Gursharan Kaur Padam, Narinder Kumar Arora, Mukul Sharma, Ramesh Kumar Sethi and Mrinal K. Banerjee

Patents granted in India

Sr No	Title	Patent No	Grant Date	Inventors
1	An improved process for the preparation of a polymer layer substrate for storing information useful for aligning liquid crystals and making a patterned liquid crystal display therefrom	194691	17.02.2006	S. C. Jain
2	An improved process for making semiconductor shallow junctions useful for the manufacture of microelectronic devices and the semiconductor shallow junctions made thereby	192398	29.09.2005	Krishan Lal, G. Bhagavannarayana, Gurdeep Singh Virdi and W. S. Khokle
3	An apparatus useful for the preparation of uniform films of a viscous fluid	192981	09.12.2005	P.K. Ghosh, Harish Chander, Parmanand and V. Shanker
4	A process for the fabrication of flat and flexible electroluminescent panel useful for displays and illumination and an electroluminescent panel made thereby	194312	03.02.2006	P.K. Ghosh, V. Shanker and Harish Chander
5	An improved composition useful for the preparation of electroluminescent powder and an improved processfor the preparation of electroluminescent powder	192512	14.10.2005	P.K. Ghosh, H.P. Narang, V. Shanker and Harish Chander

Sr No	Title	Patent No	Grant Date	Inventors
6	A device useful for as a master/slave clock for transmitting standard time over a telephone network and a telephone Network incorporating the device for transmitting and receiving standards time	193532	06.01.2006	P. Banerjee
7	An improved process for the production of raw coke useful for making high density monolithic graphite	194694	03.03.2006	G. Bhatia and R K Aggarwal
8	An improved process for the preparation of thermally stable doped polyaniline	193538	06.01.2006	S.K. Dhawan, S. Chandra and R. Mehrotra

Patents filed abroad

Sr No	Title	Application/ NF No	Country	Filing Date	Inventors
1	A process for the preparation of novel Sol-Gel based enzyme electrode useful for estimation of cholesterol in aqueous medium	2512282 0313NF2002	CA	30.06.2005	A. Kumar, B.D. Malhotra and Rajesh
2	A Lactate Bio-Sensing strip	2512281 0308NF2002	CA	30.06.2005	M.K. Pandey, A. Chaubey, K.K. Pande, R.K. Sharma, K.K. Saini, B.D. Malhotra and Rajesh
3	Novel Sol-Gel based enzyme electrode useful for estimation of cholesterol in aqueous medium	2004-563411 0312NF2002	JP	30.06.2005	A. Kumar, B.D. Malhotra and Rajesh
4	A Lactate Bio-Sensing strip	2004-563410 0308NF2002	JP	30.06.2005	M.K. Pandey, A. Chaubey, K.K. Pande, R.K. Sharma, K.K. Saini, B.D. Malhotra and Rajesh
5	A process for the preparation of novel Sol-Gel based enzyme electrode useful for estimation of cholesterol in aqueous medium	2004-563412 0313NF2002	JP	30.06.2005	A. Kumar, B.D. Malhotra and Rajesh
6	A process for the preparation of Lactate Bio-Sensing strip useful for the determination of Lactate in an Aqcars solution	2512279 0314NF2002	CA	30.06.2005	M.K. Pandey, A. Chaubey, K.K. Pande, R.K. Sharma, K.K. Saini, B.D. Malhotra and Rajesh

Sr No	Title	Application/ NF No	Country	Filing Date	Inventors
7	A process for the preparation of Lactate Bio-Sensing strip useful for the determination of Lactate in an Aqcars solution	2004-563410 0314NF2002	CA	30.06.2005	M.K. Pandey, A. Chaubey, K.K. Pande, R.K. Sharma, K.K. Saini, B.D. Malhotra and Rajesh
8	Novel Sol-Gel based enzyme electrode useful for estimation of cholesterol in aqueous medium	2512380 0312NF2002	CA	30.06.2005	A. Kumar, B.D. Malhotra and Rajesh
9	Formulation for treating Thalassemia and a process for preparing the same	95304911.1 0237NF1994	DE	13.07.2005	Ajit Kumar Sarkar, Sudershan Kumar, Priyadarshmi Harsh, Sushil Rattan Khanna, Ghansham Dass
10	Formulation for treating Thalassemia and a process for preparing the same	95304911.1 0237NF1994	GB	13.07.2005	Ajit Kumar Sarkar, Sudershan Kumar, Priyadarshmi Harsh, Sushil Rattan Khanna, Ghansham Dass
11	Formulation for treating Thalassemia and a process for preparing the same	95304911.1 0237NF1994	FR	13.07.2005	Ajit Kumar Sarkar, Sudershan Kumar, Priyadarshmi Harsh, Sushil Rattan Khanna, Ghansham Dass
12	A process for the preparation of novel Sol-Gel based enzyme electrode	02790640.3 0313NF2002	EP	26.07.2005	A. Kumar, B.D. Malhotra and Rajesh
13	Novel Sol-Gel based enzyme electrode useful for estimation of cholesterol in aqueous medium	02790639.5 312NF2002	EP	26.07.2005	A. Kumar, B.D. Malhotra and Rajesh
14	A Lactate Bio-Sensing strip	02790638.7 0308NF2002	EP	26.07.2005	M.K. Pandey, A. Chaubey, K.K. Pande, R.K. Sharma, K.K. Saini, B.D. Malhotra and Rajesh
15	Novel Sol Gel Based Enzyme electrode useful for estimation of cholesterol in aqueous medium	02830186.2 0312NF2002	CN	28.07.2005	A. Kumar, B.D. Malhotra and Rajesh

Sr No	Title	Application/ NF No	Country	Filing Date	Inventors
16	A process for the preparation of Lactate Bio-Sensing strip useful for the determination of Lactate in an aqcars Solution	02830192.7 314NF2002	CN	05.08.2005	M.K. Pandey, A. Chaubey, K.K. Pande, R.K. Sharma, K.K. Saini, B.D. Malhotra and Rajesh
17	A process for the preparation of novel Sol-Gel based enzyme electrode useful for estimation of cholesterol in aqueous medium	02830192.7 0313NF2002	CN	05.08.2005	A. Kumar, B.D. Malhotra and Rajesh
18	A Lactate Bio-Sensing strip	02830191.9 0308NF/2002	CN	05.08.2005	M. K. Pandey, A. Chaubey, K.K. Pande, R.K. Sharma, K.K. Saini, B.D. Malhotra and Rajesh
19	A Sol-Gel process for the preparation of monoclinic $CeTi_2O_6$ phase in thin film form	0327NF2005 PCT/IB06/00 694	WO	27.03.2006	Amita Verma, Suhasini Avinash Agnihotry and Ashok Kumar Bakshi
20	Monoclinic $CeTi_2O_6$ thin film and a Sol-Gel process for the preparation thereof	11/394203 0327NF2005	US	31.03.2006	Amita Verma, Suhasini Avinash Agnihotry and Ashok Kumar Bakshi

Patents Granted Abroad

Sr No	Title	Patent No	Country	Grant Date	Inventors
1	Simulated circuit layout for low voltage, low paper and high performance type II current conveyor	6931605	US	16.08.2005	Rajput, Sher Singh Jamuar and Sudhanshu Shekhar
2	A sensitive, fast responsive thin film ethanol sensor and a process for the preparation of a sensitive fast response thin film ethanol sensor and a process for the preparation of a precursor solution for ethanol sensor	6881582	US	19.04.2005	A.K. Rastogi, K. Jain, H.P. Gupta and Kumar V
3	Reusable Heat Pack, method of manufacture thereof, mixture for use in a reusable Heatpack and process for the preparation thereof	119342B1	RO	30.11.2005	C.P. Sharma, R.K. Sharma, C. Kant and A.K. Sarkar
4	Method for determining the reflectance profile of materials	6963403	US	08.11.2005	Nagarajan, Ramakrishnan, S.P. Varma and Devinder Gupta

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CR No	Title	Filing Date	Registered Date	Inventors
SW - 2353/2005	Gauge Block Interferometry : Software tool for research	-	01.06.2005	Mohd. Arif Sanjid, Bhawana Sharma, R.P. Singhal and K.P. Chaudhary

R & D COLLABORATIONS

Collaborating Institute	Area
National Accreditation Board for testing and calibration laboratories, Department of Science and Technology, Government of India	Proficiency testing, Accreditation, Laboratory assessment, Quality awareness & Training programmes
Industry, Institutions and Calibration Laboratories	Calibration, consultancy and training
• Central Food Technological Research Institute, Mysore • Central Fuel Research Institute, Dhanbad • Central Mechanical Engineering Research Institute, Durgapur • Central Scientific Instruments Organization, Chandigarh • Indian Institute of Petroleum, Dehradun • Industrial Toxicology Research Center, Lucknow • National Aerospace Laboratories, Bangalore • National Environmental Engineering Research Institute, Nagpur • National Institute of Oceanography, Goa • National Metallurgical Laboratory, Jamshedpur • Regional Research Laboratory, Jorhat • Structural Engineering Research Centre, Chennai • Indian Statistical Institute, Kolkata	CSIR Network Project No CMM 24 entitled, "Upgradation of SI base units, National Standards of measurements & apex calibration and creation of high quality network of testing and calibration laboratories and preparation & dissemination of Certified Reference Materials"
• Birla Management Corporation Limited, Bombay	Infrared spectroscopy of cellulosic materials
• Dyal Singh Collage, Delhi University, Delhi	Optical characterization of celluosic materials
Pressure and Vacuum Standard Group, National Institute of Standards and Technology (NIST), USA	Pressure & Vacuum Standards
• High pressure laboratory, Department of Physics, University of Jaipur, Jaipur • Department of Physics, Barakatullah Vishwavidyalaya, Bhopal • Department of Physics, Indian Institute of Technology, Delhi • Central Scientific Instruments Organization, Chandigarh.	Raman Spectroscopy

Collaborating Institute	Area
General Motors India Science Lab, Bangalore	Magnesium extrusion alloys
Vikram Sarabhai Space Centre, Trivandrum	Mg-alloys using spray forming
Department of Physics and Astronomy, Clemson University, Clemson, South Carolina, USA	Application of CNTs in composite - Alignment and adhesion problems
Heat and Mass Transfer Institute, Minsk, Belarus	Synthetic of carbon nanotubes and their applications in composites and hydrogen storage
University of California Davis, USA	Bulk nano metallic materials
• Dept. of Physics, Indian Institute of Technology, New Delhi • Dept. of Chemistry, Indian Institute of Technology, Kanpur • Dept. of Physics, Delhi University, Delhi. • Dept. of Chemistry, Delhi University, Delhi • Inter University Accelerator Center (NSC), New Delhi • Solid State Physics Laboratory, New Delhi	Surface physics and nanostructures
Indian Institute of Technology, Kanpur	Micro and nano-crystalline silicon by PECVD
Indian Institute of Technology, Delhi	Thick silica layers by PECVD for MEMS applications
Cooperation on International traceability in analytical chemistry (CITAC), Brazil.	Traceability in chemical measurements
The International database for Certified Reference Materials on the Internet (COMAR), BAM Federal Institute for Materials Research and Testing, Berlin, Germany	Coding and registration of CRMs developed in India and their uploading to their database.
• Central Building Research Institute, Roorkee • Central Fuel Research Institute, Dhanbad • Central Glass & Ceramic Research Institute, Kolkata • Central Salt & Marine Chemical Research Institute, Bhavnagar	Preparation and dissemination of Certified Reference Materials

Collaborating Institute	Area
• Indian Institute of Chemical Technology, Hyderabad • Indian Institute of Petroleum, Dehradun • Industrial Toxicology Research Centre, Lucknow • National Aerospace Laboratories, Bangalore • National Botanical Research Institute, Lucknow • National Chemical Laboratory, Pune • National Environmental Engineering Research Institute, Nagpur • National Geophysical Research Institute, Hyderabad • National Institute of Oceanography, Goa • National Metallurgical Laboratory, Jamshedpur • Regional Research Laboratory, Bhubaneswar • Regional Research Laboratory, Jammu • Regional Research Laboratory, Jorhat • Indian Agricultural Research Institute, New Delhi • Indian Oil Corporation, R&D Centre, Faridabad • Bhabha Atomic Research Centre, Mumbai • National Centre for Compositional Characterization of Materials (NCCCM), Hydearbad • National Thermal Power Corporation, R&D Centre, Noida • Defense Materials Research laboratory, Hyderabad • National Test House, Ghaziabad • Wadia Institute of Himalyan Geology, Dehradun • The Automotive Research Association of India (ARAI) Pune • Centre of Excellence for Structural & Chemical Characterization, Hyderabad • Delhi Test House, New Delhi	Preparation and Dissemination of Certified Reference Materials.

