वार्षिक प्रतिवेदन
annual report
2006-2007

राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली-110 012

NATIONAL PHYSICAL LABORATORY

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प्राक्कथन

मुझे वर्ष 2006–2007 की वार्षिक रिपोर्ट प्रस्तुत करते हुए अपार हर्ष हो रहा है। इस वर्ष एन. पी. एल. में बहुत सी महत्त्वपूर्ण घटनाएं हुई हैं क्योंकि यह वर्ष हमारी प्रयोगशाला का हीरक जयंती वर्ष था। एन.पी.एल. द्वारा इस पूरे वर्ष के दौरान विभिन्न क्षेत्रों में जिसमें ए.पी.ए.एम. (APAM), मर्सी (MRSI), इनकर्सी (INCURSI) आदि कुछ अन्य उल्लेखनीय सम्मेलन और मीटिंग्स शामिल हैं, आयोजित किए गए। एन.पी.एल. की हीरक जयंती स्मरणोत्सव के लिए एक विशेष चित्रात्मक पुस्तक का संकलन किया गया जिसमें एन.पी.एल के 60 वर्ष (1947–2007) पर प्रकाश डाला गया है इसमें इसके इतिहास, उपलब्धियां और भविष्य निरूपण जिसमें एन.पी.एल. के अभि लेखागार से ली गयी कुछ दुर्लभ तस्वीर शामिल है, की परिगणना की गयी है।

इस विशिष्ट पुस्तक का विमोचन हमारे माननीय विज्ञान एवं प्रौद्योगिकी मंत्री श्री कपिल सिब्बल द्वारा 29 अगस्त, 2007 को एन.पी.एल. द्वारा आयोजित विशेष समारोह में किया गया।

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 करकेक्टराइजेशन, रेडियो तथा वायुमण्डलीय विज्ञान, सुपर कंडक्टिविटी व क्रायोजेनिक्स।

जबकि मापन के राष्ट्रीय मानको का अनुरक्षण एवं अपग्रेडेशन (माप एवं तोल अधिनियम 1956 एवं 1976 के विधान के अनुसार, संसद के 1976 के अधिनियम के अन्तर्गत 1988 में पुनः जारी) राष्ट्रीय भौतिक प्रयोगशाला की संवैधानिक जिम्मेदारी है। भौतिकी के फ्रंटियर क्षेत्रों में गहन अनुसंधान एवं विकास कार्य विभिन्न निधिबद्ध और इनहाउस प्रोजेक्ट के अन्तर्गत किए जाते हैं। सी एस आई आर द्वारा प्रांरभ की गयी 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 2006–2007 में मानक प्रभाग के विभिन्न ग्रुपों ने सफलतापूर्वक चार अन्तर्तुलनाओं में भाग लिया, 2267 अंशांकन रिपोर्टें उद्योगों, संस्थाओं तथा प्रत्यायन प्रयोगशालाओं को जारी कीं, मापिकी संबंधी समस्याओं के समाधान के लिए प्राथमिक तथा द्वितीयक मानकों के विकास के लिए नौ निजी / सार्वजनिक उद्योगकर्मियों को कंसलटेन्सी प्रदान की गयी। देश में तथा पड़ोसी देशों को मापिकी के क्षेत्र में निपुण मानव शक्ति के विकास के योगदान तथा सहयोग के लिए विभिन्न प्राचलों पर सात प्रशिक्षण कार्यक्रम आयोजित किए गए।

लगभग चालीस टेलीक्लॉक रिसीवर (ग्राही) तथा आठ एस टी एफ एस प्राप्त करने वाले सैटअप्स को आठ उत्तर पूर्व राज्यों में स्थापित किया गया है। एक नए प्राप्त समुदाय / ज़ेनर डायोड आधारित संदर्भ वोल्टता मानक बैंक को डी सी वोल्टता के द्वितीयक / राष्ट्रीय मानक के रूप में स्थापित किया गया है। 600 A तक डी सी शंटन प्रतिरोध माप के लिए नई सुविधा व्यवस्थित की गयी है। ट्रांसफार्मर वोल्टता अनुपात मापों की अंशांकन दूरी 40 kV/100V से 100 kV/100V तथा 100 V/100V से नीचे 3 kV/100V तक 50 Hz पर अपग्रेड कर दिया गया है।

'एमजी–एलॉयस के लिए स्प्रे फारमिंग प्रौद्योगिकी का विकास' विषय पर आधारित विक्रम साराभाई अंतरिक्ष केन्द्र द्वारा प्रायोजित परियोजना को इस वर्ष पूरा किया गया था तथा परीक्षण व मूल्यांकन के लिए की एस एस सी को कुछ स्प्रे–फार्मूड डिपाजिट्स भेजे गए थे। उसी अजीमूथत प्लेन में कुछ माइक्रॉन रिजोल्यूशन के साथ होम्योट्रोपिक तथा प्लैनर ओरिएन्टेशन का प्रदर्शन करते हुए पैटर्नड द्रव क्रिस्टल प्रदर्श का उत्पादन करने के लिए एक नई तकनीक का विकास किया गया है। इस वर्ष के दौरान मोनो तात्विक विलयन तथा पीड़कनाशी दस नए सी आर एम बैच रिलीज किए गए। इसके अतिरिक्त जैव प्रकाश उत्सर्जन डायोड्स के क्षेत्र में लघु अणु पर आधारित सफेद ओ एल ई डी का प्रदर्शन किया गया। नैनो पार्टिकल्स (अतिसूक्ष्म कणों) से युक्त संश्लेषण का परिमाण MgB_2 इन प्रौद्योगिकीय रूप से महत्त्वपूर्ण अतिचालक पदार्थों में समग्र सूक्ष्म आचरण और विवेचनात्मक धारा घनत्व में महत्त्वपूर्ण सुधार का मार्ग प्रशस्त करता है

शुरूआत की गयी है। वी एल एफ रिसीवर पर आधारित एक लैब व्यू का डिजाइन तैयार किया गया है तथा अंटार्कटिका में स्थायी वी एल स्टेशन पर उसे कार्यवाही के रूप में स्थापित किया गया है। एन पी एल की अन्य गतिविधि वायुमण्डलीय पर्यावरण परिवर्तन में एन पी एल के परिसर में चालू वर्ष से नियमित मानीटरन के लिए प्राचलों के रूप में सी एल 4 एन एम सी का प्रेक्षण तथा बेनजीन को जोड़ा गया है, जबकि पृष्ठीय पराबैंगनी विकिरण के पूर्ववत प्रेक्षणों ओज़ोन तथा नाइट्रोजन के ऑक्साइड, ऐरोसोल्स के कॉलम मापों, ओजोन तथा जल वाष्प को जारी रखा गया है। सी एस आई आर नेटवर्क कार्यक्रम की भूमिका के अन्तर्गत इस विभाग द्वारा एन आई ओ गोवा में एक नया वायुमण्डलीय मॉनीटरन स्टेशन स्थापित किया गया है। एन पी एल ने ओ आर वी सागर कन्या और हवाई जहाज़ पर प्रेक्षण मंचों जैसे भू निश्चित स्थानों, गतिशील समुद्री यात्राओं (एस के–222 बी ओ बी एरिया तथा एस के–223 अरेबियन सी एरिया) पर एरोसोल्स तथा विकिरण (आई सी ए आर बी–06) अभियान में भाग लिया।

मानव संसाधन विकास में एन पी एल ने विश्वविद्यालयों और अन्य शैक्षणिक संस्थाओं 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 160 (एक सौ साठ) 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। पांच रिसर्च फैलो के शोध प्रबंध पूर्ण होने पर उन्हें Ph.D की डिग्री प्रदान की गयी। सोलह प्रशिक्षण कोर्स आयोजित किए गए जिनमें 350 व्यक्तियों, जिसमें उद्योगों से भी शामिल हैं, ने भाग लिया। इसके अतिरिक्त एन पी एल में आने वाले शैक्षणिक संस्थाओं / संगठनों के आगमन की व्यवस्था की गयी।

वर्ष 2006–2007 के दौरान लगभग 178 SCI जरनल्स में वैज्ञानिक एवं तकनीकी शोध पत्र प्रकाशित हुए तथा 28 अन्य जनरलस् में प्रकाशित हुए। विभिन्न राष्ट्रीय एवं अन्तर्राष्ट्रीय सम्मेलनों में 401 पत्र प्रस्तुत किए गए। भारत में सात पेटेन्ट्स और विदेश में नौ पेटेन्ट पंजीकृत कराए गए। पूर्व वर्षों में पंजीकृत कराए गए तीन पेटेन्ट्स भारत में और चार पेटेन्ट्स विदेश में 2006–2007 के दौरान स्वीकृत हुए। 23 नई परियोजनाएं (स्पांसर्ड एण्ड कन्सलटेन्सी) प्रारंभ की गयी तथा 3362 अंशांकन रिपोर्टें जारी की गयीं और लगभग छ' सौ तीस लाख रूपए का ECF अर्जित किया गया।

मैं एन पी एल के वैज्ञानिकों, इंजीनियरों और प्रशासन, वित्त, भण्डार एवं क्रय, वैज्ञानिक तथा तकनीकी सहायक सर्विसिज, राजभाषा यूनिट तथा इन्फ्रास्ट्रक्चर सर्विसिज स्टॉफ सदस्यों की रूचि एवं सहयोग के योगदान के प्रति आभार व्यक्त करता हूं। श्री प्रेम चंद, श्री मनदीप सिंह, श्री एन के वधवा, श्री वी डी अरोड़ा तथा श्री अभिषेक का विशिष्ट प्रयास सराहनीय है।

अंत में, मैं प्रकाशन समिति तथा संबंद्ध टीमों का विशेष आभारी हूं जिन्होंने इस रिपोर्ट को तैयार करने में अपना अमूल्य योगदान दिया है।

विक्रम कुमार

(विक्रम कुमार)
निदेशक

Foreword

I am extremely delighted to release this Annual Report for the year 2006- 2007. This year, at NPL, was very eventful primarily because it marked the diamond jubilee year of our laboratory. Several important conference and meetings, on diverse areas, were hosted by NPL throughout this year, including APAM, MRSI, INCURSI etc, to mention a few important ones. Also to commemorate the diamond jubilee of NPL, a special pictorial volume was compiled highlighting sixty years of NPL (1947-2007) enumerating its history, achievements and future vision including some rare pictures from NPL's archives.

This special volume was released by our honourable Minister of Science & Technology, Shri. Kapil Sibal, at a special function held at NPL on 29th August 2007.NPL being a prime laboratory for physics, the spectrum of its activities covers the areas of National Standards, Material Sciences and Atmospheric Physics. 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 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 reported in this Report.

In 2006-07 various groups of the Standards Division successfully participated in four inter-comparison, issued 2267 calibration reports to industries, institutions and accreditated laboratories, provided consultancy to 9 private/public entrepreneur in solving the metrology related problems, development of primary & secondary standards. Seven training programs in various parameters were organized in collaboration, contributing to the development of skilled man power in the field of metrology in the country as well as neighbouring countries.

About 40 Teleclock receivers and 8 STFS receiving setups have been installed in eight north eastern states. A newly procured ensemble/bank of Zener diode-based reference voltage standard has been established as a secondary/national standard of dc voltage. New facility has been established for DC shunt resistance measurement upto 600A. The calibration range of Transformer Voltage ratio measurements has been upgraded from 40 kV/100V to 100 kV/100V and from 3 kV/100V down to 100V/100V at 50 Hz.

A project sponsored by Vikram Sarabhai Space Centre on "development of spray-forming technology for Mg-alloys" was completed this year and a few spray-formed deposits were sent to VSSC for testing and evaluation. A new technique has been developed to produce patterned liquid crystal displays showing homeotropic and planar orientation with a few micron resolution in the same azimuthal plane. During this year new batches of ten CRMs on mono elemental solutions and pesticides were released. Besides this, in the area of organic light emitting diodes, white OLED based on small molecules was demonstrated. Synthesis of bulk MgB_2 with addition of nano particles led to a significant improvement in the critical current density and overall pinning behaviour in these technologically important superconducting materials.

A study has been initiated during the year to look for precursor of past major earthquake in India in ionosonde data. A Lab VIEW based VLF receiver has been designed and operated at Antarctica as a step to establish a permanent VLF station there. In another activity of NPL on 'Atmospheric Environment Change',

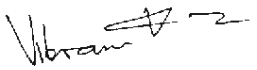
observations of CH_4, NMHC and Benzene have been added from the current year as parameters for regular monitoring from NPL campus, while earlier observations of surface ultraviolet radiation, ozone and oxides of nitrogen, column measurements of aerosols, ozone and water vapor have been continued. A new atmospheric monitoring station has been established at NIO, Goa by this Division as part of a CSIR Network Programme. NPL participated in the compaign on aerosols and radiation (ICARB-06) 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.

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 160 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. Five research fellows on completion of their thesis work have been awarded Ph.D. Sixteen training courses were organized where 350 persons including persons from industry, other institutions and NPL participated. Besides number of visits by educational institutes/organization to NPL were arranged.

During 2006-07, about 178 scientific and technical papers were published in SCI journals and 28 were published in other journals. 401 papers were presented at various national and international conferences. Seven patents were filed in India and nine were filed abroad. Three patents filed in India and four patents filed abroad in previous years were granted during 2006-07. Twenty three new projects (sponsored and consultancy) were undertaken and 3362 calibration reports were issued, which contributed to generation of an ECF of about Rs.630 lakhs.

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, Sh. V.D. Arora 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 is 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.