Collaborating Institute	Area
• Tezpur University, Napaam, Tezpur • Arunachal University, Itanagar • Indian Institute of Technology, Delhi • Thapar Institute of Engineering and Technology, Patiala • RARS, SKUAST-K, Leh, Ladakh • MISU, Stockholm University, Sweden	Environment/Metrology in chemistry
Physics Department, MD University, Rohtak	Characterization of materials
Department of Physics, Anna University, Chennai	Crystal growth and characterization
Phisikalisches Institut der Universitat Munster, Germany	Surface chemical imaging of nanophosphor material by TOF-SIMS and SNMS
Indian Association for the Cultivation of Science Kolkata	Surface and interface characterization of thin films
Inter University Accelerator Centre, New Delhi	Swift heavy ion induced interface mixing
University Sophisticated Instrumentation Centre (USIC), Kolkata	Multilayer structure characterization using SIMS
CARE, Indian Institute of Technology, New Delhi	Surface compositional analysis of PLZT thin films
Institute of Experimental Physics, Slovak	Development of nanomaterials of magnetic fluids and its polymer composites
• Navigational Electronics Research Training Unit; Univ. College of Engineering, Osmania Univ, Hyderabad • S V University, Dept. of Physics, Tirupati	Radio communications
Rajdhani College, Delhi University, Delhi	Atmospheric sciences
Frontier Research Center for Global Change, Japan Agency for Marine-Earth Science and Technology, Japan	Surface ozone
• Bose Institute, Kolkata • Jadavpur University, Kolkata	Cross-country atmospheric transport
• Guru Jambheshwar University, Hisar • Dr RML Avadh University, Faizabad • Directorate of Training & Technical Education (DTTE) Govt. of NCT of Delhi, Delhi • Directorate of Higher Education, Govt of Haryana • Istituto di GeoFisica, CNR, Italy	Antarctic environment
• Calcutta University, Kolkata • Indian Statitical Institute, Kolkata • Indian Meteorological Department, Kolkata	Rain and cloud attenuation

Collaborating Institute	Area
National MST Radar Facility, Tirupati	Upper atmosphere
• Space Physics Laboratory, Thiruvanantapuram • Barkatullah University, Bhopal	Ionospheric Tomography
NIMS, Tsukuba, Japan (Takayama-Muromachi)	HPHT synthesis of Ruthenocuprates
IUC, Indore	Thermal and electrical measurements under magnetic field on Ruthenocuprates, MgB_2 and $NaCoO_2$
Physics Deptt. BHU, Varanasi	Microstructure of various magnetic and superconducting oxides.
Engineering Faculty, BHU	Low temp. X-ray diffraction
TIFR, Mumbai	SQUID Magnetometry
IFI, UNICAMP, Brazil	Magnetometry and ESR
Univ. Jerusalem, Israel	AC susceptibility, Mossbauer spectroscopy.
IISc, Banglore, India	Electron spectroscopy of Ruthenocuprates
BARC, Mumbai, India	Neutron scattering of Ruthenocuprates
Univ. of Missouri, USA	Low temp. neutron diffraction of Ruthenocuprates

SPONSORED/SUPPORTED R&D PROJECTS

New / Continuing / Completed Projects

Rs.(In lakhs)

Sr No	Title	Agency/Client	Amount Received
New Projects			
1.	Development of speciality carbon materials for novel nuclear rectors	BARC, Mumbai	9.92
2.	Development of calibration-validation (CAL-VAL) sites at Kavartti Island	Department of Space, SAC, Ahmedabad	26.5
3.	Investigation study on microwave sintering of Beta Alumina tubes	DST	13.5
4.	Design & fabrication of Filter Transmission Meter	DST	18.00
5.	Development of Nanostructured electrochromic films with improved performance characteristics by wet chemical techniques for smart windows	DST	7.50
6.	Establishment of primary standards for Vickers & Brinell Hardness Scales	DST	200.00
7.	Synthesis and characterization of carbon nano tubes/polymer network composites	DST	6.50
8.	Low cost technology for high efficiency Silicon Solar Cell	DST, Under Indo-Bulgarian Inter Govt. Prog	0.87
9.	Generic Development of nanometrology for Nanotechnology	DIT	554.00
10.	Assessment of effects of high particulate on pulmonary health status in selected magacities of South Asia	APN – Japan	6.91
11.	Ionospheres of Venus and Mars: Chemistry, dynamic thermal structure and solar wind interaction	Physical Research Laboratory, Ahemedabad	4.70
12.	High rate deposition of the microcrystalline silicon films using high density microwave plasma and its applications in efficient large area thin film solar cells	DST	24.65
13.	Integrated campaign for aerosols, gases & radiation budget	VSSC, Thiruvanthapuram	16.33
14.	Dynamics studies at the phase transition region of SmC*- Sm-A phase in electroline liquid crystal materials	DST	11.50
15.	Physico-Chemical characterization of wet deposition at NPL, New Delhi and Pantnagar in Uttaranchal	SEI, SWEDEN	2.02

Sr No	Title	Agency/Client	Amount Received
Continuing Projects			
1.	Fabrication and characterization of organic light emitting diodes	DST (Women Scientist Scheme-A)	1.75
2.	Optical Phase Singularity and its Applications	DST (Women Scientist Scheme-A)	3.00
3.	Development of Bandpass Interference Filters for Course Wavelength Division Multiplexing (CWDM)	DST	4.00
4.	Pressure Induced Phase Transitions for Metrological Applications	DST	3.00
5.	Operation of the South Asian Regional Research Centre (SAS-RRC) for Study of Global Change Under SASCOM	International START Secretariat, Washington, USA	1.74
6.	Development of ultrasonic method to evaluate moisture in composite materials	ARDB, Bangalore	0.00
7.	Development of DNA Biosensor	DST	0.00
8.	Design and development of Urea-Biosensor	DST	0.00
9.	A study of metal oxide coatings on glass substrated by sol-gel technique	DST	2.50
10.	Interaction with Universities/Labs in the area of superconductivity	UGC	0.00
11.	Development of nonophosphors for industrial application	DST	2.00
12.	Studies on the effect of dynamic multiple scattering on frequency shift of spectral lines and applications	DST	3.50
13.	Development of plasma polymerization process and deposition system for thin film optical coatings on plastic substrates, conducting polymeric barrier membrane coatings	DST	0.00
14.	Planning preparation and dissemination of certified reference materials for quality assurance in analytical measurements	DST (NABL)	0.00
15.	Semiconductor silicon for applications in solar energy microelectronics and power electronics	Indo-Russia (ILTP)	0.00
16.	Coherent radio beacon experiment (CRABEX) for tomographic studies of the ionosphere on-board GSAT-II satellite	VSSC, Thiruvananthapuram	2.95
17.	Development of organic light emitting diodes	DIT	0.00
18.	Setting up of facilities for dissemination of Indian Standard Time in North-Eastern states	DST	0.00
19.	Studies on Bio-Mass Burning and Related Trace Gas Emissions Using IRS-P3 Satellite Data	NRSA	4.00
20.	Study of Atmospheric Aerosols Radiation and Trace Gases Under ISRO-GBP Road Campaign during February 2003: Delhi-Hyderabad-Delhi Corridor	Physical Research Lab. Ahemdabad	0.00

Sr No	Title	Agency/Client	Amount Received
21.	Metal induced crystallization behaviour on thin film of amorphous silicon	INDO-US	0.00
22.	IR spectroscopy techniques for cellulosic materials	Birla Management Corporation Limited	6.36
23.	Synthesis of carbon nanotubes and their applications in composites and hydorgen storage	Indo-Belarussian	0.00
24.	Development of injection solar cells utilizing dye sensitised nano-crystalline TiO_2 films	MNES	0.00
25.	To conduct inter-laboratory proficiency testing amongst the NABL accredited calibration laboratories in India	DST (NABL)	0.00
26.	Cloud and precipitation phenomena estimation by using different systems for propagation characteristics in microwave and millimetre wave frequency bands	DST	3.00
27.	A study of the formation of delta-doped silicon structures by surface phase control and solid phase epitaxy	DST	3.00
28.	To develop 10 pF capacitor using Quartz for use by accredited calibration laboratory	DST	0.00
29.	Surface order and structure studies of polymer solid interfaces	Indo-US	0.00
30.	Development of new formulation of indelible ink	Election Commission of India	0.00
31.	Development of spray forming technology of magnesium alloys	VSSC, Thiruvanthapuram	1.10
32.	SROSS-C2 satellite RPA aeronomy payload data management	ISRO	0.00
33.	Studies on fog occurrence on Delhi	CPCB	0.00
Completed Projects			
1.	Micro-patterning of solid surfaces for technological application in the field of microelectronics, sensors and displays	DST	0.00
2.	Design, development and fabrication of 500 kg Dead Weight Machine to calibrate the load cell used for weighing purposes	RRSL, Bangalore	0.00
3.	A new approach for memory effect in ferroelectric liquid crystal materials Based on charge accumulation phenomenon	DST	0.00
4.	Application of carbon nanotubes in composites - alignment and adhesion problems	DST/NSF	0.25
5.	Development of transducer elements for acoustic emission (AE) sensor	BARC	0.00
6.	Design & development of ceramic based oxide sensor	DST	0.00

Sr No	Title	Agency/Client	Amount Received
7.	Setting up of test and calibration facility for ceramic sensors	DST	0.00
8.	Smart electro-chromic windows for energy conservation	MNES	4.500
9.	Reducing uncertainties in emission of CH_4 and N_2O from livestock in India in relation to the enabling activities for initial communication to UNFCCC	ME & F (Winrock)	0.00
10.	Measurement of CH_4 & N_2O emissions from Rice/Wheat ecosystem in relation to reducing uncertainities in emission factor for enabling activities for initial communication.to UNFCCC	ME & F (Winrock)	0.00
11.	Design, development and fabrication of sensors and electrometers for the study of Maxwell current density and Schumann resonances	IIG, Mumbai	0.00
12.	Reducing uncertainties in emissions of CO_2, CH_4 from biomass burning in India in relation to the enabling activities for initial communication to UNFCCC	ME & F (Winrock)	0.00
13.	Spin effects and interactions in the quantum dots	DST	0.00
14.	R&D in non-invasive optical fiber probe based near-infrared spectroscopy (NIRS) for accessing brain activity	DST	0.00
15.	Agriculture sector inventory	ME & F (Winrock)	0.00
Note : *(Projects Completed in 2003-04 but amount received in 2005-06)*			
1.	Carrying Capacity Studies of Teesta Basin in Sikkim (SODAR studies)	IIT, Delhi	0.50
2.	Tetrahedral amorphous carbon (ta-c) films deposited by a filtered vacuum arc discharge (FVAD) technique	DST	0.093

CSIR NETWORKED PROJECTS

S N	Name of the Project	Project No.	Date of Start	Proposed Date of Completion	Director's Nominee	Nodal Lab
1	Catering to specialized aerospace materials	CMM0001	01.04.2004	31.03.2007	Dr. Anil Kumar Gupta	NAL
2	Study of oceanographic processes of North Indian ocean in reference to global change	CMM0009	01.04.2003	31.03.2007	Dr. B.C. Arya	NIO
3	Developing capabilities & facilities for microelectrochemical systems (Mems) and Sensors	CMM0011	01.04.2002	31.03.2007	Dr. S. T. Lakshmikumar	CEERI
4	Custom tailored special materials	CMM0022	01.04.2002	31.03.2007	Dr. Anil Kumar Gupta	CGCRI
5	Upgradation of S.I. Base units, National Standards of measurements & apex calibration facilities creation of high quality network of Testing and calibration laboratories and preparation & dessemination of certified reference materials	CMM0024	01.04.2004	31.03.2007	Dr. R.P. Singhal	NPL
6	Developing and sustaining high science & technology for national aerospace programmes	COR0001	01.04.2005	31.03.2007	Dr. R. S. Dabas	NAL
7	Development of speciality polymers	COR0004	01.04.2002	31.03.2007	Dr. S.K. Dhawan	NCL
8	Development of techniques and methodologies for exploration assessment and management of ground water in hard rocks	COR0005	01.04.2002	31.03.2007	Dr. A.K. Agarwal	NGRI
9	Pollution monitoring mitigation systems and devices	SMM0005	01.04.2004	31.03.2007	Dr. M.K. Tiwari	NEERI
10	Electronics for societal purposes	COR0007	01.04.2003	31.03.2007	Sh. S.K. Singhal	CSIO
11	Development of key technologies for photonics and opto electronics	CMM0010	01.04.2003	31.03.2007	Dr. S. S. Bawa	CGCRI