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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

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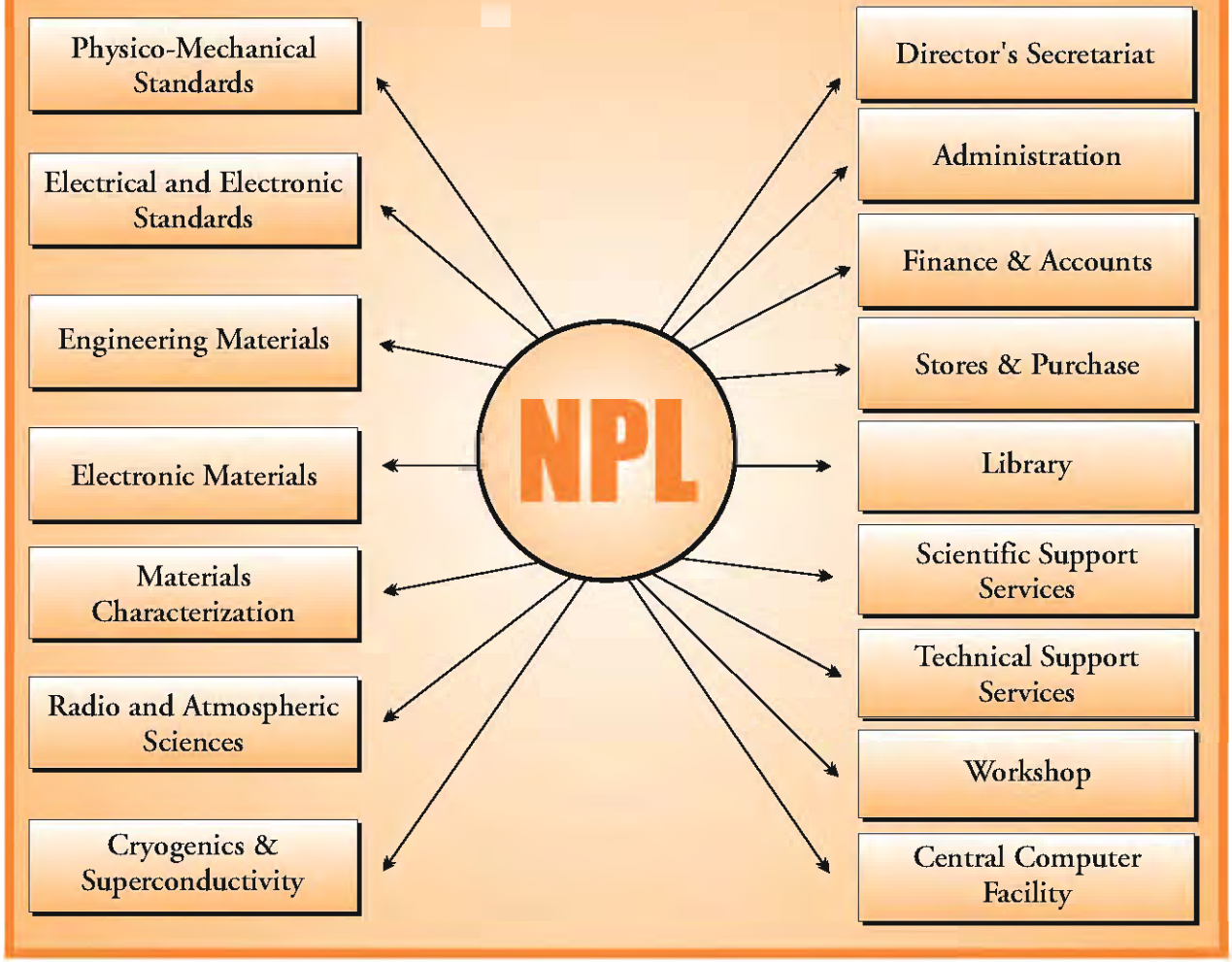
R & D GROUPS & MANAGEMENT



Foreword

I am extremely delighted to release this Annual Report for the year 2006- 2007. This year, at NPL, was very eventful primarily because it marked the diamond jubilee year of our laboratory. Several important conference and meetings, on diverse areas, were hosted by NPL throughout this year, including APAM, MRSI, INCURSI etc, to mention a few important ones. Also to commemorate the diamond jubilee of NPL, a special pictorial volume was compiled highlighting sixty years of NPL (1947-2007) enumerating its history, achievements and future vision including some rare pictures from NPL's archives.

This special volume was released by our honourable Minister of Science & Technology, Shri. Kapil Sibal, at a special function held at NPL on 29th August 2007.NPL being a prime laboratory for physics, the spectrum of its activities covers the areas of National Standards, Material Sciences and Atmospheric Physics. 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 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 reported in this Report.

In 2006-07 various groups of the Standards Division successfully participated in four inter-comparison, issued 2267 calibration reports to industries, institutions and accreditated laboratories, provided consultancy to 9 private/public entrepreneur in solving the metrology related problems, development of primary & secondary standards. Seven training programs in various parameters were organized in collaboration, contributing to the development of skilled man power in the field of metrology in the country as well as neighbouring countries.

About 40 Teleclock receivers and 8 STFS receiving setups have been installed in eight north eastern states. A newly procured ensemble/bank of Zener diode-based reference voltage standard has been established as a secondary/national standard of dc voltage. New facility has been established for DC shunt resistance measurement upto 600A. The calibration range of Transformer Voltage ratio measurements has been upgraded from 40 kV/100V to 100 kV/100V and from 3 kV/100V down to 100V/100V at 50 Hz.

A project sponsored by Vikram Sarabhai Space Centre on "development of spray-forming technology for Mg-alloys" was completed this year and a few spray-formed deposits were sent to VSSC for testing and evaluation. A new technique has been developed to produce patterned liquid crystal displays showing homeotropic and planar orientation with a few micron resolution in the same azimuthal plane. During this year new batches of ten CRMs on mono elemental solutions and pesticides were released. Besides this, in the area of organic light emitting diodes, white OLED based on small molecules was demonstrated. Synthesis of bulk MgB_2 with addition of nano particles led to a significant improvement in the critical current density and overall pinning behaviour in these technologically important superconducting materials.

A study has been initiated during the year to look for precursor of past major earthquake in India in ionosonde data. A Lab VIEW based VLF receiver has been designed and operated at Antarctica as a step to establish a permanent VLF station there. In another activity of NPL on 'Atmospheric Environment Change',

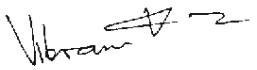
observations of CH_4, NMHC and Benzene have been added from the current year as parameters for regular monitoring from NPL campus, while earlier observations of surface ultraviolet radiation, ozone and oxides of nitrogen, column measurements of aerosols, ozone and water vapor have been continued. A new atmospheric monitoring station has been established at NIO, Goa by this Division as part of a CSIR Network Programme. NPL participated in the compaign on aerosols and radiation (ICARB-06) 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.

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 160 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. Five research fellows on completion of their thesis work have been awarded Ph.D. Sixteen training courses were organized where 350 persons including persons from industry, other institutions and NPL participated. Besides number of visits by educational institutes/organization to NPL were arranged.

During 2006-07, about 178 scientific and technical papers were published in SCI journals and 28 were published in other journals. 401 papers were presented at various national and international conferences. Seven patents were filed in India and nine were filed abroad. Three patents filed in India and four patents filed abroad in previous years were granted during 2006-07. Twenty three new projects (sponsored and consultancy) were undertaken and 3362 calibration reports were issued, which contributed to generation of an ECF of about Rs.630 lakhs.

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, Sh. V.D. Arora 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 is 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.

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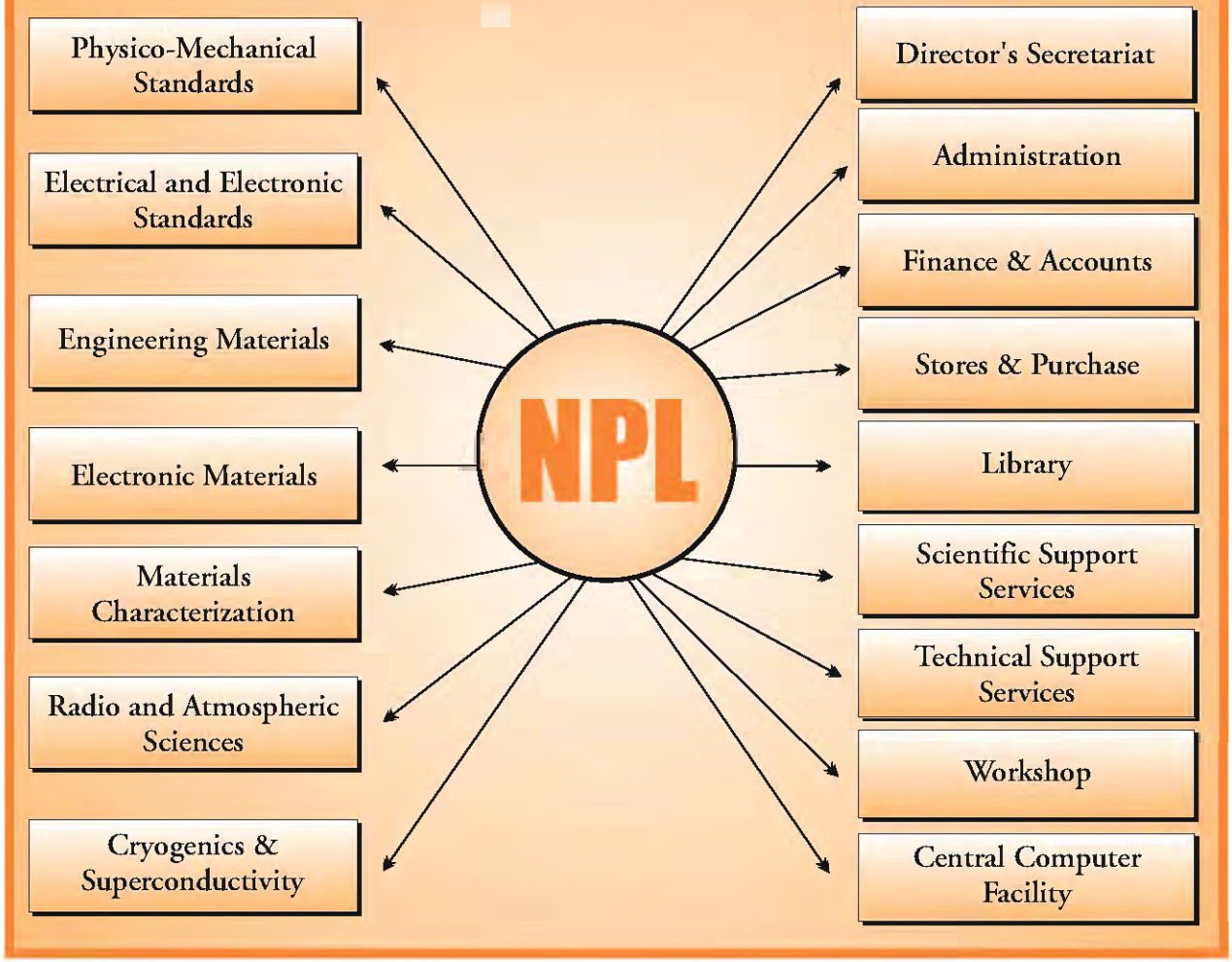


भौतिक-यांत्रिक मानक
PHYSICO-MECHANICAL STANDARDS

भौतिक-यांत्रिक मानक

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

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 संवेदक

इस प्रभाग का उपरोक्त गतिविधियों से संबंधित मापन के राष्ट्रीय मानकों की स्थापना, उनका अनुरक्षण और लगातार अपग्रेड करने और मानकों का प्रचार करने व उसके द्वारा 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 Peer पुनरीक्षण विश्व की अग्रणी के तकनीकी विशेषज्ञों द्वारा किया गया। इस प्रकार राष्ट्रीय भौतिक प्रयोगशाला BIPM के परस्पर मान्यता देने संबंधी व्यवस्था की अपेक्षाओं को पूरा करती है, जिसकी राष्ट्रीय भौतिक प्रयोगशाला एक हस्ताक्षरकर्त्ता (Signatory) है। परिणाम स्वरूप उपरोक्त गतिविधियों के CMCs BIPM वेबसाइट (www.bipm.org) पर उपबल्ध 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 अंतर्राष्ट्रीय अंतर्तुलना संगोष्ठियों में नियमित रूप से भाग लिया।

वर्ष 2006–2007 में प्रभाग की विभिन्न गतिविधियों ने चार अंतर्तुलनाओं में सफलतापूर्वक भाग लिया, उद्योगों, संस्थानों और प्रत्यायित प्रयोगशालाओं को 2267 अंशाकन रिपोर्ट जारी की, मापिकी संबंधी समस्याओं को हल करने के लिए नौ 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 सात प्रशिक्षण कार्यक्रम आयोजित किए।

प्रभाग ने जरनलस् में 27 लेख प्रकाशित किए और राष्ट्रीय व अंतर्राष्ट्रीय सम्मेलनों में 52 पेपर्स प्रस्तुत किए 41 आमंत्रित वार्त्ताएं 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।

ध्वानिकी मानकों की अंशाकन मापन क्षमताओं का पीअर पुनरीक्षण NMIA आस्ट्रेलिया के तकनीकी विशेषज्ञों द्वारा किया गया। वेबसाइट के परिशिष्ट 'सी' पर को डाले जाने से पूर्व के दिशा निर्देशों के अनुसार सचिवालय और उनके तकनीकी समिति के अध्यक्ष द्वारा 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 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 सशक्त बनाने में NABL को वैज्ञानिक एवं तकनीकी सहायता प्रदान कर रही है।

इस प्रभाग के दो वैज्ञानिकों को APMP तकनीकी समितियों के अध्यक्ष के रूप में चुना गया 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 संबंधित 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

The Physico-Mechanical Standards Division is one of seven R&D Division 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 Dimension Standards
3. Temperature and Humidity Standards
4. Optical Radiation Standard (visible infrared and ultraviolet regions)
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. 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 by these.

The calibration and measurement capabilities (CMCs) of all the activities 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 above said activities are available 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.

In 2006-07 various activities of the division successfully participated in four intercomparison, issued 2267 calibration reports to industries, institutions, organisations and accreditated laboratories, provided consultancy to nine private/public entrepreneur in solving the metrology related problems, seven training programs in various parameters were organized contributing to the development of skilled man power in the field of metrology in the country.

The division published 27 articles in Journals and presented 52 papers in National and International conferences, delivered 41invited 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 Acoustic Standards were peer-reviewed by technical experts from NMIA, Australia. The CMCs are being scrutinized by APMP Secretariat and respective Technical Committee Chairmen as per guidelines laid down by CIPM-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. NPL have thus been providing scientific and technical support to NABL in strengthening the National Measurements System in the country.

Two scientists of this division have been elected as Chairperson of APMP Technical Committees. The scientists of this division are nominated Members/Chairmen of various Sectional Committees of BIS (Bureau of Indian Standards), 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 Standards

APMP.M.M.K2 Intercomparison

The work related to the coordination and monitoring of the APMP.M.M.K2 intercomparison in mass was continued during the year, the NPL being the pilot laboratory. A set of Mass Standards from NPL (10 kg, 500 g, 20 g, 2 g, 100 mg) are in circulation among the participating laboratories.

APMP-TCM

APMP-TCM accepted the NPL proposal for international intercomparison in Mass measurement among SAARC Countries and included it in **Appendix B** of BIPM Database with the Identification as **APMP.M.M.S1.**

NPL-NABL Proficiency Testing Program

The preparatory work as coordinator and reference laboratory for NPL-NABL Proficiency Testing Program (Phase-III) in Mass Measurements in which 20 calibration laboratories are participating, was carried out. The artifact to be used for this intercomparison was procured and a revised protocol has been prepared. The comparison will be started soon.

Length and Dimension Standards

Length and Dimension standard realizes definition of SI Unit 'metre' and maintains apex level standards and disseminates traceability by way of calibration. Development work on enhancement of resolution for Autocollimator has been carried out and filing of patent in this regard is in process. It has wide applications in terms of calibration of polygon & autocollimators with improved uncertainty.

A new approach of Surface Roughness measurement using optical method and image processing has been developed. It has an advantage over traditional tracing type of stylus method as no contact is required with the surface. Experimental results demonstrated good correlation between the received signal parameters and the root mean square value of surface roughness. A range of roughness up to 10µm was detected with a resolution of 0.01µm.

The system for image acquisition is developed around National Instruments Image Acquisition Card, PCI 1408, installed on the computer. A monochrome image with a maximum transfer rate of 132 Mbytes/sec on 32 bit wide bus is grabbed. Image grabbing window is configured to acquire the image size 640 x 480 pixels and pixel depth of 8 bits. The image is transferred from the camera to the computer at a rate of 30 frames per second. Roughness standard under study was illuminated from two different angles. The image was recorded by Pulnix TMC-76 CCD camera and image acquisition system. The image was stored in the two dimensional arrayas shown in Fig.1.1 (a) and Fig.1.1 (b).

Discrete wavelet transform is used to analyze the acquired image. The two-dimensional wavelet transform decomposes the image in horizontal, vertical, and diagonal components at different level of intensities containing roughness information. The

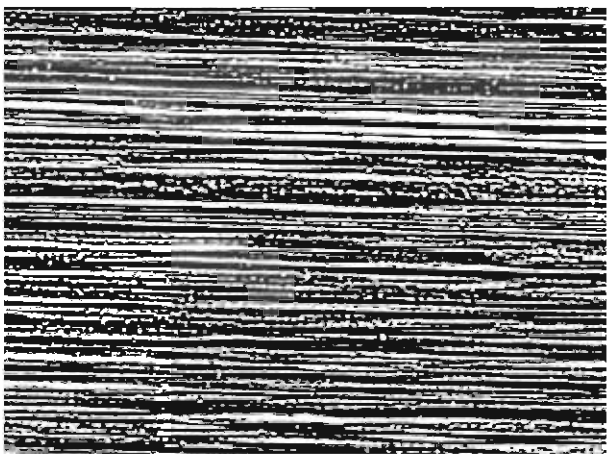


Fig. 1.1 (a) : Original image of roughness standard sample

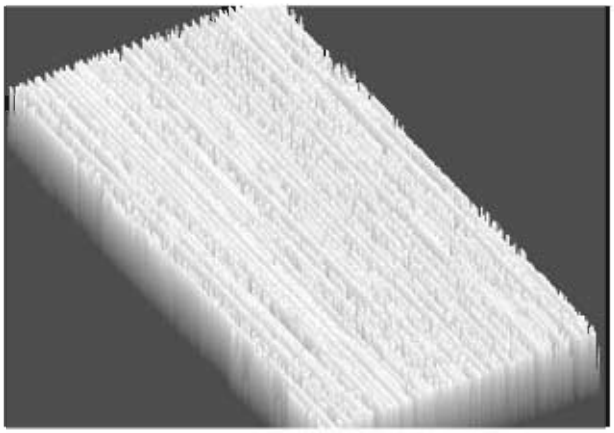


Fig. 1.1 (b) : Analyzed image of roughness standard sample

processing is done through Labview 5.1 software and Matlab 5.2. Standard roughness sample is analysed by using machine vision system and Symlet wavelet transform. Object coordinates were generated by applying the space intersection theory, where conjugate points are resulted by matching, and exterior orientation elements are obtained by the calibration process of systematic error.

In order to evaluate measurement-processing capability of the proposed system resultant values of a CCD camera were compared with the resultant values of surface roughness obtained by using standard contact type surface roughness measuring instrument perthometer model S6P.

To keep equivalence of standards to other National Metrology Institutes, the section participates in international intercomparisions. This year the section participated in several comparisons:

APMP LK1: Gauge Block Measurement: 10 Gauge Blocks (0.5, 1.01, 1.1, 6, 7, 8, 15, 80, 90, 100 mm) were calibrated interferometrically. The results have been submitted to the Pilot lab which is NMIJ, Japan. The final report is awaited.

APMP LK 5: Step Gauge 620 mm Measurement: One step gauge of length 620 mm was measured by substitution method. Nine NMIs are participating in this comparison and KRISS Korea was the Pilot lab. Results of the measurements have been submitted to the Pilot lab. The final report is awaited.

APMP LK 3: Four Angle Gauge Blocks and one polygon Measurement: 4 Angle Gauge Blocks of size 5", 5', 30', 5° and one 12 face polygon were calibrated using autocollimator and index table. Thirteen laboratories are participating. It is expected that all the laboratories will be able to complete the measurements by December 2007. National Metrology Laboratory CSIR South Africa is the pilot lab.

The Coordinate Measuring Machine was upgraded under network project. Now this machine is equipped with the windows based software, which offers ease of CNC programming and curve measurement. The performance evaluation of machine is completed. The calibration & measurements services were provided to clients from industries and other organizations and 532 calibration reports were issued.

Proficiency Testing Program (MoU with NABL)

National Physical Laboratory has MoU with NABL for assessing the technical competence of NABL accredited laboratories.

1. Conducted proficiency testing for the measurement of surface roughness parameters viz.Ra= 0.6 m , Rz =3.29 m , Rmax =4.01 m, and Pt =10.1 m and D (Depth of groove) = 9.1 m. Ten NABL accredited laboratories participated. The final report has been prepared. 87% results are in agreement.

2. Initiated proficiency testing for the calibration of Length of Length Bars of size 150 mm, 300 mm, 500 mm. Ten NABL accredited laboratories are participating. The program is in progress and is likely to be completed by March 2008.

3. Initiated proficiency testing for the calibration of Ring Gauges of diameter 5 mm, 12 mm, 50 mm and 100 mm. Ten NABL accredited laboratories are participating.

Temperature & Humidity Standards

The temperature standards group participated in the APMP Regional Comparison (APMP-T-S1-04) of Type-R thermocouples in the range from 0 to 1100 °C. The measurements were carried out at 17 different temperature points. The comparison, which started in March 2005 was coordinated by NMIA Australia. 12-NMIs namely, NMIA Australia, NIM China, SCL Hong-Kong, NPL India, KIMLIPI Indonesia, NMIJ Japan, KRISS Korea, SIRIM Malaysia, SPRING Singapore, CSIR South Africa, CMS Taiwan and NIMT Thailand participated in the comparison program, which was completed in June 2006. Our results are quite satisfactory in the range 0 to 1100 °C as per first draft copy APMP-T-S1-04 issued by NMIA, Australia.

The temperature standards group realized the copper point (1084.62 °C) by using copper sealed cell with an uncertainty of ± 0.36 °C with Type-S and ± 0.33 °C with Type-R standard thermocouples and using high temperature three-zone heating furnace. This fixed point is to be used for calibration of noble metal standard thermocouples to extend the calibration range of thermocouples from 1000 °C to 1600 °C.

A high temperature furnace of 1700 °C was procured and installed for calibration of noble metal thermocouples in the range 1000-1600 °C against a high precision Type-S/R standard thermocouple calibrated on fixed points.

A new Fluidized Bed Bath was procured and installed for calibration of precision thermometers and thermocouples. The stability performance of the bath was studied in the range 50 °C to 700 °C. The over all stability of the bath was measured to be ± 0.05 °C.

A low temperature calibration set-up with aluminum comparison block was designed and developed to work at boiling point of nitrogen (-196 °C) for calibration of special dial gauges having gas-filled temperature probes in different temperature ranges from -200 °C to -50 °C.

The performance and stability of one Type-S thermocouple and two Liquid-in-Glass thermometers were carried out which are to be used as artifacts for the intercomparison under SAARC-PTB Intercomparison in temperature metrology.

Apex level calibration was provided to various accredited laboratories and user industries in the temperature range from -200 °C to 2200 °C. This included 235 reports in calibration of high precision thermometers, gas-filled low temperature dial gauges, noble metal thermocouples and digital thermocouple indicators, temperature liquid baths, digital temperature hygrometers (RHT), optical and infrared radiation thermometers, tungsten strip lamps, high temperature blackbody sources, etc. and 71 reports in calibration of SPRTs, TPW cell, RTD / Digital Temperature Indicators.

The Humidity Standards group maintained the reference humidity standard (an aspirated psychrometer using two precise quartz thermometers) for calibrating RH instruments/ hygrometers, in the RH range 15 % to 95 % RH with an uncertainty of ±1% RH.

The Humidity Standards group developed a prototype simple and compact Dew Point/RH

Generator based on two pressure technique for humidity calibration to meet the industry requirement in the range of 15 to 95 % RH, with ± 1% RH stability. The device was tested in the whole range for its satisfactory performance. A laboratory model was given to M/s. ICL Calibration & Testing Services Pvt. Limited, Panchkula (HR) to have customer feedback at a nominal charge of Rs. 49,500/-.

The humidity standards group procured and installed 2500 Bench-top Two Pressure Humidity Generator, capable of generating Relative Humidity in the range 10 % to 95 %, with accuracy ± 0.5 % RH and resolution 0.02 %. This will be used as Reference Humidity standard for the calibration of Industrial hygrometers (Digital /Dial Type) with lower uncertainities.

In total 54 Hygrometers/RH measuring instruments (Dial and Digital type) from different industries were calibrated.

Optical Radiation Standards

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 has been established. Calibration facilities for the photometric parameters were extended to various lamp and lighting industries, R and D institutions etc. Calibration & Measurement facilities in air UV spectral region were maintained and extended to user industries and institutions.

Measurement of Ozone generated from Mercury Discharge Lamps

In a temperature and humidity controlled laboratory, the ozone production due to different low pressure and high pressure mercury lamps has been studied. The ozone produced has been measured using Teledyne, USA make Ozone Analyzer (Model 400E). This analyser has the overall uncertainty of measurement ± 2%. With low pressure Hg lamp the production of ozone is less efficient due to the low intensity of ozone absorption line. With high pressure mercury lamp, the production of ozone has found efficient and rapid and generation of Ozone as high as 110 ppb was observed. It may be due to the emission of continuum superimposed by Hg lines. It implies that most of the ozone production is from discrete emission lines in UV region. As the background surface concentration of ozone has already increased even in unconfined space, the ozone buildup could be substantial and harmful by using these Hg lamps.

Sponsored projects

"Studies on Spatial-coherence spectral filters and their applications"

The Project is completed however the research work is continued. The applications of the correlation-induced spectral changes have been extended to construction of spatial-coherence spectral filters and the phenomenon of spectral switching which in turn have led to new findings for information encoding and hiding. This study has resulted in few original papers which have been published.

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

Near infra-red and mid infra-red spectral studies of different varieties of pulp, alkcell and viscose samples obtained from the Grasim Chemical Laboratory, Nagda were analyzed using attenuated total reflectance and diffused reflectance accessories. Since the project was

completed in March 2007, a complete report on the study conducted has been submitted to Nagda.

CSIR sponsored project entitled "Optical and spectral properties of organic compounds used as building blocks for nanostructures"

Optical studies for investigating the morphology of polyaniline nanotubules of different dimensions, fabricated on a ground glass surface by a novel method, were conducted. This research was presented in the international conference on nanomaterials and the poster entitled "Optical Properties of anthracene nanotubes fabricated on a ground glass surface", presented in the Nanoscience and Technology conference was adjudged as one of the best out of four posters chosen by the Hono'ble President of India. Photograph of the nanotubes developed is shown in Fig. 1.2.

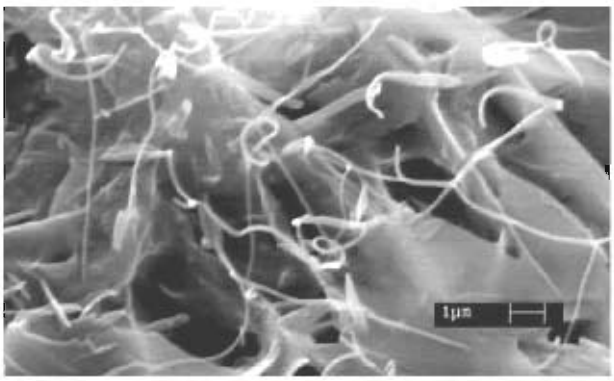


Fig. 1.2 : SEM image of synthesized polyaniline nanostructures

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

To provide explanation for discordant redshift in quasars Doppler-like wavelength shift studies by dynamic multiple scattering of radiation 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) were conducted. The redshift and broadening the lines emanated from discharge sources were studied. Results obtained have been published and presented in various forums.

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

In this particular project for developing in-situ calibration facility for spectral radiance and spectral irradiance, methods were developed for calibration of hyperspectral radiometers procured by SAC, Ahmedabad for ocean color studies. Fundamental research for determination of the immersion factor at various levels of water and various type of water was also carried. A paper on the calibration procedures developed at NPL was presented in the XXXII OSI Conference held at Vadodara in March 2007.

Force and Hardness Standards

The Force standards group became among the first ones to design, develop and fabricate a fully automated force machine (Fig.1.3) to realize force in the range 5-50 Newton by primary method with an uncertainty of ± 0.004% (k=2). The development would not only help to establish a facility to calibrate low capacity force instruments with low uncertainty, but would also act as a stepping stone to realize forces in low range for comparison purposes.

As an extension to the load cell calibrator development project for Regional Reference Standard Laboratories (Ministry of Consumer Affairs, Food & Public Distribution), design, fabrication and characterization of force transfer standards up to 5 kN was successfully

completed under the consultancy project to provide national traceability of the force calibrator maintained at the respective regional reference standard laboratories.

Fig. 1.3 : Dead weight force machine (5-50 N)

Metrological characterization of the individual load cells (700 kN) which are to be used in 2MN buildup system and its direct calibration against NPL 1MN reference standard machine was carried out (Fig.1.4). This has expedited the process to estimate the best measurement capability of 3MN hydraulic force machine.

Torque: The new torque primary standard machine to realize torque up to 2000 Nm with an uncertainty of better than ± 0.01% (k=2) was inducted in the quality management system. The group is now undertaking the calibration of higher accuracy torque transducers. A new type of the coupling was designed and developed to facilitate calibration of the conventionally used flange type torque transducers of higher accuracy using the torque standard machine as against the existing provision for the calibration of round type torque transducers only. It is now possible to provide national traceability in torque measurement with lower uncertainty and also to calibrate torque calibration machine on site.