RECEIPTS THROUGH CONSULTANCY PROJECTS

Consultancy Projects

(Rs. In lakhs)

Sr No	Client	Title	Amount Received
1.	M/s. General Motors of India Ltd., Bangalore.	Advanced magnesium extrusion alloys (since Sept. 2004)	14.21
2.	M/s. Power Grid Corporation, Gurgaon	Study of the acoustics of multipurpose hall at Power Grid Township in Gurgaon	0.68
3.	M/s. Regional Reference Standards Laboratory, Ahmedabad (Ministry of Consumer Affairs Food &Public Distribution)	Fabrication and installation of load cell testing machine	14.80
4.	M/s. Power Grid Corporation of India Ltd, Eastern Region, Lal Gaj, Purnea, Bihar	Removal of coating from aluminium panel and angle surfaces & Testing	0.55
5.	M/s. Power Grid Corporation of India Ltd, Bhojpur (Ara), Bihar	To remove paint coating from aluminum false ceiling materials before chemical testing and measurement of thickness of coating	0.59
6.	M/s Nitiraj Engineers Pvt Ltd, Parwanoo, Solan (H.P)	Characterization of load cells of 500kg used in weighing platform	3.31
7.	M/s. DDA, Delhi	Commissioning of feasibility study at 'Village Commonwealth Games', Delhi	5.00
8.	M/s. Regional Reference Standards Laboratories, Bangalore (Ministry of Consumer Affairs Food &Public Distribution)	Design and fabrication of transfer force standards confirming to Class A	1.95
9.	M/s. National Thermal Power Corporation, National Capital Power Station Vidyut Nagar, Gautam Budh Nagar-(UP)	Purchase of low noise converter	2.24
10.	M/s Coal Chem., Bhilai	QI free coal tar pitch from coal tar	0.81
11.	M/s Central Pollution Control Board, Agra	Sodar system for central laboratory, Agra	9.99
12.	M/s Bajaj Allianz Gen. Insurance Co. Ltd, New Delhi	Expert opinion for the damaged copper tube of heat exchanger of imperial malt	0.34

Total amount received during 2005-2006 - Rs. **54.47**
(except GM all are new projects)

EARNING FROM CALIBRATION & TESTING

PHYSICO-MECHANICAL STANDARDS

Activity	No of Reports	Charges (Rs.)
Mass Density	638	4537362.00
Length & Dimension	568	4194278.00
Temperature & Humidity	329	2134400.00
Optical Radiation	451	6039604.92
Force Standard	498	4932305.20
Pressure & Vacuum	108	2146282.00
Acoustic Standards	246	4244243.00
Fluid Flow	33	277049.00
Ultrasonic	20	130036.00
Shock & Vibration	15	99180.00
Optical Testing	1	22040.00
Sub-total (A)	**2907**	**28756780.12**

ELECTRICAL & ELECTRONICS STANDARDS

Activity	No of Reports	Charges
Time & Frequency	25	255774.00
Josphson Voltage Std, OC, I, V & R DC Standards	55	997156.00
DC High Voltage	3	45721.00
AC Power & Energy	196	2301798.80
AC High Current & High Voltage (CT/PT) AC & LF (CT/PT)	24	713085.00
LF & HF Impedance	45	637785.40
RF Power LF & HF Voltage, Current	27	1054927.50
RF Attenuation & Impedance	25	429388.00
Megnetic	30	160948.00
Sub-Total(B)	**430**	**6596583.70**

ENGINEERING MATERIALS & ELECTRONIC MATERIALS

Activity	No of Reports	Charges
Adv Carbon Products	7	174557.00
Metal & Alloys	14	39675.00
Polymeric Films & Devices	2	2865.00
Advance Ceramics Devices & Optical Thin Films	1	22040.00
Surface Physics & Nano Str	1	2755.00
Sub-Total(C)	**25**	**241892.00**

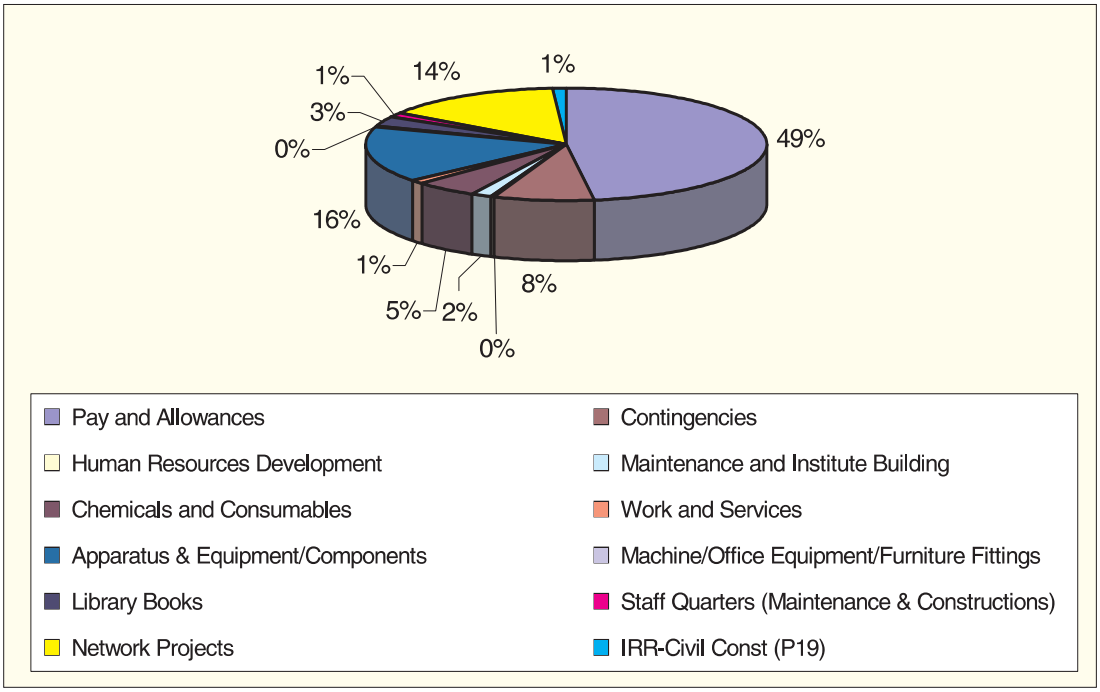
MATERIALS CHATACTERISATION

Activity	No of Reports	Charges
Chemical & Analysic	91	668000.20
EPR & IR	7	50031.00
X-Ray	8	37745.00
Electron Microscope	29	382805.00
IRM	17	120815.00
Sub-Total(D)	**152**	**1259396.20**
Grand Total (A)+(B)+(C)+(D)	**3514**	**36854652.02**
Taxable Amount(Total-IRM)		36579714.02
Service Tax @ 10.2%		3731130.83
Net Calibration & Testing Charges		**32848583.19**

ACTUAL EXPENDITURE 2005 - 06

(Rs in lakhs)

Sr No	Budget Heads	Expenditure
1	Pay and Allowances	2250.886
2	Contingencies	378.246
3	Human Resources Development	3.544
4	Maintenance and Institute Building	80.447
5	Chemical and Consumables	237.646
6	Work and Services	47.478
7	Apparatus & Equipment/Components	761.278
8	Machine/Office Equipment/Furniture Fittings	7.277
9	Library Books	136.806
10	Staff Quarters (Maintenance & Constructions)	69.245
	(Maintenance Capital)	0.920
11	Network Projects	671.706
12	IRR-Civil Const (P19)	53.959
	Total	**4699.438**



Recognitions

P. Banerjee
Vice Chair Commission A (Electromagnetic Metrology), URSI, P. Banerjee

R.P. Singhal
Vice President, Metrology Society of India.

V. Mohanan, Omkar Sharma & M. Singh
Sir C.V. Raman Award for the best paper published, J. Acoustical Society of India

V. Mohanan
Chairman, Recording & Acoustics Sectional Committee LTD5 of BIS , New Delhi, Member, National Committee on Noise Pollution & Control constituted by Central Pollution Control Board
President, Acoustical Society of India

R.K. Garg
General Secretary, Metrology Society of India

Anil K. Gupta
Fellow: The Indian National Academy of Engineering (FNAE)
Distinguished Visiting Professor: AICTE-INAE, IIT, Kharagpur with Department of Metallurgical Engineering & Materials Science
Chairman: Materials Research Society of India (MRSI), Delhi Chapter

B D Malhotra et al, Best Poster Presentation Award, XVI conference on Biomaterials tissue engineering and diagnosis organized by Society for Biomedical and Artificial Organs-India at Centre of Biomedical Engineering, IIT Delhi, 24th-26th February 2006.

Nirmal Prabhakar, Kavita Arora, S.P. Singh, Harpal Singh and B.D. malhotra, Gold Medal in Poster Presentation, DNA biosensor based on electrochemical entrapment of DNA in conducting Polypyrrole - Polyvinylesulphonate films for pesticide detection, Biotech 2005 - Concept to commercialization held in Manesar, Gurgaon (22nd-24th Dec. 2005) organized by Centre for Biotechnology, JNU, New Delhi

Pratibha Pandey, S.P. Singh, Sunil Arya, Monika Datta and B.D. Malhotra, Best Poster Presentation Award, Immobilization of biomolecules on nanoparticles for development of biosensors, Biotech 2005 - Concept to commercialization, Manesar, Gurgaon (22nd -24th Dec. 2005) organized by Centre for Biotechnology, JNU, New Delhi

S.M. Shivaprasad
MRSI-Medal Lecture Award, presented at the Materials Society of India AGM-2006, Lucknow, 13th Feb. 2006.

Mahesh Kumar, Govind and S.M. Shivaprasad
Awarded Best oral presentation, "Formation of antimony nanowires on high index silicon (5 5 12) surfaces, workshop on material science and its applications, organized by NPL & MRSI Delhi Chapter – (Hindi Conference)

Mahesh Kumar, Govind, Vinod Kumar Paliwal, S. M. Shivaprasad
Awarded the Outstanding Paper Prize at RIVA V, (Title: "Formation of Sb nanowires on the high index Si (5512) surface") at the Meeting of the Iberian Vacuum Societies, held at Guimaraes, Portugal, from 17th to 21st Oct., 2005.

M Deepa
Supervisor: Dr. S.A. Agnihotry
G.C. Jain Memorial Prize for the best Ph.D. Thesis in Materials Science (A citation alongwith a cash prize of Rs. 6000.00 by Materials Research Society of India)

V.P.S. Awana
Received DAE-SSPS "GOLDEN JUBILEE" YAA (Young Achievers Award)- Year 2005.

M.K. Goel
Coordinator, Scientific Programmes, URSI-General Assembly 2008 to be held at Chicago, USA.

S.L. Jain

Member, Project Management Board, Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital.

Member, Special Committee, School of Environmental Sciences, Jawaharlal Lal Nehru University, New Delhi

H.N. Dutta

External Expert Member, Board of Studies in Physics, Guru Jambheshwar University, Hisar, 2004-2006.

External Expert Member, Board of Studies, Dept of Future Studies & Planning, Devi Ahilaya University, Indore 2004-06.