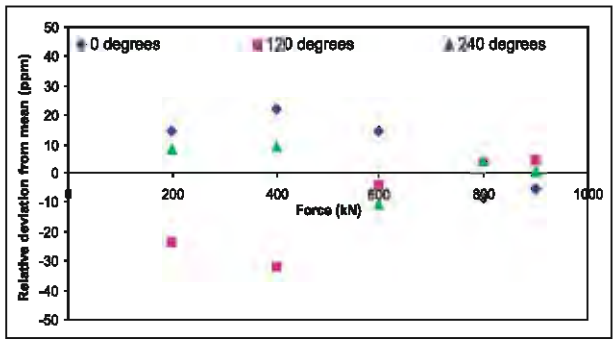


Fig. 1.4 : Rotation effect on build-up system output

CCM.TK1 Torque Key Comparison: The group also participated in CCM sponsored key comparison up to 1000 Nm, where PTB, Germany is the pilot Laboratory and 7 other NMIs around the world including NPL (UK), NMIJ (Japan), KRISS (Korea), CEM (Spain), CENAM (Mexico), INMETRO (Brazil), METAS (Switzerland) etc. are participating in this exercise. Two artifacts of 1000 Nm torque transducers, received from PTB, Germany, were calibrated directly against the torque primary standard machine established at NPL. The draft of the intercomparison reports is awaited.

Establishment of Vickers hardness primary standard machine : It is a unique facility at NPL to be used as national standard of Vickers hardness (Fig.1.5). The group has now the capability to provide national traceability in calibration of Vickers hardness reference/ standard blocks used by quality control, NABL accredited laboratories and different industries operating both in public and private sectors.

The group is providing national traceability in force, torque and Rockwell hardness through the calibration of force and torque measuring devices and hardness blocks to various users from industries, defence and other government organizations and also from other countries including Kuwait, Oman and Nepal. The facilities are being used extensively, which is well reflected in the ECF of Rs 47 lakhs (approx.) and the number of calibration reports issued as 500, which is 10% more than last year due to addition of new users.

Fig. 1.5: Vickers cum Rockwell superficial Hardness standardizing Machine recently established

A training course was organized during September 15-16, 2006 at Jadavpur University as a part of a proposed project to be sponsored by the University to NPL for setting up a Calibration centre for force, dimension, pressure and DC voltage at the University. The aim of the training course was to give lectures and practical training to technical personnel at the University in some of the metrological parameters such as force, a.c. voltage and current, dimensional measurements, etc. About 40 participants from the university and the industries from the nearby region attended the course. It is expected that more such courses in remaining parameters would be organized at Jadavpur University in future.

An Indo-Italian training course was organised during 5-8 Dec. 2006 in collaboration with ICE-INRIM (Italy). The aim of the training program was to train middle level managers and quality assurance personnel from accredited calibration laboratories and industries operating both in public and private sectors within India and in neighbouring countries by providing them first hand knowledge, exposure and hand on experience in the modern practices of force and torque measurement. In all 42 participants from India and one each from Nepal, Malaysia and two each from Thailand, Saudi Arabia were selected for the training course. The faculty comprised of experts from NMIs of Italy, Germany and India. Ten invited talks including those from eminent speakers such as Dr. Konrad Herrmann, Head, Hardness Standard Laboratory and Dr. Jens Illemann, Force Standard Laboratory, both from PTB Germany, Dr. Carlo Ferrero, Head Force & Torque Laboratory INRIM, Italy, Mr. G. J. Gyani, Secretary General, Quality Council of India, etc. were delivered during these four days deliberations. The practical training was provided on calibration of force transducers against dead weight & hydraulic multiplication force machine, calibration of torque transducers against the dead weight lever type torque standard machine.

Pressure and Vacuum Standards

Heydemann and Welch (HW) model:

HW model is based on a thermodynamic fluid flow equation known as Navier-Stokes (NS) Equation in the laminar flow approximation. There are several limitations of this model equation. We have attempted to overcome these limitations through introducing a rigorous statistical analysis. Based on this method, a complete characterization of a Controlled

Clearance Piston Gauge (CCPG) was carried out at the NIST (USA) in a span of two years. The HW parameters determined from the characterization have also been repeated to within the Type A uncertainty from the two characterizations. The relative combined standard uncertainty of the effective area using the HW model ranges from 23.6×10^{-6} at 20 MPa to 36.8×10^{-6} at 200 MPa. Operating at a jacket pressure up to 40% of the system pressure, reduces the uncertainty slightly. The effective area from the HW model agrees to within the combined standard uncertainty of a direct comparison to the NIST pressure scale at all conditions from 20 MPa to 200 MPa.

Experimental study on the effect of phase sensitive detector (PSD) outputs in the uncertainty measurement of UIM

During experimental evaluation of measurement uncertainty of Ultrasonic Interferometer Manometer (UIM), it was observed that there is significant difference between this value and the theoretical value, particularly at low pressure below 1000 Pa. After analyzing the detailed behaviour of variation of uncertainty in real operating conditions it was found that the variation depends significantly on the PSD output parameters, such as imperfection in 90 degree phase difference between two singles, unequal gain in two channels and eccentricity of the circle thus formed by the two signals. After this finding, further experimental work was carried out and as a result of which the PSD parameters were properly adjusted to the extent that maximum reduction in uncertainty was obtained. After these adjustments the output signals of PSD in the form of sine and cosine values were measured at different multiple frequencies. The results obtained are reproduced in Fig. 1.6, which shows a significant improvement in the signals such as perfect 90 degree phase difference and same amplitude of sine and cosine values. This work has improved the measurement uncertainty of UIM in low pressure region.

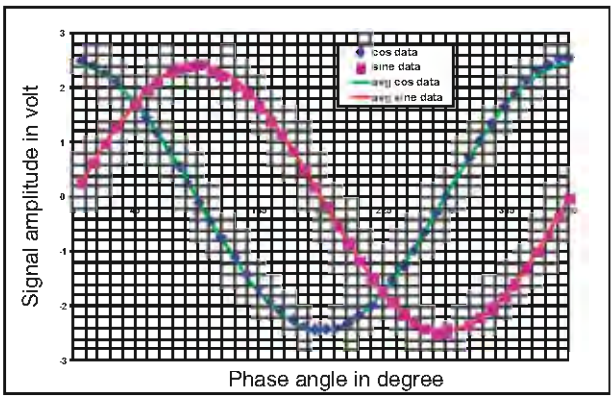


Fig. 1.6 : Phase sensitive detector (PSD) outputs in the uncertainty measurement of UIM

Final report: APMP.SIM.M.P-K1c: Bilateral comparison between NIST (USA) and NPL (India) in the pneumatic pressure region 0.4 MPa to 4.0 MPa

A bilateral comparison of pressure measurement between NIST and NPLI using a piston gauge transfer standard (TS), designated as NPLI-4, over the range of nominal applied pressure 0.4 MPa to 4.0 MPa was carried out.

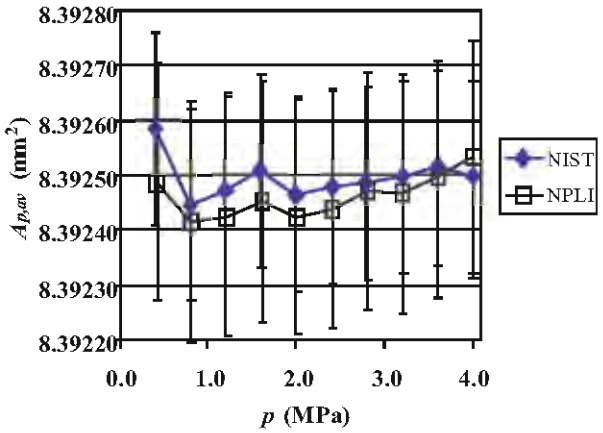


Fig. 1.7 : Effective areas as a function of pressure as measured by the laboratory standards at NIST (USA) and NPL (India). Standard uncertainty shown as error bars.

Fig. 1.7 shows the effective area as a function of pressure as measured by the laboratory standards at NIST (USA) and NPL (India). The comparison data were analyzed in terms of the effective area [Ap (mm^2)] as a function pressure [p (MPa)] of the TS at the above-mentioned pressures. The zero pressure effective area [A_0 (mm^2)] and the pressure distortion coefficient [λ (MPa^{-1})] of the transfer standard were also estimated. The degree of equivalence between NPLI and NIST is 11.4×10^{-6} or better.

Final report APMP.SIM.M.P-K7: Bilateral comparison between NIST (USA) and NPL (India) in the hydraulic pressure region 40 MPa to 200 MPa

Another bilateral comparison of pressure measurement between NIST (USA) and the NPLI over the range of nominal applied pressure 40 MPa to 200 MPa was carried out. The comparison data were analyzed in terms of the effective area [Ap (mm^2)] as a function of pressure [p (MPa)] of the two transfer standards in the respective pressure ranges of (40 to 80) MPa and (80 to 200) MPa. The degree of equivalence between NPLI and NIST evaluated as the relative difference in the institutes' results for effective areas of the transfer standards is within 7.7×10^{-6} in the whole pressure range (40 to 200) MPa.

Coordination of NABL Sponsored Proficiency Testing in the Hydraulic Pressure Measurements up to 70 MPa

In view of the success of the previous three NABL-NPL sponsored proficiency testing exercises in the hydraulic pressure measurements, NABL-NPL has entrusted our group to coordinate three more proficiency testing programs, namely PT004, PT005 and PT006 in the pressure range 0 - 70 MPa using dead weight tester, digital pressure calibrator and pressure dial gauge respectively as the artifacts. A total number of 65 NABL accredited pressure laboratories from all over India are participating in these programmes.

Raman work under high pressures

High pressure Raman experiments were carried out at BARC, Mumbai wherein the pressure induced behaviour of polycrystalline rare earth sesquioxides, Gd_2O_3, Sm_2O_3 and Y_2O_3, were studied. Interestingly, high pressure studies on Gd_2O_3 (shown in Fig. 1.8) and Sm_2O_3 have not been reported anywhere and in addition, being nano-sized samples, the results obtained have been found to be very interesting. These samples showed a partial amorphization as the pressure was increased. However, Y_2O_3

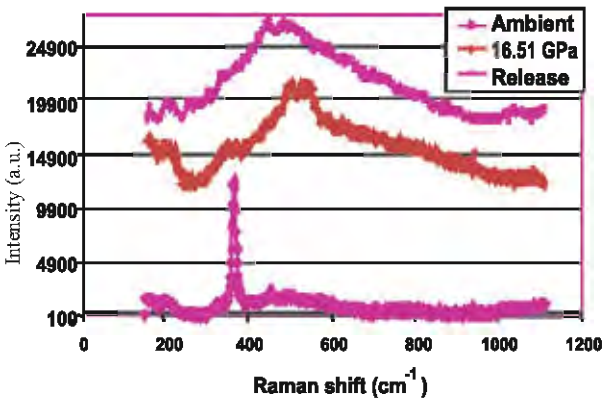


Fig. 1.8 : Pressure induced changes observed in Gd_2O_3

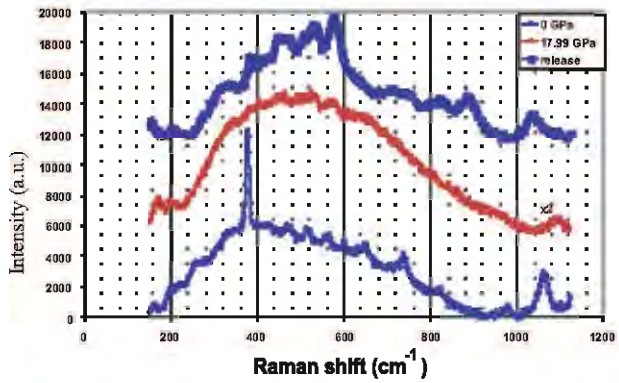


Fig. 1.9 : Pressure induced changes observed in Y_2O_3

(shown in Fig. 1.9) showed transformation to a new phase while releasing the pressure. These results are presently being analyzed and preliminary findings were reported at the MRSI meeting.

Acoustic Standards

The International Peer Review of Acoustics Standards was carried out during 3-5 October, 2006 under the supervision of Dr. Prem Narang of NMI, Australia and Mr. Basavaiah, Quality Expert, Bangalore and 9 CMCs were approved.

APMP AUV.A-K3 Key Comparisons: The Acoustics Section participated in APMP AUV.A-K3 Regional Key Comparison involving two LS2P microphones with KRISS, Korea as the pilot laboratory. The comparison results showed that the NPL sensitivity values were within ± 0.03dB of the average value. Also the repeatability of NPL results was within ± 0.01 dB.

CCAUV.V-K1.1 Key Comparison: Acoustics Section also participated in a tetralateral key comparison CCAUV.V-K1.1 involving two standard accelerometers (B&K Type 8305) with NIM, China, PTB, Germany and INMETRO, Brazil as participating laboratories. The results are in compiling stage.

The Acoustics Section organized the National Symposium on Acoustics (NSA-2006) in collaboration with Acoustical Society of India as a part of NPL Diamond Jubilee (1947-2007) celebration during November 16-17, 2006. Also, a one day workshop on 'Noise Control Measures for D.G. Sets' was arranged on November, 15, 2006 as a curtain raiser to NSA 2006.

A continuous sodar monitoring system was deployed at CPCB, Agra. The mixing height studies at Paradeep, Orissa for EIA in respect of the upcoming mega steel project in Orissa were successfully completed. The group participated in multi-technique/ multi-institutional on ship measurements of Atmospheric boundary layer (ABL) parameters under Integrated Campaign for aerosols, gases and radiation budget (ICARB).

Ultrasonic Standards

The ultrasonic Standards continued to provide services to the industries for the calibration of ultrasonic non-destructive testing equipment and ultrasonic medical equipment. Calibration procedure was developed for ultrasonic response and dimensional accuracy of test rails for the on-line ultrasonic inspection of rails manufactured in India for high speed trains and high volume of traffic. Since uncertainty is seldom mentioned in the test reports of nondestructive testing, NPL has taken the initiative to develop procedures for estimating uncertainty in ultrasonic NDT. The first of its attempts has been made in the angle beam testing of ultrasonic NDT where uncertainty has been estimated for location of defect in a parallel plate.

In an attempt to degas water to DO (Dissolved Oxygen) level of 2mg/L,a methodology has been developed and standardized. The method to retain this level for 8 hours of experimentation has also been developed and found satisfactory.

In yet another experiment, a new procedure has been developed which increases the frequency resolution in digital signal processing from 1/T to 1/2^{n}T.

Fluid Flow Standards

The primary Standard Facility for Fluid Flow (water) has been upgraded and

modernized to make it operator friendly, with indigenous software. Now the upgraded system is under evaluation for its performance. Testing of the water meters was carried out for the water meter industry.

Shock and Vibration Sensors

The indigenous accelerometers, developed at NPL, with proven overall excellent performance characteristics of International quality, is now being used confidently by the high profile users from both core and strategic sectors. The Technological Process Know-How for the commercial production of the device has already been transferred to the two industries. Many other industries are also likely to acquire this technology, in the near future. Currently, the group is engaged in the development of a tri-axial accelerometer.