VISITS ABROAD

S. No.	Name & Designation	Country Visited	Duration	Purpose
1.	Dr. R. S. Dabas, Sci. F	USA	03-04-2005 08-04-2005	To attend International Space Environment Science (ISES) & SPACE Weather Week (SEC) at Boulder, USA
2.	Dr. K K Jain Sci F	Saudi Arabia	04-04-2005 13-06-2005	Under POC on foreign terms & conditions to SASO under CSIR-SASO program on technical cooperation
3.	Sh. J K Gupta T.O.E-I	Thailand	18-04-2005 20-04-2005	To hand carry & deliver the artifacts to NMI after the calibration and also to discuss technical details of the inter comparison.
4.	Dr. Harish Bahadur Sci E-II	China	23-05-2005 07-06-2005	To attend & deliver a principal lecture at Int. W/S on Computational Materials Science & to deliver a series of lecture to graduate Students of Lanzhou University
5.	Dr. Vikram Kumar, Director	Belgium, Germany	22-05-2005 24-05-2005	To attend the board meeting of URSI general assembly and to visit PTB, Germany
6.	Dr. P Banerjee Sci G	Belgium	21-05-2005 24-05-2005	To attend board meeting of URSI general assembly & visit to OBSERVATOIRE ROYAL DE Belgiue
7.	Dr. Vikram Kumar, Director	Thailand	30-05-2005 31-05-2005	To attend 10th Developing Economies Committee (DEC) of APMP at NIMT
8.	Dr. T L Dhami Sci F	Belarus	26-06-2005 for 13 days	Under Project " Synthesis of Carbon Nanotubes & their applications in the Composites & Hydrocarbon Storage between Indo- Belarus POC in S&T"
9.	Dr. R B Mathur Sci F	USA	01-07-2005 01-08-2005	Under project "Alignment & Adhesive problems between DST-NSF"
10	Mr. Alok Mukherjee, STA	Sri Lanka	11-07-2005 13-07-2005	To attend International Workshop for Section Edition & Authors for the MARSSARAP (11-12 July, 05) & meeting of SA Committee (13 July, 05)
11	Dr. Y.P. Singh, Sci.EII	Germany	04-07-2005 10-07-2005	For Equipment Training at M/s. AGNI GmbH, Aachen & visit to PTB to deliver lamp for calibration & later on to collect the lamps after its calibration
12	Dr. A.K. Srivastava ,Sci. C	Singapore	03-07- 2005 09-07-2005	To attend ICMAT 2005 Int. Conference on Materials for Advanced Technology
13	Dr. Harish Chander, Sci. F	Singapore	03 -07 -2005 08-07-2005	To attend ICMAT 2005 Int. Conference on Materials for Advanced Technology
14	Dr. S.L. Jain, Sci.F	China	02-08-2005 11-08-2005	To attend the Scientific Assembly of the Int. Association of Metrology & Atmosphere Science (IAMAS,2005)
15	Sh. M. Arif Sanjid, Tech. Officer	Thailand	01-08-2005 05 -08-2005	To participate in the joint training on Measurement Stds. at NIMT
16	Dr. Nahar Singh, Sci.B	Thailand	01-08-2005 05-08-2005	To participate in the joint training on Measurement Stds. at NIMT

17	Dr. K.P. Chaudhary, Sci.F	USA	31-07 –2005 02-08- 2005	Int. Conference of Optics & Photonics
18	Dr. B.D. Malhotra, Sci. EII	Japan	28-08-2005 10-08- 2005	Asian Student Seminar on "Advanced Technologies and Energy Saving and Environment Preservation"
19	Dr.V.P.S. Awana, Sci. B	Japan	01-09-2005 (for 6 months)	Under INSA-JSPS bilateral exchange Programme
20	Dr. S.K. Singhal Sci. F	Denmark	26-09-2005 27-09-2005 E.L.28.9.2005	To attend training course on the accelerometer calibration system PULSE 7700
21	Dr. Vikram Kumar, Director	South Korea	05-09- 2005 08-0 9-2005	To attend 21st APMP 2005 General Assembly & related meetings
22	Dr. P.C. Kothari, Sci. G	South Korea	05-09- 2005 06-09-2005	To attend 21st APMP 2005 TCEM meeting and symposium
23	Dr. R. P. Singhal, Sci. G	South Korea	05-09-2005 08-09-2005	To attend 21st APMP 2005 General Assembly & related meetings
24	Dr. A. K. Bandyopadhyay, Sci. F	South Korea	05-09-2005 08-09-2005	To attend 21st APMP 2005 TCM meeting and symposium
25	Dr. Ashok Kumar, Sci. F	South Korea	05-09-2005 06-09-2005	To attend 21st APMP 2005 TCAUV meeting and symposium
26	Sh. V.K. Rustagi, Sci. F	South Korea	05-09-2005 06-09-2005	To attend 21st APMP 2005 TCEM meeting and symposium
27	Dr. A.K. Hanjura, Sci. F	South Korea	05-09-2005 06-09-2005	To attend 21st APMP 2005 TCQS meeting and symposium
28	Dr. V.R. Singh, Sci.G	Denmark	18-09- 2005 22-09-2005	For oral presentation at the International Wireless Summit (IWS)
29	Dr. S. M. Shivprasad, Sci. E-II	Portugal	18-09- 2005 21-09-2005	To present an invited talk at RIVAV Conference at Minho University
30	Dr. Vikram Kumar, Director	France	29-09- 2005 30-09- 2005	To attend meeting of Directors of National Metrology Institute (NMIs) of Metre Convention
31	Mr. M.K. Pandey T.A.	Netherland	10-10-2005 15-10-2005	To attend equipment training on Biochemical Interaction Analysis at M/s. Micro Devices Metrohm Ltd.
32	Dr. Pradeep Mohan, Sci.F	NIST,USA	28-10-2005 13-11-2005	To attend 52nd International Symposium at Boston for i) oral presentation & ii) for bilateral comparison of Vacuum Std. Between NPL & NIST in the range 10^{-3}-1.0 Pa using two spinning gauges as transfer Std.
33	Dr. K.K. Jain Sci.F	PTB, Germany	07-11-2005 for 3 weeks	To establish inter comparability of Stds. and to carry out experiments for unified calibrations procedures
34	Dr. P.K. Singh Sci.F	Bulgaria & Germany	17-10-2005 11-11-2005	To visit central lab. of solar energy sources , Sofia under India-Bulgaria Joint S &T Project. Germany - to explore the possibility of project under Indian EU prog.
35	Dr. Ram Kishore Sci.F	China	10-10-2005 13-10-2005	15th Int. Photovoltaic Science & Engineering Conf.& Solar Energy Exhibition (PVSEC-15)
36	Dr. Rina Sharma Sci.EI	France	15-11-2005 20-11-2005	To visit BIPM for participation in LK-II Measurement campaign

38	Dr. S.L. Jain, Sci.F	China	21-11-2005 22-11-2005	To participate in the First Asia Ozone Pollution in Eurasian perspective
39	Dr. B.C. Arya, Sci.F,	China	21-11-2005 22-11-2005	To participate in the First Asia Ozone Pollution in Eurasian perspective
40	Dr, T.K. Mandal, Sci.C	China	21-11-2005 22-11-2005	To participate in the First Asia Ozone Pollution in Eurasian perspective
41	Dr.A.K.Bandyopadhyay, Sci.F	Indonesia	29-11-2005 01-12-2005	To attend Technical Assessment of Pressure Measurement in KIMCP
42	Dr. A.K. Agrawal Sci.F	Thailand	09-11-2005 15-11-2005	To attend seminar on Metrology
43	Dr. N.D. Kataria Sci.F	South Korea	14-11-2005 21-11-2005	1. To visit Pohang University. 2. To deliver a talk in the third East Asia Symp. on Superconducting Electronics (EASSE).& 3. To visit KRISS
44	Dr. A. Basu Sci.F	USA	27-11-2005 08-12-2005	To attend a training in Kennedy school of Harvard Univ. under STIP programme
45	Dr. Ashish Agarwal, Sci.B	Japan	04-12-2005 10-12-2005	To attend Asian Scholarship meeting in Tokyo
46	Dr. Vikram Kumar, Director	Canada	16-11-2005 18-11-2005	As a member of the Indian Delegation for discussion about Indo-Canadian calibration in the field of Nano-Technology
47	Dr. B.D. Malhotra Sci.F	USA	15-12-2005 22-122005	To attend International Symposium on Immobilization & applications of Functional Proteins, Nuclear Acids & cells at Solid Interface & visit to Bio design Institute Arizona State Univ.
48	Dr. Hari Kishan Sci.F	Brazil	01-02-2006 28-02-2006	Under INSA-Brazilian Academy of Sciences Exchange Prog.
49	Dr. K.K .Jain, Sci. F	Saudi Arabia	31-01- 2006 for 10 weeks	To visit National Measurement & Calibration Lab., SASO under Foreign Service Terms as per CSIR- SASO agreement
50	Dr. Anil Kumar Gupta, Sci. G	Japan	23-01-2006 09-02-2006	i) To visit AIST (Advanced Industrial Science & Technology) as guest researcher in the fusion Technology Team of Digital Manufacturing Research Centre to carry out research on " Advanced (CFTT/DMRC) Techniques in precision & Micro Metal Forming ii) visit to Prof. Enbury, Mc. Master Univ. .
51	Dr. Anil Kumar Gupta, Sci.G	USA Canada	03-03-2006 22-03-2006	1. To Visit Prof. Embury, Mc.Master University in Canada on 3rd March 2006 in connection with Metal Forming & Nano Science (4th-5th March, 2006 Saturday & Sunday). 2. To Visit Prof Pradeep Rohtagi, University of Milwaukee, USA during 6th & 7th March 2006 for discussion on composite activities. 3. ToVisit General Motors Warren Detroit during 8th - 10th March, 2006 4. (i) To make oral presentation of paper entitled" Composite

				Development Activity at NPL" at the Rohtagi Honorary Symposium on "Solidification Processing of Metal Matrix Composites" to be held at San Antonio during 12th – 16th March, 2006 and also to (ii) To visit Prof. E.L. Lavernia, Dean University of California and Prof. P. Rohatagi, University of Wisconsin during 17th – 22nd March, 2006
52	Dr. A.K. Bandyopadhyay, Sci. F	Singapore	30-03-2006 31-03-2006	To attend 5th TC chairs meeting
53	Dr. A.K. Agrawal, Sci. F	Malaysia	20-02-2006 21-02-2006	To attend the seminar & workshop on Chemical Metrology
54	Sh. Prabhat Kumar Gupta, Sci. F	Phillipines	20-03-2006 24-03-2006	To attend & participate in the Science Planning meeting of IRRI
54	Sh. Shiv Kumar Jaiswal, Sci. B	USA	30-03-2006 29-03-2007	To visit NIST, Gaithersburg under BOYSCAST fellowship 2005-2006 to o carry out advanced research /training in the area of Electrical Metrology / Nano Technology
55	Dr. Divi Harnath , Sci. B	USA	30-03- 2006 29-03-2007	To visit the Laboratory Nano Crystals Technology (NCT) under BOYSCAST fellowship 2005-2006 for conducting advanced research undergoing specialized training in the area of Nanophase materials

Ph D AWARDS BASED ON RESEARCH WORK DONE AT NPL

	Title	Awardee	University/Institute	Guide(s)
1	The Study of Green-House Gases Over Maitri, Antarctica	Sachin Dinkar Ghude	Delhi University, Delhi	Dr. S. L. Jain (NPL) Prof. M.M.Bajaj (DU)
2	Synthesis of Alkaline Earth Aluminate Phosphors by various routes and study of their luminescent characteristics	Pooja Sharma	Jamia Millia Islamia, New Delhi	Dr. Virendra Shankar, Dr. Harish Chander , (NPL) Prof. Anwar Ali (JMI)
3	A study of the sol-gel derived cerium-titanium oxide, cerium oxide, titanium oxide thinfilms for electrochromic device applications.	Amita Verma	Delhi University, Delhi	Dr. S.A.Agnihotry (NPL) Prof. A.K. Bakshi (DU)
4	Studies of Pure and Doped Tetrahedral Amorphous Carbon Films Deposited by Novel Filtered Cathodic Vacuum Arc Technique	Mohd. Alim Khan	Jamia Millia Islamia, New Delhi	Dr. O. S. Panwar (NPL) Prof. M.Y. Khan & Prof. M. Husain (JMI)

CONFERENCES, SYMPOSIA, WORKSHOPS, TRAINING PROGRAMMES AND EVENTS ORGANISED BY NPL

August 2 – 4, 2005
Temperature & Humidity Standards Group has been peer reviewed by the International Technical Expert, Dr. J. Fischer from PTB, Germany.

August 17-19, 2005
Organized Training Courses on "Mass Metrology", in which 44 participants from NABL accredited laboratories, Industries and other agencies have participated.

September 13, 2005
Training Programme on "Evaluation and Expression of Uncertainty in Measurements".

September 14, 2005
Training Programme on "Surface Roughness and Roundness Measurements".

September 14-15, 2005
Training Programme on "Temperature Metrology" organized jointly by NPL & NABL.

October 23 - 29, 2005
XXVIIIth General Assembly on International Union of Radio Science (URSI).

September 8-10, 2005
Training Programme on "Temperature Metrology" organized jointly by NPL & NABL.

December 13-17, 2005
XIII International Workshop on the Physics of Semiconductor Devices (IWPSD-2005). It was organized by NPL in collaboration with the Society for Semiconductor Devices. The Workshop was preceded on 12 December 2005 by two tutorials, (i) Advances in Photovoltaics and (ii) A course in Nano-Technology.

December 19 – 23, 2005
Conducted a course on "Radio Metrology and Radio Wave Propagation over the sea".

January 16 – 17, 2006
A training course on "AC Voltage and Current Measurement, Standards and Calibration Techniques" was conducted for the trainees of NTH, Kolkata and ERTL (North).

January 19 - 20, 2006
National Symposium (in Hindi) on "Atmospheric and Environmental Sciences".

January 23, 2006
A half day seminar on "Use of Vector Network Analyzer in Material Measurements" by Dr. Stoyan Ganchev of Agilent Technologies, USA.

January 24-25, 2006
Meeting to review the status of the BND Programme. Nearly 50 scientists had attended the meeting.

February 14-15, 2006
Training Programme on Pressure & Vacuum Metrology, organized jointly by NPL and NABL.

February 22 – 24, 2006
35th National Seminar on "Crystallography".

February 27-28, 2006
Training programme on "IntelliSuite" software for MEMS design and simulation.

February 28 - March 3, 2006
National Workshop and Training Course on "Coordinate Metrology", organized jointly by NPL and MSI.

LECTURES BY EMINENT SCIENTISTS

Sr. No.	Name & Address	Date	Topic
1.	Dr. P.J. Abbott NIST,USA	03-08-2005	Vacuum Standards in the new Advance Metrology Laboratory , NIST, USA
2.	Dr. M.G.K. Menon	22-08-2005	Dr.A.S.Paintal Memorial Lecture, Responsibilities & Ethics in Science & Technology
3.	Mr.Stephen Maqsuillan,Managing Director,NPL,UK	29-11-2005	Nano Technology opportunities and challenges
4.	Dr.Kamal Hassan Director, S& T, N.P.L., Teddinton, U.K.	29-11-2005	Nano technology, Opportunities & Challenges
5.	Dr. Upendra N. Singh, Chief Technologist, NASA Langley Research Center, Hampton, Virginia, USA	09.12.2005	Space-based Laser remote Sensing Technologies and Techniques
6.	Dr. Arun Majumdar SPIE USA	09.12.2005	Free-space Laser Communications: Effects of Atmospheric Turbulence and Scattering Medium on the Communication Performance
7.	Dr. D.B. Jadhav, Sr. Scientist, IITM,Pune	22.12.2005	Some New Concepts for Mitigation/Reduction of Air/Water/Soil Pollution
8.	Prof. Paul De Bievre, Member, ISO Council on Reference Materials; Member, Consultative Committee on Amount of Substance and Editor-in-Chief, Journal Accreditation and Quality Assurance ("ACQUAL") SPRINGER, Belgium	23-01-2006	The Ongoing Redeterminations of the Avogadro Constant (1980-2009): Why and How? Their Importance for Amount-of-Substance Measurements
		24-01-2006	Why is MiC important? What is MiC? Role of CRMs/RMs in Intercontinental Trade, Environmental Regulations and Chemical Measurements.
		24-01-2006	Target Measurement Uncertainty, Evaluation of Measurement Uncertainty of Measurement Results in Intercontinental Trade, Environmental Regulations.
9.	Dr.Serguei Magonov,Senior application scientist from Veeco,Santa Barbara,USA	13-03-2006	AFM Applications in the field of Polymer Applications.

Lectures organized under NPL Seminar series

S.No.	Date	Speaker	Affiliation	Title of the talk
1	27-09-05	Prof. R.N. Bhargava	Nanocrystals Technology, New York, USA	Quantum Confined Atom Based Nanomaterials and Nanophosphors
2	21-10-05	Dr. S.T. Lakshmikumar	NPL	Nobel Prizes (2005) in Science: An Appreciation
3	18-11-05	Prof. Mukunda P Das	Australian National Univerisity, Canberra	How Relevant is the Occam's Razor in the Realm of Mesoscopic Electron Transport
4	02-12-05	Dr. V.R. Singh	NPL	Nano-biotechnological Approach for Cancer Diagnosis and Treatment
5	08-12-05	Prof. Yukio Kagawa	Akita Prefectrual Univeristy, Japan	Discrete Huygen's Modelling and Application to Acoustic Field Problem
6	09-12-05	Dr. Arun Majumdar	Jet Propulsion Laboratory, NASA, USA	Free Space Laser Communication: Effects of Atmospheric Turbulence and Scattering Medium on the Communication Performance
7	09-12-05	Dr. Upendra N Singh	NASA Langley Research Centre, Virginia, USA	Space-based Laser Remote Sensing Technologies and Techniques
8	09-12-05	Prof. J. G. Lu	University of California, Irvine, USA	Electrical and Chemical Sensing Properties of ZnO Nanowires
9	12-12-05	Professor Iwamoto	Tokyo Institute of Technology, Japan	Characterization of Surface Polarization by Optical SHG and Modulation of SHG Signals from Pentacene FET Channels
10	23-12-05	Dr. S.A. Agnihotri	NPL	Electrochromic Smart Windows: Science and Technology
11	02-01-06	Prof. G.P. Agrawal	Institute of Optics, Univ. of Rochester, NY, USA	Non-linear effects in Optical fibres and their applications
12	06-01-06	Prof. Vikram Kumar	NPL	Below bandgap absorption in InGaSb system
13	27-01-06	Dr. V. Mohanan	NPL	Environmental Noise Pollution: Standards and Control Measures
14	03-02-06	Dr. S. N. Singh	Division of Electronic Materials, NPL	Electrical and electronic properties of Polycrysalline semiconductors
15	13-02-06	Dr. H. Akimoto	Frontier Research Center, Japan	Hemispherical Pollution of ozone in the troposhere
16	03-03-06	Dr. Harish Chander	Luminescent Materials and Devices Grou p, NPL	Synthesis and Developments in Nano Luminescent Materials
17	04-03-06	Dr. R.P.Singhal	Standards, NPL	Development of a System to measure the Taper Bore of a Flywheel and Corresponding Shaft

Foreign Scientists Visited NPL

S.N.	Name & Address	Date	Area of Specialization
1.	Ms. Eng. Fowziya Al Zadi, Kuwait Govt.	19-04-2005 21-04-2005	Force Standards
2.	Five Taiwanese delegation led by Prof. Ching-Jyhshieh, Dy. Minister & Vice Chairman, National Council of Taiwan	09-05-2005	Standards
3.	Ms. Eng. Fauziya Al Zadi, Kuwait Govt.	19- 04-2005 21-04-2005	Force Standards
4.	Prof. Ching-JYH Shieh, Dy. Minister and Vice Chairman of National Science Council of Taiwan	09-05-2005	Standards Group
5.	Dr. Ibrahim Ahmed & Dr. Azman Jalar, Eng. Faculty, University of Kebangsaen, Malaysia	22-08-2005 25-08-2005	Electronics Materials
6.	Mr. A.Yamazaki from JETRO, Japan	16-11-2005	Standards
7.	Dr, Quillian, NPL Teddingon, UK & Dr. Kamal Hossain, Director, Science and Technology, NPL, UK	30-11-2005	Standards
8.	Dr. Serge Darrenouge, Director ENSICA, France	02-12-2005	Meeting with HODs
9.	Ms. Rebcca Benn and others, National Science Foundation, USA	02-12-2005	Nanotechnology
10.	Prof. Tam Sridhar from Australia	02-02-2006	Nanotechnology & Radio Science
11.	Dr. Ing. H.C.Hartmut Fuess, Darmstadt University of Technology, Instt. of Materials Science Structure research, Petersestr, Germany	22-02-2005 24-02-2005	Crystallography
12.	Prof. V.G. Mokerov, Director, Instt. of UHF Semiconductor Electronics, Moscow, Russia	22-02-2006 28-02-2006	Crystallography
11.	Dr. J.J. Finely & Dr. A.S. Manocha PPG, USA	24-02-2006	Marketing purpose
12.	Prof. John Haynes Assistant Director, Head Business Development, IOP Publishing, Dirac House , U.K.	06-03-2006	IOP Publishing
13.	Dr. Majumdar, Professor, University of California, Berkey, USA	17-03-2006	Carbon & Nanotechnology
14.	Dr. Peter Hatto, Chairman ISO for Nanotechnologies	27-03-2006	Nanotechnology
15	Prof Raj Narain Singh, Dept of Chemical and Materials Engineering, University of Cincinati, USA	21-06-2005	Nanostructured thin films in the C-B-N system

INVITED TALKS, LECTURES BY NPL SCIENTISTS

Sr. No.	Speaker's Name	Topic	Event and Venue
1.	A.K. Agrawal	i) Quality System Needed for Quality and Safe Food Products.	National Seminar on Food Quality and Safety Standards of Agricultural Raw and Processed Procedure, Central Institute of Post Harvest Engineering and Technology, Ludhiana April 26, 2005.
		ii)Traceability of Measurements and Certified Reference Materials	CEP Course on Recent Advances in Chemical Analysis, Defence Materials Research Laboratory, Hyderabad, January 16, 2006
		iii) ICP Emission Spectrometer:	Management Development Programme on Operation, Maintenance and repair of Analytical Equipment, CSIO, Delhi Centre, New Delhi, February 08, 2006.
2.	A.K. Bandyopadhyay	i) International Traceability in Vacuum and Pressure Standards at NPLI, New Delhi	Training Programme on Vacuum and Pressure Standards organized at NPL, New Delhi during Feb. 14-15, 2006
		ii) Future Programmes in Vacuum and Pressure Standards	- do -
3.	A.K. Saxena	Realization of LF Impedence at NPL	Seminar on "Advance Calibration Concept & Practices" at Electronics Test and Development Centre Guwahati

4.	Anil K. Gupta	i) Need for Sustained R&D in Globalised Scenario for Automobile Industries ii) Structure – Property Correlations of Wrought Magnesium Alloys iii) Bulk Nano Structured Materials & Composites iv) Significance of Wrought Magnesium Alloys for Automobile Applications- New Opportunities & Challenges	Management of Rane Group of Industries, April 27, 2005. General Motors R&D Centre, Warren, USA, March 9, 2006 University of Wisconsin, Milwaukee, USA, March 27, 2006 Management of Hero Group of Industries, February 27, 2006
5.	Ashish Agarwal	i) New developments of Atomic Clocks at NPL ii) Entanglement of Atomic Ensembles iii) Atomic Clocks: Recent developments	National seminar on perspectives in Engineering Optics and Spectroscopy held at Indraprastha Engineering College, Ghaziabad, April 27 2005 2nd International Conference on current developments in atomic, molecular & optical physics with applications, held at University of Delhi, Delhi, March 22, 2006 Invited lecture at Kalindi College, University of Delhi, Delhi on November 17, 2005
6.	B R Chakraborty	Project crisis management – a case study	DST programme on "Multidisciplinary prospective of science and technology" held at NIAS, Bangalore
7.	B.C. Arya	Lidar measurements of the Atmosphere	CEP Course (Continuing Education Programme) held at Laser Science and Technology Centre (LASTEC), Delhi July 4, 2005.
8.	D.P. Singh	i) Processing of Aromatic and Medicinal Crops ii) Erection & Setting of Fractional Distillation and Extraction Plants for Perfumery Industries	Fragrance & Flavour Development Centre, a Government of India Autonomous Body, Ministry of SSI, Kannauj on September 24, 2005 - do -

9.	G. Bhagavannarayana	i) Characterization of single crystals and epitaxial films by high resolution diffuse X-ray scattering method	Crystal Growth and Characterization held at Physics Department, Loyola College, Chennai during Sept. 29-30, 2005.
		ii) High-resolution X-ray diffraction methods-Versatile and nondestructive tools for characterization of single crystals and expitaxial films	Second National Symposium on Crystal Growth of Laser related materials held at SSN College of Engineering, Kalavakkam, Chennai during 19-20th December 2005.
		iii) Characterization of single crystals and epitaxial films by high-resolution X-ray diffractometry, topography and diffuse scattering techniques	National Conference on Preparation and Characterization of Crystalline Materials held at S.T. Hindu College, Physics Research Centre, Nagercoil, Tamil Nadu during Jan. 19-21, 2006.
10.	H. N. Dutta	i) Commercial opportunities in the Antarctic Research	Sri Ram Institute of Industrial Research , New Delhi, June 11, 2005.
		ii) Opportunities in Antarctica	Govt Science College, Gwalior on August 4, 2005.
		iii) Antarctica:Tourism potential	Indian Institute of Tourism & Travel Management (Ministry of Tourism), Govt of India, Gwalior, August 6, 2005.
		iv) Antarctica: Engineering aspects and avenues	Madhav Institute of Technology, Jiwaji University, Gwalior, August 6, 2005.
		v) Earthquake precursors	Kasturba Women's Polytechnic, DTTE, New Delhi, September 8, 2005.
		vi) Antarctica : present perspective	Govt Girl's College, Gurgaon, September 10, 2005.
		vii) Antarctica: Aaj ke sandhrabh mein	INSA, Bahdur Shah Zafar Marg, New Delhi, September 20, 2005.
		viii) Talk & Phone-on-line 40 minute program on Antarctica	All India Radio, Inderdhanush, Delhi October 19, 2005.
		ix) Invited discussion on "Azadi ke 58 saal"	All India Radio, August 15, 2005