As part of its regular on going activities the group has continued to provide its specialized scientific services to the users from almost all sectors, and provided them low cost, high value solutions for their requirements. A special accelerometer was also developed for the Defence Lab., SSPL, Delhi. Test and Calibration services were also provided to a large number of industries and other organizations.

विद्युत तथा इलेक्ट्रॉनिक मानक

ELECTRICAL AND ELECTRONIC STANDARDS

विद्युत तथा इलेक्ट्रॉनिक मानक

विद्युत एवं इलेक्ट्रानिक 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, वोल्टेज एवं प्रतिरोध मानक
4. डी सी हाई वोल्टेज 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 इलेक्ट्रानिक 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 BIPM, APMP इत्यादि जैसी अंतर्राष्ट्रीय निकायों द्वारा आयोजित अंतर्राष्ट्रीय अन्तर्तुलनाओं में संलग्न हैं। कुछ द्विपक्षीय तुलनाएं भी आयोजित की जाती है।

प्रभाग के अंतर्गत आने वाले अधिकांश मानदण्डों की अंशाकन और मापन क्षमताओं को अंतर्राष्ट्रीय स्तर पर स्वीकार किया गया है और वह BIPM वेबसाइट पर उपलब्ध 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 Measurements & Standards

Various Primary / National Standards of Electrical and Electronic parameters are maintained by this Division. Traceability of these standards is provided to industry and other laboratories through calibration.

Many areas of this Division are engaged in international inter-comparisons organized by international bodies like BIPM, APMP etc. Some bilateral comparisons are also conducted.

The Calibration and Measurement Capabilities of most of the parameters in the Division are internationally accepted and appear on the BIPM website.

Time and Frequency Standards

UTC(NPLI) has been switched over to a new Cesium Clock on 13.01.07 replacing a 10-year-old clock. The earlier cesium clock has been, from time to time, given the desired frequency offset to match the UTC. Phase offset to the cesium clock is also given to maintain NPLI's time within 100 ns of UTC. The uncertainty of UTC(NPLI) has been improved to ± 7.6 ns. (Fig. 2.1 and Fig. 2.2)

Independent frequency stability of all the five cesium clocks has been determined by a special technique as the essential requirement for generating a time scale.

Extensive study is being carried out to reduce the noise in GPS time through identifying different causes of noise and efforts are being made to reduce or eliminate the cause.

NPL renders calibration service to industry and other customers for stop watch, timer, frequency sources like crystal oscillators, Rb clock, Cs clock etc. Evaluation of the performance of many GPS timing receivers has been conducted by NPL with special arrangements.

Since the commissioning of the Teleclock service, 700 clocks are linked to this service. Time Service via telephone line has been commissioned in Nepal with the help of NPL developed equipments.

Around 40 Teleclock receivers and 8 STFS receiving setups have been installed in eight north eastern states.

The following subsystems of the Cs Fountain have been designed. Fabrication of some of these individual parts are also completed:

a) Ultra high vacuum enclosure including optical viewports

b) Outer frame for the physics package

c) Rectangular Helmholtz coils for the MOT

d) Anti-helmholtz coils for MOT generation

e) Microwave cavity for atom interrogation

f) Detection chamber

g) Design of the optical set up

h) Design of fountain sequence control circuitry

It has been theoretically shown that noisy quadrature of squeezed light can be used for increasing the laser cooling force in atomic Fountain Clocks.

In connection with the development of CPT atomic clock the VCSEL wafer has been packaged and VCSEL driver with digital control of bias and modulation current has been

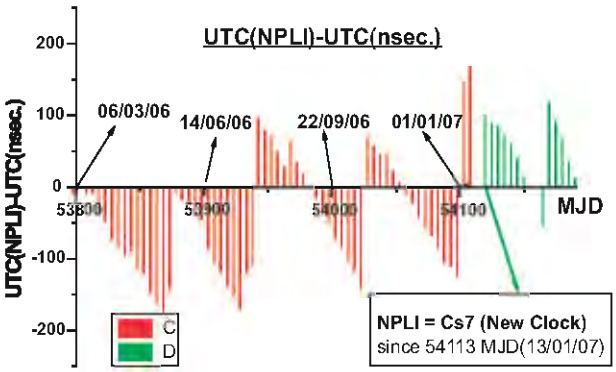


Fig. 2.1: Current Status of UTC (NPLI) with respect of UTC

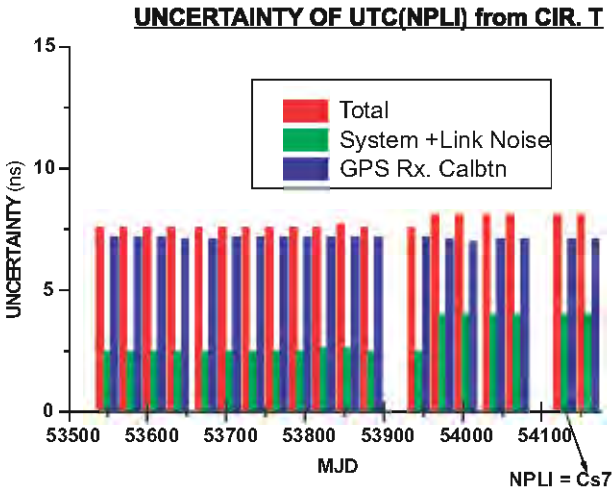


Fig. 2.2: Uncertainties of UTC (NPLI)

designed and tested. A 1.5 GHz synthesizer has been fabricated for creating the side bands for optical pumping of Rb-85 atoms. 537 Hz, 10 kHz Oscillator has also been developed for CPT Rb clock. The testing of Physics Package of CPT atomic clock is being done.

Quantum Hall Resistance Standard and Superconducting Devices

Development and fabrication of Cryogenic Current Comparator (CCC)

The development and fabrication of CCC was carried out at the Quantum Electrical Metrology department of P.T.B. (Germany). The incorporation of CCC will bring the NPL resistance calibration capability at par with international level and the uncertainty will improve to 0.005 ppm from the existing 0.08 ppm. The principle of a CCC rests on Ampere's law and perfect diamagnetism of the superconductor in the Meissner state. A complete CCC bridge system (Fig. 2.3) has three major constituents, viz., Pb shielded CCC windings torus (called the HEART of the system), SQUID as NULL detector and the electronics which includes two double current sources, compensation arrangement, nano-voltmeter, optical isolator, voltage-frequency and frequency-voltage converters. The NPL CCC torus consists of 18 separate windings made from Nb wires. Seventeen windings have number of turns according to the bit scheme 2^n where n=0-10. For achieving the ratio **129.06 (N_P=2065=1024+1024+17):1(N_S=16)** for comparing QHR to 100 Ω an additional winding having 17 turns has been incorporated. The ratio error has been found to be better than 3×10^{-10} for all the windings. Isolation resistance has been found to be better than 100 TΩ. The CCC SQUID current sensitivity has been measured to be 9.2 μA-turns Φ_0. The CCC+SQUID mounted at one end of the specially designed stick made of stainless steel is covered with Pb and cryoperm shields.

In quantum resistance metrology the standard practice is to measure 100 Ω resistors against QHR. For this measurement primary and secondary winding turns are N_P=2065 (1024+1024+17) and N_S=16 respectively. The primary current I_P through the winding N_P is 39 μA. The secondary current I_S through the windings N_S tracks the primary current and is adjusted by the SQUID system using a feedback circuit so that flux balance ($I_PN_P=I_SN_P$) in the CCC is achieved. For achieving the proper balance condition of the bridge a resistive divider, called compensation arrangement, is used and it is adjusted such that the bridge is balanced up to a remaining potential difference V<10 nV. Input parameters for the final calculation of the resistance ratio R_P/R_S are: (i) the winding ratio N_P/N_S, (ii) the settings of the resistive divider and (iii) the potential difference V. The measured potential difference V and the value of the compensation yield the deviation

Fig. 2.3: The CCC torus with DC SQUID in the center (left Fig.) and the complete CCC-bridge with full electronics. From top of the rack: EM N11 nano-voltmeter, windings box, compensation arrangement, two double current sources, optical isolator, transmitter (VFC) and receiver (FVC). The CCC dipped in the L-He and the three multiply shielded cables carry the winding out put wired to the winding box are also seen. The SQUID electronics (MAGNICON, XXF-1) is connected to the top of the probe.

from the nominal ratio (δ). The value of the unknown resistor R_S is calculated from the formula: $R_P/R_S=N_P/N_S(1+\delta)$. A 100 Ω PTB standard resistor was measured against QHR (R_P = 12906.4035 Ω) using both the NPL and PTB CCC bridges. Using the NPL-CCC measured value of the 100 Ω was found to be 100.000031906 Ω and the same using PTB#1-CCC was found to be 100.000033540 Ω.

Room temperature magneto-resistance and temperature coefficient of resistance in $La_{0.7}Ca_{0.3-x}Ag_xMnO_3$ thin films

In order to clarify the existing doubts regarding the doping of Ag at La/Ca site, $La_{0.7}Ca_{0.3-x}Ag_xMnO_3$ ($0 \le x \le 0.3$) polycrystalline films were prepared at relatively at low temperature by spray pyrolysis. It was conclusively shown that Ag is indeed substituted at La/Ca site and that Ag doping can be effectively used to tune the transport properties to yield significant magneto-resistance (MR~30-60% Fig. 2.4B) around room temperature even in polycrystalline films. At 30% Ag doping an enhancement of ≥ 55K was observed in T_C/T_{IM} (Fig. 2.4A). Interestingly T_{IM} of all Ag doped films was larger than the corresponding T_C. Ag doped films also have good TCR~4 %/K in the vicinity of room temperature.

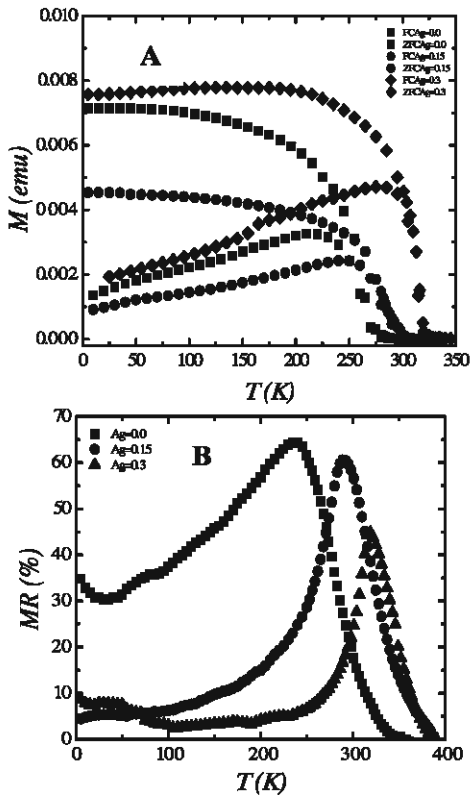


Fig. 2.4: Temperature dependence of dc magnetization (A) and magneto-resistance measured at magnetic field of 7 T (B)

Effect of large compressive strain on low field electrical transport in $La_{0.88}Sr_{0.12}MnO_3$ thin films

It has been predicted that manganites having tolerance factor t~0.96 should exhibit the optimum effect of compressive strain and which

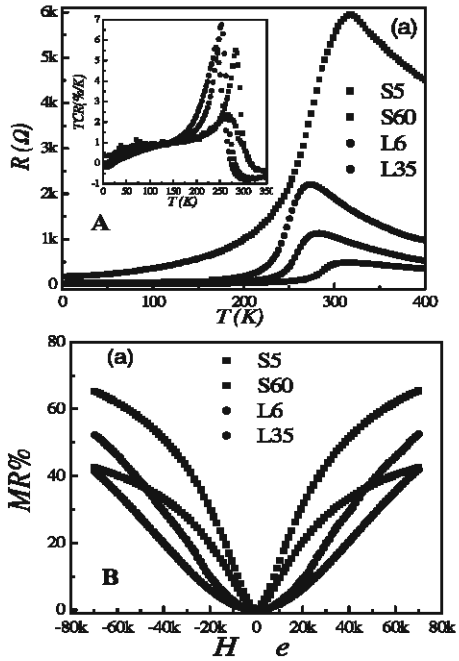


Fig. 2.5: (A) Resistance *versus* temperature (R-T) curves of 5nm (S5) and 60nm (S60) thin films on STO and 6nm (L6) and 75 nm (L35) thin films on LAO substrates. Inset shows the variation in TCR as a function of temperature for all samples, (B) Magnetoresistance (MR) *versus* applied magnetic field curves measured at room temperature (300 K)

in turn may cause huge T_C/T_{IM} enhancement. The critical thickness at which relaxation occurs is inversely related to magnitude of lattice mismatch. In order to study the effect of compressive strain on magnetic and magneto-electrical properties, thin films of $La_{0.88}Sr_{0.12}MnO_3$ (t~0.96) having 5-60 nm thickness, were grown on (100) $LaAlO_3$ and (100) $SrTiO_3$ substrate by DC-magnetron sputtering. Large enhancement in T_C and T_{IM} of films as compared to the bulk of the same material (T_C~175 K, T_{IM}~145 K) was observed. The 5 nm thin film on STO has T_C~315 K/T_{IM}~320 K while 6 nm film on LAO shows T_C~275 K/T_{IM}~282 K (Fig. 2.5A). T_C/T_{IM} are observed to decrease with increasing thickness suggesting a relaxation in the strain. Further, the partially strain-relaxed films exhibit large enhancement in MR (Fig. 2.5B).

Josephson Voltage Standard and DC Current, Voltage and Resistance Standards

Josephson Voltage Standard

Josephson series array voltage standard (JSAVS) is being maintained at 1 volt level. The 'National Standard' of volt is being calibrated at regular interval against the JSAVS. Josephson series array voltage standard at 10 V level (Fig. 2.6) was integrated and characterized using PTB, Germany & NIST, USA based chips. The 10 V output of Zener reference standard is calibrated against JSAVS using comparison method with an uncertainty of ± 400 nV (at k=1). The work is in progress to improve the uncertainty in measurement, which is observed higher in the present measurement.

Fig. 2.6 : Experimental setup of Josephson series array voltage standard at 10 V level.

One of the group members was on deputation to National Institute of Standards and Technology (NIST), USA for one year (April 2006-March 2007) under BOYSCAST fellowship of Department of Science and Technology, Govt. of India. At NIST, he worked on various types of Josephson voltage standards namely NIST 10 V conventional Josephson voltage standard (NIST10), 2.5V Programmable Josephson voltage standard (PJVS), 10 V Compact Josephson voltage standard (CJVS) and 282 mV AC Josephson voltage standard (ACJVS). He has also acquired knowledge on low level voltage (nV) measurement techniques during the characterization of low thermal scanner for automatic voltage measurement with the NIST 10 V Josephson voltage standard. Based on this work, we have started the characterization of our low thermal scanner for automatic resistance measurement using DCC bridge.