11.	H.C. Kandpal	i) Spatial Coherence Spectroscopy and its Applications	National seminar on Perspectives in Engineering and Spectroscopy, Inderprastha Engineering College, Ghaziabad April 27-29, 2005
		ii) Photometric Measurements and Problems	Central Institute for Road Transport, Pune May 21, 2005.
		iii) Photometry and Colorimetry	M.Tech Students Automotive Research Association of India, August 25-28, 2005.
		iv) Coherence and intreferometry,	A course to the School Teachers on Modern Optics, Indira Gandhi Open University, New Delhi, October 28, 2005
		v) Optical coherence Tomography and its applications	- do -
		vi) Parametric fluorescence and its application in quantum metrology.	National Symposium on Recent Trends in Fluorescence Spectroscopy and its Applications held at Physics Department Kumaon University, Nainital during Dec 1-3, 2005
		vii) Spatial-Coherence Spectral Filters and their Applications and Determination of Surface Flatness by Spectral interferometry	International conference on optics and optoelectronics held at IRDE Dehra Dun held during Dec 12-15, 2005
12.	Harish Chander	i) Developments in Nano Luminescent Materials	Workshop on Recent trends in Nanomaterials held at Kamla Nehru College, Nagpur on 14th January 2006
		ii) Studies on CdSe/CdS Nanophosphors	National Conference on Luminescence and its Applications held at Amaravati University, Amaravati on 7-9 February 2006
		iii) Status of Nanophosphor development at National Physical Laboratory	National Symposium on Recent Trends in Fluorescence Spectroscopy and its Applications held at Department of Physics, Kumaun University, Nainital on December 1-3, 2005
		iv) Status of Nanophosphor Synthesis	Institute of Materials Research and Engineering, Singapore on 5th July 05.
		v) Synthesis and Developments in Nano Luminescent Materials	Seminar Series of National Physical Laboratory, New Delhi on 3rd March 2006.

13.	K. P. Chaudhary	i) Guidelines for Calibration of Roughness Standards/ Machines	Training Programme On Surface Roughness And Roundness Measurements, National Physical Laboratory, New Delhi National Physical Laboratory, New Delhi September 14, 2005,.
		ii) General concept of calibration and Uncertainty Evaluation in Analytical Instruments	Management Development program on Operation, Maintenance and repair of Analytical Equipment Sponsored by Min. of External Affairs, at CSIO center, New Delhi Feb 2nd 2006
		iii) General concept of calibration and Uncertainty Evaluation in Bio-medical Instruments	- do -
		iv) General concept of Uncertainty and calibration of Geo-seismic instruments	- do -
		v) "Investigation of Opto –tactile probes regarding to their Optical characteristics and roundness"	National Symposium on Coordinate Metrology, NPL, New Delhi, Feb 28th – March 1st 2006
		vi) Improving Uncertainty of Measurement using Substitution Method – A Study	- do -
		vii) Investigations of Source of Errors in Triangulation Probes	- do -
		viii) Accurate Sphere Measurement using CMM as a comparator and evaluation of uncertainty of measurement – A case study	- do -
		ix) Volumetric Accuracy, Its Evaluation Using CMM	- do -
14.	M V S N Prasad	i) Performance assessment of fixed & mobile communications	A short-term course for the Indian Navy Officers on "Radio Meteorology and Radio Wave propagation over sea" conducted by RASD/NPL during December 19-23, 2005.
		ii) Trans-horizon microwave propagation.	- do -
15.	M. Arif Sanjid	Angle Measures at NPL	Training Programme On Surface Roughness And Roundness Measurements, National Physical Laboratory, New Delhi, September 14, 2005,
16.	Mohan Lal	Achieving higher efficiency goal in manufacturing silicon solar cells	National Symposium on Recent Trends in Material Science, Andhra Loyola College, Vijayawada, Feb. 9 - 11, 2006

17.	Mukesh Kumar,	Guidelines for Calibration of Roundness Standards/Machines	Training Programme On Surface Roughness And Roundness Measurements, National Physical Laboratory, New Delhi, September 14, 2005,
18.	N. Vijayan	Effect of post growth annealing on the Bridgeman grown single crystals of benzimidazole	National Conference on Preparation and Characterization of Crystalline Materials held at S.T. Hindu College, Physics Research Centre, Nagercoil, Tamil Nadu during Jan. 19-21, 2006. (Keynote address)
19.	Om Prakash	Calibration and Measurement Uncertainty of a Pressure Dial Gauge	Training Programme on Calibration and Uncertainty Measurements organized by RTC, New Delhi on during Nov. 7-11, 2005
20.	P. Banerjee	i) GPA and GPS Time ii) "Shodhkaryon per kendrit" in Bhaintvarta	CMRI, Dhanbad, 12th March 2006 All India Radio, 20th June 2005
21.	P.K. Gupta	i) Chemical metrology & Environment: Atmospheric aerosols, trace species and reference measurements at NPL ii) Physico-chemical characterization of aerosols over Delhi iii) Atmospheric nitrogen and its deposition रसायनिक मापन की चुनौतियां	First workshop on Astroparticle physics and space sciences - Scope of the national facility in eastern Himalayas, Bose Institute, Darjeeling Campus, Darjeeling, W.B. Nov. 3-5, 2005, One day brain storming session on 'Urban Aerosol Climatology', IITM Delhi Branch, Nov.25, 2006 Workshop in environment, industry and agriculture', INSA, New Delhi, March 16-17, 2006. वायुमण्डलीय एवं पर्यावरण विज्ञान : नए आयाम, १६–२० जनवरी, २००६ राष्ट्रीय भौतिक प्रयोगशाला नई दिल्ली ।
22.	P.N. Dixit	i) Preparation and characterization of thin film nano-crystalline silicon ii) Hydrogenated Amorphous Silicon Based Devices	IWPSD 2005, New Delhi, Dec. 13-17, 2005. National brain storming seminar on thin film transistor technology, Amity University, NOIDA, 15-16 Sept. 2005.
23.	R.K. Garg	i) Calibration and measurements of UV Radiation ii) UV Emission from General Purpose Lamps	Training course on photometry and Calorimetry held at NPL during 27th – 31st March 2007 - do -

24.	R. Mehrotra	i) Infrared Spectroscopy	National Workshop on Optical & Spectroscopic Methods for Sensor Instrumentation, , Manipal Institute of Technology, Manipal, 21st September - 7th October.2005
		ii) Optical Radiation Standards' Activities	Management development programme on operation, maintenance and repair of analytical equipment, CSIO, New Delhi, October 1, 2005,
		iii) IR Spectrophotometers	- do -
		iv) Recent advances in Infrared technology for food analysis	National Workshop –cum-Symposium on Sensors and instrumentation for food processing, CFTRI, Mysore, Jan 20th to 21st, 2006
		v) Infrared Spectroscopy and its Applications	Dyal Singh College, University of Delhi, Delhi, 28th Feb 2006
25.	R. S. Dabas	i) Ionospheric effects on Space based Communication and Navigation Systems.	DST SERC School on Basics of GPS and Ionosphere held at Osmania Univ., Hyderabad during December 2005.
		ii) Anomalous Radar Propagation over sea.	A short-term course for the Indian Navy Officers on "Radio Meteorology and Radio Wave propagation over sea" conducted by RASD/NPL during December 19-23, 2005.
26.	R.P. Singhal	i) Uncertainty for Beginners	Specialized Training Program on Calibration at RTC Okhla New Delhi.
		ii) Dimensional Metrology	NPL-NABL Training Programme on Uncertainty in Dimensional Measurements, National Physical Laboratory, New Delhi, December 8-10, 2005,
		iii) Surface Texture:Terms Definition And Evaluation	Training Programme On Surface Roughness And Roundness Measurements, National Physical Laboratory, New Delhi, September 14, 2005
		iv) Roundness: Terms Definition and Evaluation	- do -

27.	Rina Sharma	i) Evaluation and Expression of Uncertainty in Measurements	Training Programme On Surface Roughness And Roundness Measurements, National Physical Laboratory, New Delhi, September 14, 2005
		ii) Evaluation and Expression of Uncertainty in Measurements	Training Programme on Evaluation And Expression Of Uncertainty In Measurements, National Physical Laboratory, New Delhi, September 13-14, 2005
		iii) Calibration of Artifacts of Dimensional Metrology -A Case Study	- do -
		iv) Traceability of Surface Roughness and Roundness Measurements to Unit Metre	- do -
28.	S. K. Singhal	A Critical Appraisal of Design, Selection and Application of Ultrasonic Transducers	National Conference on Sensors, Thapar institute of Engineering and Technology, Patiala, Nov., 25-26, 2005
29.	S.K.Gupta	उन्नत पदार्थों का इलेक्ट्रान पैराचुंबकीय अनुनाद स्पेक्ट्रोमिकी अभिलक्षणन	पदार्थ विज्ञान एवं अनुप्रयोगों की प्रगति पर राष्ट्रीय कार्यशाला, राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली 3–4 मई, 2005
30.	S.L. Jain	i) A study of Ozone and precursor gases at Leh and Hanle (Western Himalayas).	The Scientific Assembly of the International Association of Meteorology and Atmospheric Sciences (IAMAS) held at Beijing International Convention Center in Beijing, China, during August 2-11, 2005
		ii) Laser Based Detection of Chemical & Biological Species	CEP (Continuing education programme) course on "Technological Advances in Defence Laser Systems", held at Laser Science & Technology Centre (LASTEC) , Delhi, October 27, 2005, (during 24th Oct. to 28th Oct, 2005)
		iii) LIDAR	CEP (Continuing Education Programme) course on "Development in laser and photonics" at Laser Science & Technology Centre (LASTEC) , DRDO, Delhi, November 7-11 , 2005
		iv) Atmospheric Green House Gases and Ozone over Maitri, Antarctica	Department of Physics M. L. S. University Udaipur , Dec., 19, 2005

31.	S.M. Shivaprasad	i) Nanoscience and Nanotechnology	Academic Staff College, Jawaharlal Nehru University, New Delhi, 14th March. 2006.
		ii) Probing the nanophases X-ray Photoelectron Spectroscopy	Delhi University, South Campus, New Delhi, 27th Dec. 2006
		iii) Hetero-epitaxial Growth of Low-Dimensional Phases and Nanostructures	International Workshop on Physics of Semiconductor Devices, IWPSD-2006, New Delhi, 17th Dec. 2006
		iv) Aspects of Heteroepitaxial Growth: some examples	RIVA V, The Meeting of the Iberian Vacuum Societies, held at Guimaraes, Portugal, from 17th to 21st Oct., 2005.
		v) In-situ monitoring growth of Heteroepitaxial structures	National Seminar on Thin Film Technology, Organized by Amity University and DST, New Delhi, on 16th Sept. 2005
		vi) The versatility of X-ray photoelectron spectroscopy in understanding the exotic properties of the Nanophase	ACTON 2005, Indian Institute of Roorkee, from 24-26 Aug 2006.
		vii) Alice in Nanoland	Springdales School, Dhaula Kuan, and Bal Bharati, Rohini, New Delhi, August 2006, Sept. 2006
		viii) An Introduction to the marvels of the Nano-world	Chinmaya Vidyalaya, Vasanth Vihar, New Delhi, July 2005
32.	S.N. Singh	i) Anomalous Photovoltaic Effect in Obliquely Deposited Polycrystalline Semiconductor Thin Film	Shri Ram Murthy Smarak College of Engineering & Technology, Bareilly, November 21-22, 2005.
		ii) Advances in Solar Photovoltaics Based on Single and Multicrystalline Silicon	National Workshop on Recent Trend in Optoelectronics, Govt Degree College Bemma, Srinagar, Kashmir, October 3-4, 2005.
33.	S.S. Rajput	i) Analog VLSI	NCETET 2006/IEEE at SMVDU, Jammu
		ii) Low Voltage design Techniques	Guru Teg Bahudur Institute of Technology, Harinagar, Delhi
34.	Sanjay Yadav	i) Calibration Facilities in Hydraulic Primary and Secondary Pressure Standards - a Case Study for Uncertainty in Measurements	Training Programme on Vacuum and Pressure Standards organized at NPL, New Delhi during Feb. 14-15, 2006
		ii) Recently Concluded NABL-NP PT Programme in Pressure Metrology	- do -
		iii) Calibration of Pressure Measuring Instruments	Training Programme on Calibration and Uncertainty Measurements organized by RTC, New Delhi on during Nov. 7-11, 2005
		iv) Computation of Measurement Uncertainty in Pressure Metrology	- do -

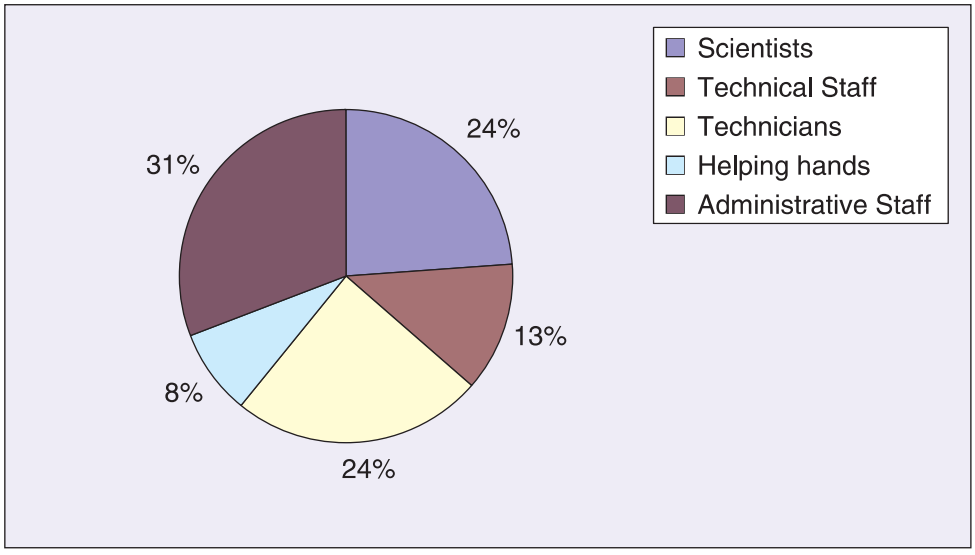
35.	Shashi Moitra and K.P.Chaudhary,	Error Corrections in Optical Probes to Improve Measurement Accuracy	Training Programme on Calibration and Uncertainty Measurements organized by RTC, New Delhi on during Nov. 7-11, 2005
36.	Suresh Chand	Plastic Electronics	Maitreyi College, University of Delhi Under Einstein Year of Physics,Dec., 14, 2005
37.	Sushil Kumar	i) Plasma Processing of Materials ii) Plasma Science and its applications iii) Science and Technology for nanoscience and technology	CSIR Programme on youth for leadership in science (CPYLS), NPL, May 6, 2005 Shahid Harikishan Singh School, Delhi Oct. 27 2005 Vanasthali Public School, Delhi
38.	Tripurari Lal	i) Standards of Mass and Calibration of Weights ii) Uncertainty Evaluation in Mass Measurements iii) Volume Standards and Calibration of Volumetric Glassware iv) Techniques for Mass Calibration and Uncertainty Evaluation in Calibration of Weights and Balances and Calibration of Volumetric Glassware	"Need and Relevance of Calibration for Industries for Global Competitiveness" organized by National Research & Technology Consortium, Parwanoo (HP) and NPL New Delhi at Barog , Solan in Himachal Pradesh, on August 11th & 12th 2005 - do - - do - Specialized Training Program on Calibration at RTC Okhla New Delhi.
39.	V.K. Rustagi	AC Voltage and Current measurements LCR, CRO and Counter measurements	Workshop on "Need and relevance of Calibration for Industries for Global Competitiveness" organized by NRTC Himachal Pradesh and NPL at Parvanoo on August 11th and 12th 2005 - do -
40.	V.K. Sankaranarayanan	Ferromagnetic Semiconducting Oxides and Spintronics	'International Conference on Optoelectronic materials and Thin Films for Advanced Technology' OMTAT-2005, Department of Physics, Cochin University of Science and Technology, Kochi, India. 24-27 October 2005

41.	Vikram Kumar	i) Smart MEMS Devices	Workshop on Sol-Gel Techniques, Delhi University South Campus during June 17, 2005
		ii) Peizo-MEMS Device	Recent Trends in Micro-electronics and MEMS, IIT Madras during July 02, 2005
		iii) Organic Electronics and Optoelectronic Devices	National Symposium on Recent Trends in Fluorescence Spectroscopy and its Applications, Department of Physics, Kumaun University, Nainital during Dec., 01, 2005
		iv) MEMS based Sensors	DAE Symposium on Solid State Physics, BARC Mumbai during Dec., 08, 2005
		v) Current in Polymer Solar Cells	13th International Workshop on the Physics of Semiconductor Devices, NPL, New Delhi during Dec., 13, 2005
		vi)Future of Electronic Devices	11th International Conference of Electronic Components, Materials and Equipment, Electronics Today, Pragati Maidan, New Delhi during Jan., 23, 2006
		vii) An Overview of MEMS Development in India	ISSS Training Programme for Teachers of Vishweshraiah Technical University, Indian Institute of Science, Bangalore during Jan.,18, 2006
		viii) Innovation and Organization	CSIR Workshop on Innovation, NPL, New Delhi during July 18, 2005
		ix) Nanotechnology for Future	Special Evening Lecture, Computer Society of India, Delhi Chapter during March 30, 2006
		x) An Overview of MEMS Development in India	Innaugral Address at the MEMS Nanoelectronics Conference, IIT Kharagpur during Dec., 20, 2005
		xi) Below Band Gap Absorption in Semi-conductors	Colloquium, NPL, New Delhi during Jan., 06, 2006
		xii) नैनो प्रौद्योगिकी एवं विकास	पदार्थ विज्ञान एवं अनुप्रयोगों की प्रगति पर राष्ट्रीय कार्यशाला, राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली 3–4 मई, 2005
		xiii) Recent Developments in MEMS Technology	11th International Conference of Electronic, Components, Materials and Equipment, Electronics Today, Pragati Maidan, New Delhi during Feb., 03, 2005
		xiv) Role of Metrology in International Trade	CII Workshop on Metrology, Calcutta during July 17, 2005

HUMAN RESOURCE

As on March 31, 2006

GROUP IV		
Director		1
Scientist G		10
Scientist F		88
Scientist EII		54
Scientist EI		14
Scientist C		39
Scientist B		13
	Sub-Total	**219**
GROUP III		
TO (A)		8
TO (B)		25
TO (C)		33
Exe. Engg.		2
Assist. Exe. Engg.		1
TO (EI)		15
TO (EII)		1
Tech. Asst. VIII		16
Junior Engg.		2
STA		11
	Sub-Total	**114**
GROUP II		
	Sub-Total	**222**
GROUP I		
	Sub-Total	**77**
ADMN-D		110
ADMN-D (Cafeteria Staff)		13
ADMN-C		48
ADMN-C (Cafeteria Staff)		11
ADMN-B		90
ADMN-A		8
	Sub-Total	**280**
	GRAND TOTAL	**912**



SCIENTISTS AND OFFICERS AS ON 31.03.2006

Director

Dr Vikram Kumar

Scientists and Officers as on 31.03.2006

NAME	DESIGNATION
Physico-Mechanical Standards	
Head : Dr Raghunandan Prasad Singhal	
Dr Raghunandan Prasad Singhal	Scientist G
Dr Vellur Mohanan	Scientist G
Dr Kamlesh Kumar Jain	Scientist F
Dr Ashis Kumar Bandhyopadhyay	Scientist F
Dr Ashok Kumar	Scientist F
Sh H N P Poddar	Scientist F
Dr Bhim Sain Gera	Scientist F
Dr Desh Raj Sharma	Scientist F
Sh S Uma Maheshwar Rao	Scientist F
Dr Sushil Kumar Jain	Scientist F
Dr Pardeep Mohan	Scientist F
Dr Hem Chandra Kandpal	Scientist F
Sh Tripurari Lal	Scientist F
Sh B V Kumaraswamy	Scientist F
Sh Omkar Sharma	Scientist F
Dr Rakesh Kumar Garg	Scientist F
Sh Subodh Kumar Singhal	Scientist F
Sh K P Chaudhary	Scientist F
Sh Mati Lal Das	Scientist F
Dr Yesh Pal Singh	Scientist F
Sh Anil Kumar	Scientist F
Dr Mukesh Chandra	Scientist EII
Sh Navin Kumar Srivastava	Scientist EII
Sh Raj Singh	Scientist EII
Dr (Ms) Ranjana Mehrotra	Scientist EII
Dr Sanjeev Sinha	Scientist EI
Dr Mahavir Singh	Scientist EI
Dr Mrs Rina Sharma	Scientist EI
Sh D Arun Vijayakumar	Scientist EI
Dr S Seela Kumar Titus	Scientist C
Dr Miss Nita Dilawar	Scientist C
Sh Rajesh Kumar	Scientist C
Dr Sanjay Yadav	Scientist C
Sh Gautam Mandal	Scientist B
Naveen Garg	Scientist B

Sh Virendra Babu	Tech Ofcr (EII)
Sh B K Roy	Tech Ofcr (EI)
Sh Satish Kumar Nijhawan	Tech Ofcr (EI)
Sh Ravi Khanna	Tech Ofcr (EI)
Sh Jagdish Kumar Gupta	Tech Ofcr (EI)
Sh Jai Bhagwan	Tech Ofcr (EI)
Sh S L Thind	Tech Ofcr (EI)
Sh Gurbir Singh	Tech Ofcr ©
Mrs Reeta Gupta	Tech Ofcr ©
Sh T K Parameshwaran	Tech Ofcr ©
Sh Gurcharanjit Singh	Tech Ofcr ©
Sh V K Ojha	Tech Ofcr ©
Dr Yudhisther Kumar Yadav	Tech Ofcr ©
Sh Ishwar Singh Taak	Tech Ofcr (B)
Sh Gurdeep Singh Lamba	Tech Ofcr (B)
Sh Mukesh Kumar	Tech Ofcr (B)
Sh K N Basavaraju	Tech Ofcr (B)
Sh Bhikham Singh	Tech Ofcr (B)
Sh Mahargha Baran Das	Tech Ofcr (A)
Sh Sudama	Tech Ofcr (A)

Electrical & Electronic Standards

Head : Dr Prafulla Chandra Kothari

Dr Prafulla Chandra Kothari	Scientist G
Dr P Banerjee	Scientist G
Dr Amitava Sengupta	Scientist G
Sh Vijay Kumar Rustagi	Scientist F
Dr G M Saxena	Scientist F
Dr Surender Kumar Mahajan	Scientist F
Dr Ashok Kumar Hanjura	Scientist F
Dr Vijay Narain Ojha	Scientist F
Dr Sita Ram Gupta	Scientist F
Sh Anil Kumar Govil	Scientist F
Sh Mukesh Kumar Mittal	Scientist F
Sh Anil Kishore Saxena	Scientist F
Sh Ritander Aggarwal	Scientist EII
Dr R K Kotnala	Scientist EII
Sh Pramendra Singh Negi	Scientist EII
Sh Vijay Kumar	Scientist EII
Mrs Arundhati Chatterjee	Scientist EII
Dr Neeraj Khare	Scientist EII
Sh Naib Singh	Scientist EII
Sh H R Singh	Scientist EII
Sh T Raghvendra	Scientist EII
Sh M P singh	Scientist EII
Sh Ajeet Singh	Scientist EI

Sh Joges Chandra Biswas	Scientist EI
Sh Kavindra Pant	Scientist EI
Dr Harikrishna Singh	Scientist C
Ms Manju Singh	Scientist C
Sh Rajbeer Singh	Scientist C
Dr Aloysius R P	Scientist C
Sh Saood Ahmed	Scientist C
Sh Chockalingam Sreekumar	Scientist B
Dr Ashish Agarwal	Scientist B
Sh Shiv Kumar Jaiswal	Scientist B
Sh Kamlesh Kumar Patel	Scientist B
Sh Anil Kumar Suri	Tech Ofcr (EI)
Sh Kul Bhushan Ravat	Tech Ofcr (C)
Sh Mohammad Saleem	Tech Ofcr (C)
Sh Avdhesh Kumar Goel	Tech Ofcr (B)
Sh Bijendra Pal	Tech Ofcr (B)