DC Current, Voltage and Resistance Standards

A newly procured ensemble/bank of Zener-diode-based reference voltage standard (Fluke 734A) has been established as a secondary/ national standard of dc voltage. It consists of four modules of individual reference standard, each having 10 V and 1.018 V output. The individual modules of the ensemble/bank have been characterized for drift rate and uncertainty. The average drift rate of 10 V output of the

modules were ranging from -16 nV to -29 nV per day. The uncertainty in measurement of the 10 volt and 1.018 volt output of the modules was evaluated as ≤ ± 0.3 ppm and ≤ ± 1.0 ppm respectively. Now this ensemble/bank is used for calibration of the other reference standard of voltage.

The performance of another bank/ ensemble (four module of individual reference standard having 10 V & 1.018 V) of the Zener-diode-based reference voltage standard (Fluke 7004N) was evaluated using Statistical Process Control (SPC). Fig. 2.7 (a-d) shows the control chart of the individual modules of the bank/ensemble of reference standard (Fluke 7004N) establishment. The average deviation (CL) of 10 V output of all the modules were -1.38 μV to -1.41 μV from the last calibration values and the deviations were well within the UCL & LCL. The average drift rates of all the modules were also estimated (-18 nV/day to -20 nV / day) and observed that the values are well within the specified limits (22 nV/day). The applications of SPC in metrology strengthen us to understand the present performance of a re-calibrated standard based on the past performance and may further suggest that the same will follow in the near future.

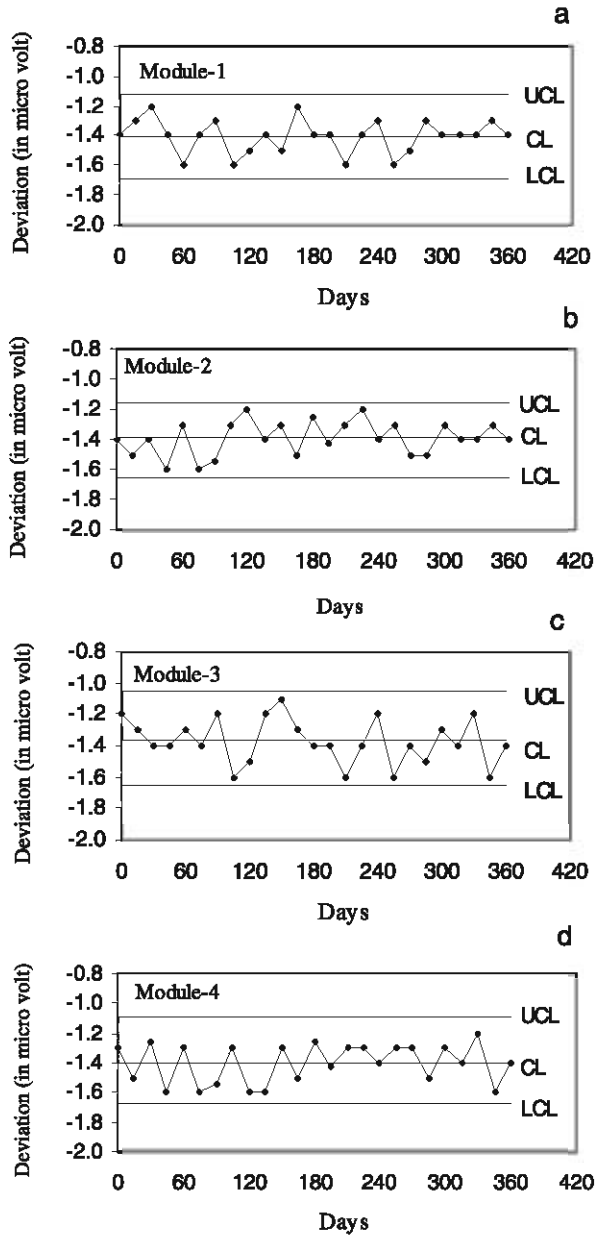


Fig. 2.7: Control charts of the individual module of the bank/ensemble of Zener Reference Standard after establishment

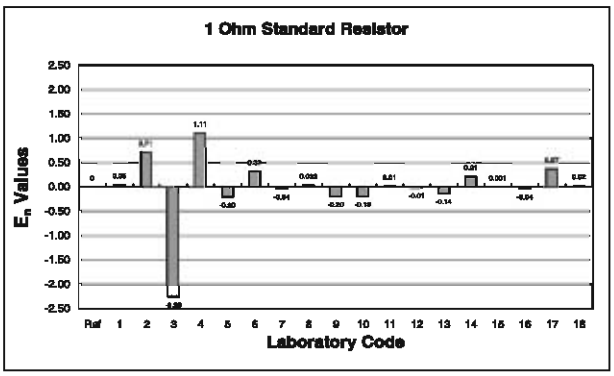


Fig. 2.8: Results of Proficiency Testing in DC Resistance measurement.

The second phase of Proficiency Testing program (under NPL-NABL) on DC Resistances (1 Ω, 100 Ω, 1 kΩ and 10 kΩ) has been completed and report submitted to NABL, New Delhi. In this phase, 18 laboratories were selected based on their technical competence and NPL has coordinated as reference laboratory in this programme. Out of total 72 measurement results, 68 (94.5%) results were in agreement with the reference laboratory. Fig. 2.8 shows typical results of the E_n value of all the participating laboratories. The E_n value of two laboratories were found to be > ± 1.

Under the project entitled "*Generic development of nanometrology for nanotechnology at NPLI*", funded by Department of Information Technology, we have procured and characterized the various instruments such as Precision Calibrator, Multimeter, Nanovoltmeter, AC & DC Current Source, Electrometer, Sub-Femto Ampere Remote Source Meter with accessories for establishment of traceable nano level measurement facilities of dc voltage, dc current, electric charge and dc resistance ranges.

DC High Voltage Standards

This group is providing calibration facility for DC High Voltage equipments ie. probe, Voltage divider, Power Supplies and Volt meter, upto 100 kV. Primary standard of DC High Voltage is the Resistive Divider, which is traceable to Josephson voltage standard.

Following two new facilities have been established in this group.

Fig. 2.9: Set up for shunt resistance measurement at high current

a. ***DC shunt resistance measurement at high current:*** Fig. 2.9 shows the setup established for shunt resistance measurement. Shunts can be measured as low up to 0.001 Ω at 600 A with an uncertainty of 10 to 15 ppm.

b. ***DC high current measurement:*** Fig. 2.10 shows the setup for DC High Current measurement. Now DC High current power supply can be calibrated up to 600 A with an uncertainty of 0.01%

These facilities will be useful for the Manufacturer of "Electrical Measuring Instruments" and other calibration laboratory.

Fig. 2.10: Set-up for DC high Current Measurement

AC Power & Energy Standard

Under NPL-NABL PT programme, Proficiency Testing (PT), has been carried out in ac power & energy for assessing the measurement capability of 12 participating NABL accredited laboratories. The Artifact chosen was a 3 Phase Reference Power & Energy Standard RMM3000. The correction factors were taken at 240 V/1 A, 5 A, 50 A with Unity Power Factor, 0.5 (lag & lead) power factors at 50 Hz in 3 phase 4-Wire mode and measurement uncertainties were calculated at coverage factor k=2 with approximately 95% confidence level. NPL acted as pilot laboratory

and the Error Normalized (En) values were calculated both for ac power and energy for all the 12 laboratories. It has been observed that two laboratories were outlier at some points while the En value from 10 laboratories was within ±1 and results were quite satisfactory.

In July 2006, the section has participated in EUROMET Key Comparison Supplementing CCEM-K5. The traveling standard (artifact) was a HEG, Germany make C1-2 Watt Converter which is configured as an ac power-to-dc voltage transducer, with a full-scale dc output of 10 volts. The measurements were taken at 120 V/5 A, UPF, 0.5 (lag & lead) and 0.01(lag & lead) power factors at 53 Hz using transfer standard ILM-03-3. Measurements were also taken for output offset dc voltages for No Power conditions (120 V/0 A, 0 V/5 A & 0 V/0 A) and DC reference voltages (+7.044 V & -7.044 V) and measurement uncertainties were calculated. The set up is shown in Fig. 2.11. The results were sent to the coordinating Laboratory, (UME) National Metrology Institute of Turkey for compilation.

Fig. 2.11: Set-up for Comparison of C1-2 Watt Converter against ILM-03-3

AC High Current & High Voltage Standards

This section is maintaining National Standards of AC High Current and High Voltage Ratios at power frequencies (50 Hz) by using Reference Standard Current Transformers and Reference Standard Voltage Transformers. Calibration services were provided for Current Transformers, Current Transformer Testing Sets, Clamp Meters, Weld Testers, CT Burdens and for Voltage Transformers, Voltage Transformer Testing Sets, HV Probes, Electrostatic Voltmeters (ESVMs), HV Break Down Test Sets and Voltage Transformer Burdens etc. As many as 40 Calibration Certificates were issued to the electrical manufacturers and utilities.

The facility for the calibration of Voltage Transformers of any ratio was upgraded. The calibration range of voltage ratios has been extended from 40 kV/100 V to 100 kV/100 V and from 3 kV/ 100 V down to 100 V/100 V at 50 Hz. The uncertainty of voltage ratio measurements using the CVD method is

Fig. 2.12 : National Standard of AC High Voltage Ratio

Fig. 2.13 : Experimental Set-up for VTs

±0.005%. The National Standard of AC High Voltage Ratio up to 100 kV/100 V comprising of the Compressed Gas Capacitor, Air Capacitor & the Electronic Voltage Divider (EVD) is shown in Fig. 2.12.

The experimental set-up for the calibration of Voltage Transformers of any ratio from 100 V/100 V to 100 kV/100 V at 50 Hz is shown in Fig. 2.13.

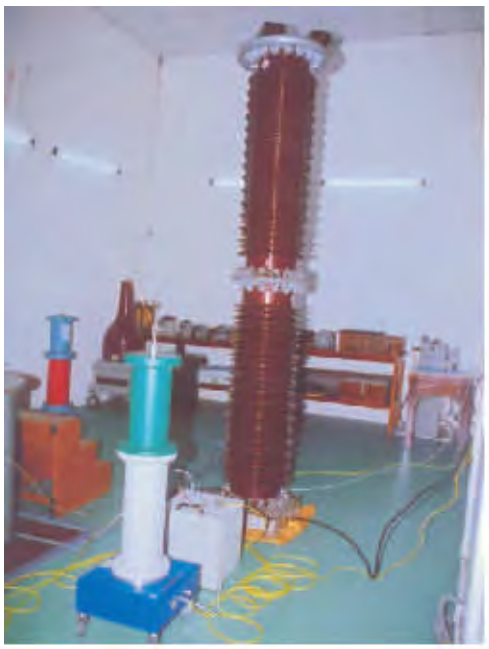


Fig. 2.14 : Calibration of Ref. Std. CVD

Fig. 2.15 : Calibration of $\frac{132\ kV}{\sqrt{3}}$ VTs.

The set-ups for the calibration of the reference standard Capacitive Voltage Divider (CVD) and 3 VTs of 132 kV/$\sqrt{3}$ are shown in Fig. 2.14 and 2.15 respectively.

LF and HF Impedance Standards

This group of electrical and electronic standards is disseminating the traceability for measurement of capacitance, inductance and ac resistance at low and high frequency to calibration laboratories and R & D organizations. The traceability starts from primary standards of capacitance, Calculable Cross Capacitance, based on Lampard-Thompson theorem and traceable to base unit length. The unit of resistance, Ohm, is also realized from capacitance using Quadrature Bridge and other precision ac bridges. The unit of inductance, Henry, is realized from capacitance and ac resistance using Maxwell-Wien Bridge. A set of high precision coaxial reference air lines with traceability to calculable cross capacitor is used as primary standards of HF impedance.

Calibration facility for measurement of high value capacitors (> 1μF to 1 F) is re-established as per demand of users.

LF & HF Voltage, Current & RF Power Standards

Coaxial micro-calorimeter system established as the primary standard of RF power in the frequency range of 10 MHz to 18 GHz is an absolute method for the determination of effective efficiency of the coaxial thermistor mounts, which are transfer standards. These thermistor mounts in turn are used for calibrating reference standard power mounts or power meter with sensors of different user organizations.

Evaluation of effective efficiency of these mounts manually using microcalorimeter system is very tedious and time consuming. Complete measurements at a single frequency require 8 hours of continuous data recording. A data acquisition system has been developed for automating the calibration procedure of the above-mentioned primary standard in the frequency range of 10 MHz to 18 GHz. A view of the data acquisition system with coaxial microcalorimeter is shown in Fig. 2.16. The software for this system has been developed using the VEE Pro application, which is a graphical programming environment optimized for use with electronic instruments. This software enables the computer to continuously acquire the raw data from the electronic equipment, display it in a real time environment and save in a tabular form. A major part of the power going into the mount is absorbed in the element and a small part of the power also gets absorbed in the body of the mount. The power absorbed by the body of the mount has to be determined by the rise in temperature of the mount in terms of thermopile output voltage as shown in Fig. 2.17 (Real time plot of thermopile emf with time.)

The power sensed by the element of the mount is determined by connecting it in one arm of the Self Balancing Bridge [SBB]. As soon as the RF power is applied to the mount, its dc resistance is maintained at a constant value by reducing the dc bias power by an amount equal to the RF power. From these measurements the absolute Effective efficiency of the reference standard thermistor mount is determined by

$$\eta_e = g\left[\frac{1-(v_2/v_1)^2}{(e_2/e_1)-(v_2/v_1)^2}\right]$$

Where,

g frequency dependent total correction factor

v_1, v_2 SBB voltage for RF power OFF and ON conditions respectively

e_1, e_2 Thermopile output voltage corresponding to v_1 & v_2 at steady state condition

Developing this system minimizes human involvement as it eliminates the need to record the reading manually and therefore reduces the chances of errors. It also helps in avoiding the huge strain from the operator to record the equipments readings manually throughout the

Fig. 2.16: View of the Data Acquisition System with Coaxial Microcalorimeter

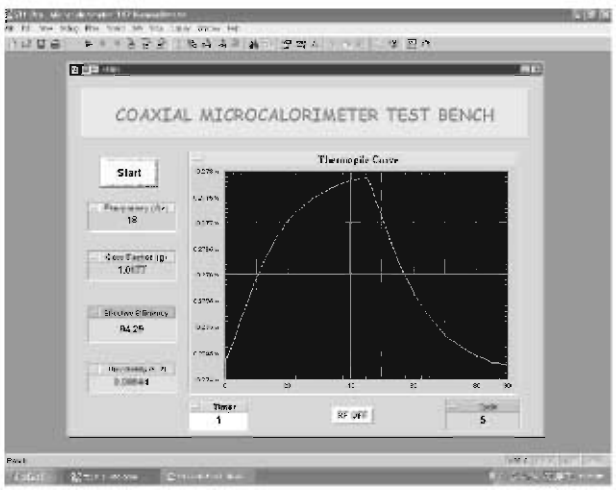


Fig. 2.17: Real Time Plot of Thermopile EMF with Time

calibration cycle. The software performs lot of scientific calculations on the raw data along with uncertainty calculations and produces the useful and meaningful results in terms of Effective Efficiency with their uncertainties.