Engineering Materials

Head : Dr Anil Kumar Gupta

Dr Anil Kumar Gupta	Scientist G
Dr Sukhmal Chand Jain	Scientist G
Dr Sukhwant Singh Bawa	Scientist G
Dr Gopal Bhatia	Scientist F
Sh Subhash Chandra Gera	Scientist F
Dr Rakesh Behari Mathur	Scientist F
Dr M N Kamalasanan	Scientist F
Dr R K Aggarwal	Scientist F
Dr Chhatra Pal Sharma	Scientist F
Dr A M Biradar	Scientist F
Dr Bhanu Pratap Singh	Scientist F
Dr Suresh Chand	Scientist F
Dr Mrs Vasantha Raman	Scientist F
Dr Tarsem Lal Dhami	Scientist F
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Sh Ramesh Chandra Anandani	Scientist F
Dr Sunil Kumar Singhal	Scientist F
Dr Chhotey Lal	Scientist F
Dr Rajeev Chopra	Scientist EII
Dr Tushya Kumar Saxena	Scientist EII
Dr Ajay Dhar	Scientist EII
Dr Krishan Kumar Saini	Scientist EII
Dr S K Dhawan	Scientist EII
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Sh Sudhanshu Dwivedi	Scientist EII
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Dr Surendra Pal Singh	Scientist C
Dr G Sumana Gajala	Scientist C
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Sh. Bhanu Pratap Singh	Scientist B
Sh Rajiv Sikand	Tech Ofcr (EI)
Sh Gauri Datt Sharma	Tech Ofcr (C)
Sh Pinaki Ranjan Sengupta	Tech Ofcr (C)
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Sh Rajesh Kumar Seth	Tech Ofcr (B)
Sh Mohan Chandra Singh	Tech Ofcr (B)
Sh Jokhan Ram	Tech Ofcr (B)
Sh. J.P. Singh	Tech Ofcr (B)

Electronic Materials

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Sh Amar Singh	Tech Ofcr (A)

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Head : Dr Hari Kishan

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Sh Rajan Babu Saxena	Scientist F
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Sh Pratim K Dutta	Scientist EII
Dr Ratan Lal	Scientist EII
Sh Umesh Chandra Upreti	Scientist EII
Dr S K Agarwal	Scientist EII
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Sh Man Mohan Krishna	Scientist C
Dr Anurag Gupta	Scientist C
Sh M A Ansari	Scientist C
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Sh S B Samanta	Tech Ofcr (EI)

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Sh Lalit Jain	Tech Ofcr (C)
Sh G K Kapoor	Tech Ofcr (B)
Sh Jagan Nath Prasad	Tech Ofcr (B)
Mrs Shashi Lekha Bhatnagar	Tech Ofcr (B)

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Sh N K Wadhwa	Scientist EI
Sh Hasan Haider	Tech Ofcr (EI)
Sh Jagdish Prasad	Tech Ofcr (C)
Sh Rajpal Zamaji Walke	Tech Ofcr (A)

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Sh S K Chakladar	Scientist F
Sh Narinder Kumar Babbar	Scientist F
Mrs Shikha Mandal	Scientist EII

Sh Pashricha	Scientist EII
Dr (Ms) Jyoti Lata Pandey	Scientist EII
Sh Sushil Kumar Sharma	Scientist EII
Sh Tushar Kanti Chakravarty	Scientist EII
Sh Mohinder Kumar Chhibber	Tech Ofcr (EI)
Sh V D Arora	Tech Ofcr (C)
Sh Ashwani Kumar Suri	Tech Ofcr (C)
Sh Vinod Kumar Sharma	Tech Ofcr (B)

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Head : Dr P Banerjee

Sh Jagdish Chandra Sharma	Scientist EII
Sh Deepak Bansal	Tech Ofcr (C)
Sh J B Soni	Tech Ofcr (C)
Sh Prabhu Shankar Tripathi	Tech Ofcr (B)
Sh I P Singh	Exe. Engg.
Sh Dharam Jit Singh	Exe. Engnr.(Civil)
Sh Anuj Gaur	Astt. Exe. Engg.

Workshop & GTU

Head : Sh Surendra Singh Verma

Sh Surendra Singh Verma	Scientist F
Sh Srinivas P	Scientist C

Central Computer Facility

Head : Dr Ravi Mehrotra

Dr Ravi Mehrotra	Scientist F
Sh V Sakthivel Samy	Scientist C
Sh Ashish Ranjan	Scientist C
Ms Deepti Chaddha	Scientist B
Sh Kanwaljit Singh	Tech Ofcr (B)
Sh Ashok Kumar	Tech Ofcr (B)
Sh Vijay Sharma	Tech Ofcr (B)

Administration & House Keeping

Head : Sh R P Sharma

Sh R P Sharma	COA
Sh Swapan Mukherjee	F & A O
Sh Brijesh Sharma	SPO Gr. I
Sh Prem Singh	SPO
Sh Dhirender Kumar	Admn. Ofcr
Dr Mrs Shakuntala Sharma	Sr Hindi Ofcr
Sh Vijay Kumar	Sr Security Ofcr
Sh Lakhpat Singh	Sr Security Ofcr
Sh Chhering Tobden	SO(G)
Sh D K Salone	SO(G)

Ms Veena Anupa Kullu	SO(G)
Sh B K Singh	SO(G)
Sh Umesh Gupta	SO(G)
Sh S K Thakur	SO (F&A)
Sh K B Joshi	SO (F&A)
Sh Gyan Chand	SO (F&A)
Sh Kuldeep Kaushik	S O (str & pur)
Sh Surender Kumar	S O (str & pur)
Sh Bhag Singh	S O (str & pur)
Sh Naveen Pavithran	S O (str & pur)
Sh J D Batra	S O (str & pur)
Sh R K Bhasin	PS
Sh Mange Ram	PS
Mrs Paramjit Kaur	PS
Sh Indrajeet	PS
Sh Rama Shankar Singh	Tech Ofcr (EI)

Retired Persons

Sh Jagdish Kumar Dhawan, Scientist F
Sh Ram Niwas, Jr Sec Grd (ACP)
Sh Vijay Kumar Vohra, Scientist EII
Dr Lakha Singh Scientist F
Dr Ramesh Babu Tripathi, Scientist EII
Mrs Munni Devi, Sr Mech Asstt.
Sh B S Rawat, Controller of Fin & Accounts
Sh Balbir Singh, Gr II(4)
Sh Raja Ram, Workshop Asstt VII
Sh V K Sharda, Gr II(4)
Sh Akhilesh Chandra Gupta, Scientist G
Sh Sagar Prasad, Workshop Asstt VII
Sh Mehar Singh, Sr Mech Asstt
Sh Trilok Singh, Gr II(4)
Sh Ram Kaleshwar, Sr Mech Asstt
Sh Om Prakash, Workshop Asstt VII
Sh Om Prakash, Sr Mech Asstt
Dr Mrs S A Agnihotry, Scientist F
Dr Om Kar Nath, Scientist F
Sh Ramesh Chander Maheshwari, Sr Mech Asstt
Sh Gurdip Singh, Sr Mech Asstt
Sh G C Joshi, Gr II(4)
Sh M K Dasgupta, Tech Ofcr C
Ms Chandra Kanta Sharma, Asstt (G) Grade-1
Sh Sohan Lal, Sr Mech Asstt
Sh Islamuddin Anwar Malik, Tech Ofcr (EII)
Dr Om Prakash, Scientist F
Dr V G Kulkarni, Scientist F
Sh Satish Chand Garg, Scientist G
Sh Subhash Chandra, Tech Ofcr (EI)
Sh Dharam Bir Sharma, Tech Ofcr C
Sh Ram Sarup, Tech Ofcr C
Dr Ved Ram Singh, Scientist G
Dr B V Reddi, Scientist EII
Dr Jnanendra Nath Som, Scientist F
Mrs Saroj Dhingra, F&AO

Obituaries

Dr Mansha Ram, Scientist EI
Sh V K Singh, Asst. Exe Engnr (Civil)
Sh Jogeshwar, Mali (Gr 1)
Dr Satish Chandra Kant Mishra, Scientist F
Sh Phool Singh, Mali (Skilled)
Sh N C Soni, Tech Ofcr C
Dr N D Kataria, Scientist F

Scientists Fellow & Emeritus Scientists

Dr A P Mitra, Hony Scientist of Eminence
Dr A R Varma, INSA Hony Scientist
Dr K K Mahajan, INSA Sr. Scientist
Dr O P Bahl, Emeritus Scientist
Dr P K Ghosh, Emeritus Scientist
Dr U N Sinha, Emeritus Scientist
Dr Subhash Chandra, Emeritus Scientist
Dr Krishan Lal, Emeritus Scientist
Dr A V Narlikar, Emeritus Scientist
Dr Ashok Kumar Gupta, Emeritus Scientist
Dr B S Mathur, Emeritus Scientist
Sh S C Garg, Emeritus Scientist
Dr R Bhattachryya, Emeritus Scientist
Mohd. Dilshad, Research Sceintist
Dr Vikram Soni, UGC Research Scientist

Research Fellows/Associates/Interns

Smt Pryinka Heda Maheshwari, JRF
Sh Vikram Sen, JRF (CSIR)
Sh Praveen Kumar Singh, JRF (CSIR)
Ms Safia Yasmin, JRF (CSIR)
Km Rachna Gupta, JRF (CSIR)
Sh Sunil Kumar Arya, JRF (CSIR)
Sh Rajesh Kumar, JRF (CSIR)
Sh Amit Singh, JRF (CSIR)
Sh Anil Ohlan, JRF (CSIR-UGC)
Sh Umesh kumar, JRF (CSIR-UGC)
Sh Jai Prakash. JRF (CSIR-UGC)
Smt Anjula, Res. Intern
Sh Himanshu Tiwari, Res. Intern
Sh Ashok Kumar, Res. Intern
Sh Vinod Kumar, Res. Intern
Ms Anita Rani, Res. Intern
Ms Taranuum Bano, Res. Intern
Sh Arif Faiz Khan, Res. Intern
Ms Gayatri Chauhan, Res. Intern
Ms Jyoti Shah, Res. Intern
Ms Neha Goel, Res. Intern
Sh Puna Ram Sinha, Res. Intern

Sh Gautam Singh, JRF (CSIR-UGC)
Sh Vivek Kumar Varma, JRF (CSIR-UGC)
Sh Vikash, JRF (CSIR-UGC)
Ms Arpita Vajpayee, JRF (CSIR-UGC)
Sh Bikash Ghosal, JRF (GATE)
Km Priyanka, JRF Ph D
Dr Kanchan Saxena, P.I.
Dr Suman Anand, P.I.
Dr Shilaja Pande, P.I.
Sh Rahul Singhal, Prov. Res. Assoc.
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Dr Mitali Shah, RA
Dr S P Singh, RA
Dr Sippy Calra Chauhan, RA
Dr Umendra Kumar, RA
Sh Anand Kumar Dwidi, RA
Sh Raj Kishore Sharma, RA
Km Aparna Mishra, RA
Dr Anil Kumar, RA
Km Punita Singh, RA
Km P Jemima, RA
Sh Ravinder Singh Parmar, RA
Sh Prem vir Singh, RA
Meena Kumari, Res. Intern
Km Sushri Parul, Res. Intern
Sh Jitendra Kumar, Res. Intern
Sh Nitesh, Res. Intern
Sh Shailesh Kumar, Res. Intern
Km Kavita Sharma, Res. Intern
Km Pallavi Pukhar, Res. Intern
Sh Prashant Gautam, Res. Intern
Km Lakshmi Manral, Res. Intern
Km Shaili Sharma, Res. Intern
Smt. Kavita Varshany, Res. Intern
Km Jyoti Tripathi, Res. Intern
Km Neha Gera, Res. Intern
Sh Sunny Sehgal, Res. Intern
Akhsay J Deshpandey, Res. Intern
Ms Archna Mishra, Res. Intern
Sh Jai Govind Varma, Res. Intern
Ms K Jayanthi, Res. Intern
Ms Suman, Res. Intern
Sh Akhilesh Chandra Yadav, Res. Intern
Sh Abhishek Bhattacharya, Res. Intern
Sh Ravinder Pratap Singh, Sr. Res. Assoc.
Dr Manoj Kumar Srivastava, Sr. Res. Assoc
Sh Neeraj Panwar, SRF
Sh Rajeev Kumar Singh, SRF
Km Amita Varma, SRF
Km Shampa Das, SRF
Sh Amit, SRF
Sh Bhaskar Gahtori, SRF
Sh P Tyagrajan, SRF
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Sh Ajay Kumar Gupta, SRF
Sh Sanjay Kumar, SRF
Sh Arvind Kumar Jha, SRF
Sh Bhupendra Singh, SRF (CSIR)
Sh Jitendra Kumar, SRF (CSIR)
Km Kavita Arora, SRF (CSIR)
Km Vandana Gupta, SRF (CSIR)
Km Sarabjeet Kaur, SRF (CSIR)
Km Diva, SRF (CSIR)
Sh Prafull Mathur, SRF (CSIR)
Sh Dwijendra Pratap Singh, SRF (CSIR)
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Sh Sachin Dinkar Dudhe, SRF (CSIR)
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09	Dr H S Maiti Director, Central Glass & Ceramic Research Institute, 196 Raja S C Mullick Road, Kolkata - 700 032	-	Member Sister Lab
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