Data Acquisition system performance has been evaluated form 10 MHz to 18 GHz successfully by calibrating coaxial thermistor mount HP 8478B. The previous (year 2002) and present (year 2006) results of effective efficiency and their uncertainties along with their plots are shown in Tables 2.1 & 2.2 and Fig. 2.18 respectively.

Table 2.1 : Effective Efficiency

Thermistor mount HP 8478 B		
Frequency	Effective Efficiency	
GHz	Year 2002	Year 2006
0.10	97.86	97.96
0.30	97.83	97.86
0.50	97.80	97.76
0.80	97.70	97.67
1.00	97.45	97.58
2.00	96.91	96.86
4.00	96.00	96.10
6.00	95.37	95.52
8.00	94.85	94.89
10.00	94.80	94.82
12.00	94.78	94.77
14.00	94.70	94.70
16.00	94.60	94.50
18.00	93.95	94.03

Table 2.2: Uncertainty in Effective Efficiency

Thermistor mount HP 8478 B		
Frequency	Uncertainty	
GHz	Year 2002	Year 2006
0.10	0.0020	0.0016
1.00	0.0020	0.0020
2.00	0.0020	0.0024
6.00	0.0026	0.0032
8.00	0.0027	0.0030
12.00	0.0030	0.0026
15.00	0.0030	0.0028
18.00	0.0033	0.0032

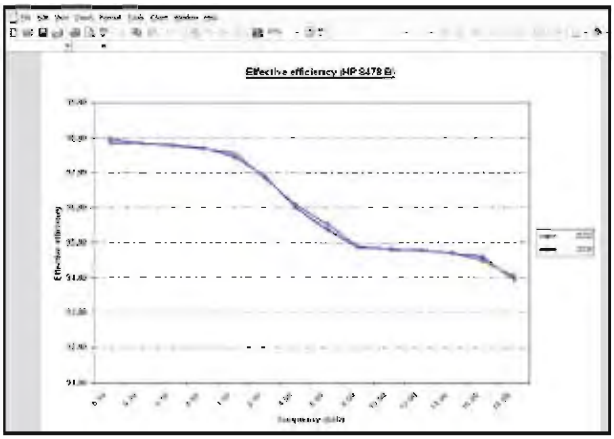


Fig. 2.18: Plot of the Effective efficiency

RF Attenuation and Impedance Standards Section

The RF Attenuation and Impedance Standards Section is maintaining the national standards of RF Attenuation and Impedance. The calibration service is being provided at 30 MHz & 1-18 GHz (coaxial system) and 5.85 to 18 GHz (waveguide systems) in the attenuation parameter and from 2-18 GHz (coaxial system) & 5.85 to 18 GHz (waveguide systems) in impedance parameter.

Intercomparison participation:

(i) BIPM Key comparison (Scattering parameters): We participated in the BIPM key comparison CCEM.RF-K5b.CL titled **"Scattering Coefficients by Broad- Band Methods 2-18 GHz Type N connector"** (NPL, UK as the pilot laboratory). The combined standard uncertainty in each measured parameters has been estimated for 17 frequency points in 2-18 GHz range. The measured

complex S-parameters and the computed correlation coefficients have been reported to the pilot laboratory.

(ii) APMP Comparison (Impedance): P1-APMP.EM.RF-S3 with NPL, India as the pilot laboratory. The calibration results from all the participants have been received and the preparation of Draft A is in progress.

Application of measurement techniques:

(i) Insertion loss and return loss of Pre-localised Graphite filled Poly (Vinyl Chloride) composites for Dept. of Electronic Science, Univ. of Delhi South Campus has been measured in X-band (8.2 to 12.4 GHz) waveguide system for EMI shielding applications.

(ii) Gain of an arbitrary Horn antenna has been measured using three-antenna gain method in X-band waveguide bench in process to study the distribution of electric field in near-field region.

Magnetic Standards

Calibration of magnetic field measuring equipment and testing of magnetic materials has been undertaken and issued 24 certificates, earning an ECF of 1.23 lakhs. Establishment of electromagnetic interference measurement (EMI) facility upto the frequency of 30 kHz using electromagnetic field analyzer is in progress.

Research and development of ferrites have been undertaken to exploit them as effective microwave devices and RF shielding. In this direction lithium ferrite and manganese zinc ferrite were prepared by conventional solid state sintering and chemical sol-gel process and were fully characterized. The effect of substitution of nano SiO_2 on lithium cadmium ferrite also has been studied. It was found that optimum content of nano SiO_2 (2 wt %) yields uniform grain structure in LiCd ferrite with a lower dielectric loss and tangent loss in the frequency range of 1 kHz to 1 MHz. Studies are in progress to prepare high quality thin films and bulk materials with reduced loss factors for versatile applications. The typical magnetization curve for the SiO_2 added samples in different percentages with respect to external field is shown in Fig. 2.19

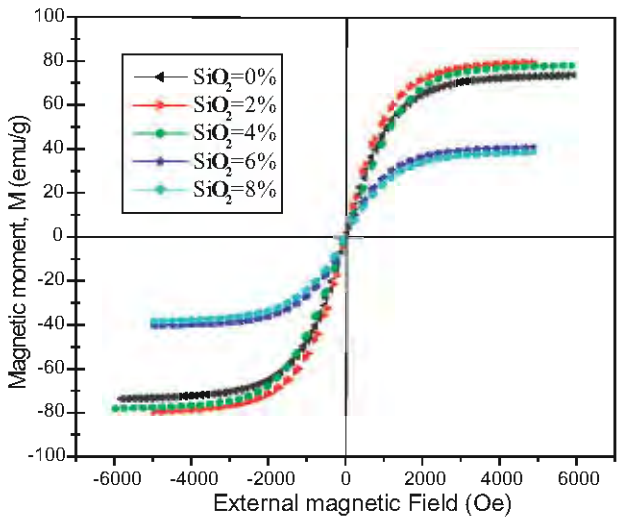


Fig. 2.19 : Variation of M with H

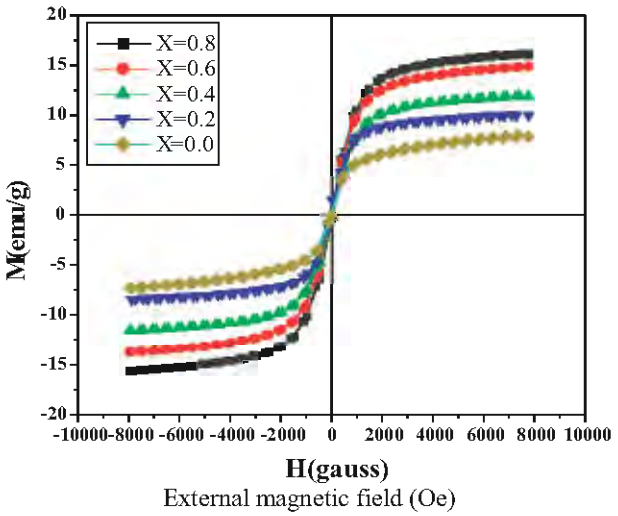


Fig. 2.20 : Magnetization curves of Ba_2FeMoO_6 substituted with Sr in place of Ba in varying stoichiometries

Research on room temperature tunneling magneto-resistance (TMR) of double perovskite compounds has been undertaken to develop magnetic field sensors. In this direction preparation and characterization of CMR materials such as Sr_2FeMoO_6 and Ba_2FeMoO_6 and its derivatives have been carried out. The saturation magnetization value obtained is 11.86 emu/g, the Curie temperature being 340 K. The change in magnetoresistance at a field of 1 T is 7.25 %. The results obtained are at par with that of reported values in literature. The magnetization curves of $Ba_{2-x}Sr_xFeMoO_6$ with x $0 \leq x \leq 0.8$ is shown in Fig. 2.20.

Magnetic particles of nano size are reported to be effective decontamination agents of water. One such study was done by the preparation of nano particles of iron by an exploding wire technique. The particle size was in the range 10-50 nm. The particles showed superparamagnetic behavior and are found useful in removing arsenic from ground water.

Bio-medical measurements

Development of Microcontroller Based ECG machine with LCD display and online data transmission facility

Designed, developed and tested a compact, hand-held, portable micro-controller based ECG machine using graphic LCD display. The ultra low value ECG signals obtained from the ECG electrodes put on the patient is passed through a preamplifier filter and isolation amplifier for acquiring, amplifying and filtering these low value signals. The ECG signal after being processed by the microcontroller is displayed on the screen online along with other vital parameters like PR, QR and QRS complex durations to help doctors and professionals to arrive at a quick diagnostic decision. The system has the capability of recording ECG or other biomedical signals for 1-5 minutes duration. This facility makes it an ideal diagnostic tool for processing the data for further analysis later on by the doctor at his clinic.

An algorithm/software package is being developed for transmitting this data directly from the patient in the field to a medical doctor sitting in his clinic using internet. This will facilitate the doctors / professionals to see live and assess on the spot, the patient's heart ailment and send his recommendations for necessary actions. This will make it a novel online diagnostic tool.

ECG Calibration facility

1. Action plan, necessary guidelines and procedure for calibration of 12 leads ECG machine were prepared.
2. The system Bio-calibrator with an in-built capability of generating sine, square and triangular waves was calibrated against 1 mV at 10 Hz standard primary signal source. This unit will be used as secondary reference for providing 1 mV signal at 10 Hz for calibrating 12 leads ECG machine.
3. A 1 mm column graph paper also got calibrated against 1x1 mm standard length. This will be used as a secondary reference of 1 mm to measure the % drift with values of 1 mm x 1 mm in the calibration of ECG machine.

   The graph paper is used to obtain the ECG waveform. Observations for amplitude and time were taken on calibrated graph sheet for sine wave input from Bio-system Calibrator on three alternate days. Amplitude and time were measured using

mm scale of graph sheet and average of the three days reading were taken. Evaluation of uncertainty in measurements for Amplitude and Time period of sine wave has been done.

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, all the activities except fluid flow, HF impedance and magnetic standards have been Peer Reviewed by technical experts from other NMIs. A total of 136 Calibration and Measurement Capabilities (CMC) claimed by NPLI have been verified, found correct and appear on the BIPM website. Another 54 CMCs are being verified. Similarly, 107 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 ISO/IEC 17025:2005 is being followed and new documents have accordingly been prepared by the various activities. A number of lectures on Quality System were delivered to the members of material and chemical testing who are preparing the documents for following the Quality System. Professional training on Quality System and 17025 standard was organized for 26 scientists.

इंजीनियरिंग पदार्थ
ENGINEERING MATERIALS

इंजीनियरिंग 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 युक्तियों और प्रणाली को विकसित करना है। प्रभाग के अनुसंधान एवं विकास उत्पादन में एरोस्पेस मैटेलिक सामग्री, कंपोजिट्स, उन्नत कार्बन उत्पाद, द्रव क्रिस्टल, चालक पालिमर्स, ऑप्टो इलैक्ट्रॉनिक्स युक्तियां, आर्गेनिक विद्युत युक्तियां और सैंसर्स आदि शामिल है। इनमें से कुछ पदार्थों का प्रयोग सामरिक व औद्योगिक क्षेत्रों में किया जाता है। जनरल मोटर्स ने ऑटोमोबाइल 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।

वास्तव में इस प्रभाग के अंतर्गत कई विकासशील परियोजनाओं में जैसे सी एस आई आर नेटवर्क, प्रायोजित, सहायता अनुदान (ग्रांट इन एड), सहयोगी और परामर्शी परियोजनाओं 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 electronic devices and sensors etc. A few of these materials find applications in strategic and industrial areas; 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. In fact, under this division 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 light weight Magnesium alloys and Metal Matrix Composites

Work was concentrated on developing light weight magnesium & aluminium alloys and Metal Matrix Composites under different sponsored, network and consultancy projects, four of which have successfully concluded this year realizing the specific deliverables laid out in each of these projects. The thrust, however, was on developing extruded rods, tubes and sections of different grades of Mg-alloys for their possible automobile applications under a consultancy project sponsored by General Motors on "Advanced Magnesium Extrusion Alloys" which was successfully concluded this year. CSIR Network project on the development of different grades of magnesium alloys employing rapid solidification and using spray-forming was successfully completed this year. Under this project, the process for spray-forming of Mg-alloys has been developed (~ 4-5 kgs of melt) and the spray-formed deposit exhibits equiaxed microstructure, fine sized intermetallics and with properties better than cast mother alloy. The project sponsored by Vikram Sarabhai Space Centre on "development of spray-forming technology for Mg-alloys" was also completed this year and a few spray-formed deposits were sent to VSSC for testing and evaluation. Another CSIR Network project on the development of Cu-based MMCs using Powder Metallurgy technique for prototype brakepad applications was also completed this year. Under an in-house project, in order to synthesize cylindrical tubes of functionally gradient MMC, a vertical centrifugal casting unit was set-up at NPL.

Magnesium Alloys

General Motors Sponsored Project entitled "Advanced Magnesium Extrusion Alloys"

Successfully completed joint project between NPL and General Motors on the development of extrusion technology of magnesium (Mg) alloys with the objective of achieving high ductility and formability at room temperature. Under this project, effect of several processing parameters, such as die design, alloy composition, extrusion temperature, pressing speed, etc. was investigated on the microstructure and mechanical properties of Mg alloys that were extruded in the form of rods, tubes and strips. A wide range of Mg alloys including novel compositions, e.g., pure Mg, Mg-RE, AM30, AM50, Mg-Al-RE, etc were investigated. The extruded products were thoroughly characterized for their metallurgical and mechanical properties at NPL and GM laboratory in Bangalore. An important outcome of this project was that room temperature ductility of Mg was enhanced significantly under optimized process parameters of hot extrusion. It is believed that the investigation results of this project would play an important role in the replacement of conventional Al alloys with novel Mg alloys in the near future.

CSIR Network project on synthesis of Mg-alloys using rapid solidification and employing spray forming

This CSIR Network project on the spray forming of Mg-alloys was successfully completed this year. The main deliverables of this project were the synthesis of Mg-alloys employing spray forming to obtain low porosity, equiaxed microstructure, low grain size and improved mechanical properties (w.r.t. the cast mother alloy).

The spray-formed deposits were characterized using optical microscope, scanning electron microscope /energy dispersive spectrometer and X-ray diffraction. The microstructure spray-formed deposit indicated (Fig.3.1) homogeneous magnesium equiaxed matrix with grain size of 20-40 μm throughout the interior of the deposit with fine uniformly distributed $Mg_{17}Al_{12}$ intermetallic particles of 6-9 μm. The porosity was observed to be about 2.5-3.5% in the central core of the spray-formed deposit but increases near the peripheral region and becomes very high in the extreme peripheral region of the spray-formed deposit, where the microstructure exhibited loosely bound pre-solidified particles of 1-4 μm. The microstructural features, observed at different regions in the spray formed deposit, have been explained in the light of solidification of droplets in-flight and subsequent droplet consolidation on the deposition surface.

The comparison of mechanical properties of the spray formed (& cast) Mg-alloys AZ31 (Mg-Al-Zn) were found to be *UTS (MPa)* : 202 209 (176-190); *%elong* : 10-11 (8-9); *Microhardness (HV_{100}):* 76.3(67.2). Similar comparison of properties for Mg-alloys EZ33 (Mg-RE-Zn-Zr) exhibited *UTS (MPa)* : 215-228 (117-123); *%elong* : 8-9 2.8-3.3; *Microhardness (HV_{100}):* 79.3(60.2). The results of the mechanical property measurement suggested that these were reasonably uniform throughout the central interior region of the spray-formed deposit and there is an improvement in the tensile strength, ductility and micro-hardness of the spray-formed alloy as compared to the cast mother alloy, used for spray forming. The fractured surfaces of the tensile test samples of AZ31 were examined using a scanning electron microscope and Fig. 3.1 depict typical SEM fractographs of the tensile fracture surfaces.

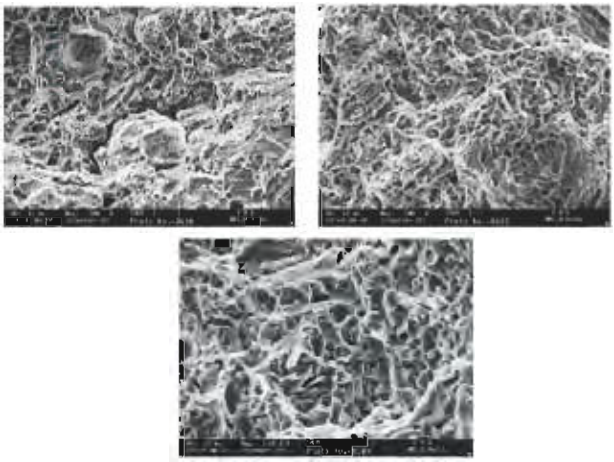


Fig. 3.1: Scanning electron micrographs of tensile fractures surfaces of spray-formed Mg-alloy

These microstructures reveal macroscopically brittle fracture due to the presence of fine cracks. However, at a microscopic level the fractured surfaces also reveal isolated pockets of shallow ductile dimples, voids of varying size intermingled with tear ridges, features reminiscent of ductile failure. This suggests that final failure in spray-formed alloys is due to a mixture of ductile and brittle mode of fracture, which is also corroborated by the moderate values of ductility observed in this alloy.

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

This project sponsored by Vikram Sarabhai Space Centre (VSSC) was completed this year. Under this project, spray-forming experiments to synthesize Rare-earth based EZ33 Mg-alloy were conducted in order to synthesize spray-formed alloys in nearly-gaussian shapes with a minimum height of 50 mm and base diameter of 100 mm and with target properties of UTS 225 MPa, YS - 190 MPa & elong - 3%. Different process parameters like, melt temperature, flight distance, atomization pressure, design of atomizing nozzle and delivery tube, were optimized in order to spray-form Mg-alloys in

nearly-gaussian shape with low porosity, good yield and equiaxed microstructure and with no traces of MgO phase. A final batch of ten spray formed deposits, meeting the dimensional and property targets, was supplied to VSSC, Trivandrum for testing and evaluation.

Composites

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

Under Xth Five Year plan, a CSIR network project entitled "Development of copper based sintered composites prototype brakepads" has been completed successfully. Under this project, copper based sintered metallic prototype brakepads have been developed as shown in Fig. 3.2.

Fig. 3.2 : Copper sintered brakepads

A powder metallurgy processing route was adopted which involved ball milling of ingredient powders followed by compaction for prototype brakepads and sintering under protective atmosphere. Detailed characterization of the brakepads was carried out.

In-house project on the "development of functionally gradient metal matrix composites"

Functionally gradient materials are a new class of materials where the composition/ microstructure varies in one specific direction. Cylindrical tubes of functionally gradient MMC find applications in high wear resistant components, such as cylinder liners, gears, etc. In order to synthesize cylindrical tubes of functionally gradient MMC, a vertical centrifugal casting unit was set-up at NPL. The density difference between the reinforcement and matrix alloy produces redistribution of the two phases due to centrifugal action leading to formation of a gradient in reinforcement across the thickness of the MMC cylinder tube.

Trial runs were undertaken on the vertical centrifugal casting unit using a hollow cylindrical moulds to make MMC tubular sections and their process parameters optimization and characterization is currently underway.

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.

Synthesis and characterisation of SiC nanomaterials.

SiC nanomaterials were synthesized using TEOS/MTEOS/DMTEOS+TEOS as silicon source and carbon black as carbon source. The SiC precursors were heat-treated to 1400 °C in argon atmosphere to obtain pyrolysed product (SIC nm). The final product was characterized by X-ray, FTIR, SEM and TEM studies. It was found that SiC obtained from carbon black incorporated sol gel silica synthesized from MTEOS/DMTEOS+TEOS were mixtures of nano wires, nano fibres and nano rods while the product from TEOS + Carbon Black led to formation of SiC nano fibres. The diameter of the SiC nano wires, nano fibres and nano rods were found to be 25-35 nm, 40-45 nm and 75-90 nm respectively. Impregnated jute cloth while the pyrolysed products of pre-carbonised and carbonised jute cloths impregnated with MTEOS derived silica showed coiled and straight nano fibres. SiC nano material was also synthesized using jute cloth (as such and pyrolysed forms) and silicon alkoxides. It was observed from SEM and TEM studies (Fig.3.3) that formation of silicon nano fibres and nano rods were observed from TEOS/MTEOS derived

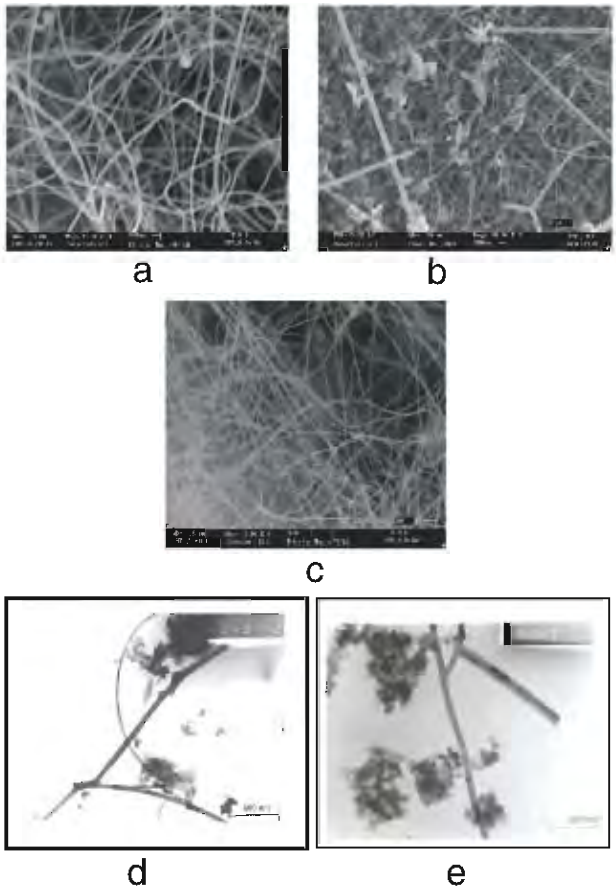


Fig. 3.3 : SEM photographs of Nano SiC from (a) TEOS + Carbon black (1400°C) (b) DMEOS TEOS + Carbon black (oxidized and HF treated) (c) MTEOS+ Carbonised (1400°C) TEM photographs of Nano SiC from (d) MTEOS Silica + carbon black (e) carbonized (1000°C jute cloth + MTEOS silica

Development of carbon-ceramic composites (C-SiC-B_4C) through in-situ formation of nano-SiC

Composites were prepared by isostatically moulding the ball milled NPL developed coal tar based green coke, sol-gel silica, silicon, carbon black and boron carbide and heat-treating the moulds at 1400 °C and then at 2200 °C. The products showed oxidation resistance at 800 °C

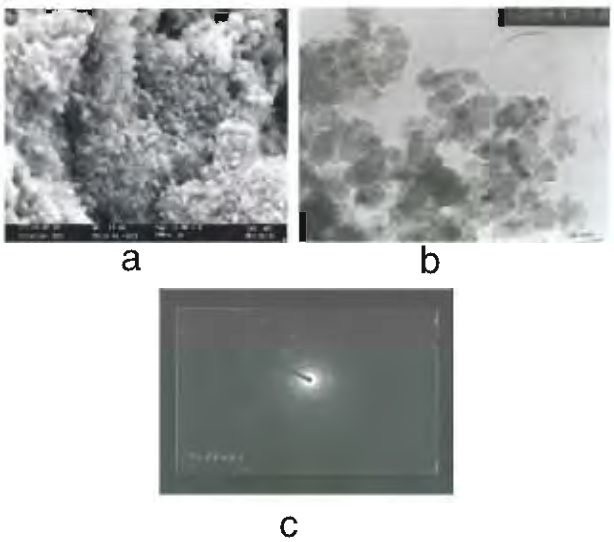


Fig. 3.4: (a) SEM, (b) TEM, (c) TEM of selected area diffraction pattern showing the ring pattern of C-SiC-B_4C

and 1000 °C for about 10 hrs. The X-ray studies showed the formation of SiC and crystallite size calculated from the X-ray data was found to be 56 nm. The SEM and TEM studies (Fig.3.4) showed the nano-sized SiC and TEM showed the formation of SiC nanoparticles in the range of 14-30 nm.

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. The samples of 3-D carbon-carbon composites of size 45 mm x 45 mm x 20 mm prepared from T-300 carbon fibres and impregnated with performing pitch and novel pitch (developed in-house) showed a density of 1.68 gcm^{-3} at NPL. The determination of thermal conductivity and mechanical properties are in progress. The isostatically-molded blocks made from green coke possessed the characteristics desired under the project.

Development of carbon-carbon composites for thermal management

The major objective is to develop of high thermal conductivity carbon-carbon composites possessing bulk density of 1.8 cm^{-3}, thermal conductivity values of the order of 250-275 W/mK in the longitudinal direction and 75-90 W/mK in the transverse direction. Three different types of carbon fibre performs of size 100 mm x 50 mm x 50 mm with balanced and unbalanced weave using PAN based and pitch based carbon fibres subjected to different impregnation/Graphitization cycles at NPL possessed bulk density of 1.2 gcm^{-3}. The samples have been sent to ASL, Hyderabad for densification to achieve a density of 1.8 cm^{-3} using HIPIC assembly available there. These composites will be tested for mechanical and thermal properties.

Development of fuel cells based on hydrogen (NMITLI Project)

Porous conducting Carbon paper and Advanced composites bipolar plate

The major objective during the period was to optimize the properties of the bipolar plates and porous carbon paper and to supply carbon paper and bipolar plates of size 20 cm x 15 cm to CECRI as per specifications for evaluation in the unit fuel cell. These samples of desired characteristics were evaluated by CECRI, Chennai center, for their I-V performance on the unit fuel cell assembly and the results are reproduced below. As shown in Fig.3.5, the power density obtained from NPL plates is almost matching with Schunk plates at lower current densities and is nearly 100 % of the peak value.

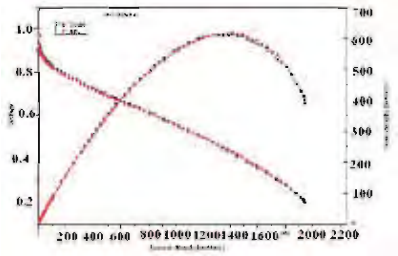


Fig. 3.5: I-V performance of the NPL composite Bipolar plates carried out at CECRI.

Development of specialty carbon materials for novel nuclear reactor

Under the project sponsored by BARC, NPL is working on the development of specific Carbon/carbon composite tubes for new generation high temperature nuclear reactors. Initially prototype tubes with dimensions OD 60 mm, ID 20 mm and Length 100 mm were fabricated by filament winding technique using T-300 CFs, angle of winding being ±55° and T-300 CFs based fabric. These tube samples were

further processed at NPL using number of impregnation/carbonization/graphitisation cycles using coal tar pitch as matrix to achieve the desired bulk density of 1.65 to 1.70 g/cc. Fig. 3.6 shows the photograph of tubes after carbonization stage.

Fig. 3.6: T-300 Carbon fiber based composites tubes after carbonization

Carbon Nanotubes : synthesis and application in Polymer Composites

MWNT produced by CVD technique were dispersed in phenolic resin matrix to produce isotropic composites of 50x5x3 mm^3 size. Flexural strength of this type of composites were reached upto 160 MPa which is approximately 2.5 times higher than as such phenolic resin even with small volume i.e 2% of CNT loadings. By employing a suitable dispersion technique it was possible to develop CNT/Phenolic composites possessing flexural strength of 160±10 MPa even with small volume i.e 2% of CNT loadings. The neat phenoilc resin value is around 60±5 MPa only. These strength values for MWNT-Phenolic isotropic composites are maximum achieved so far (Fig. 3.7).

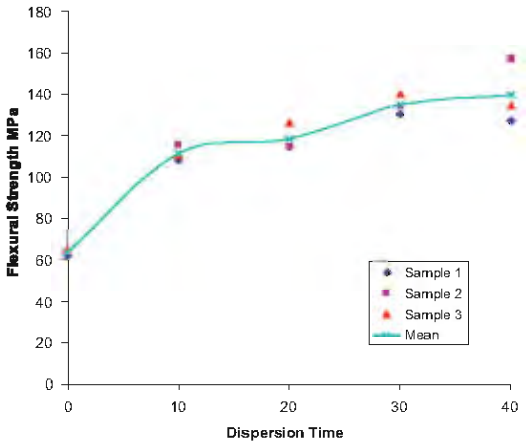
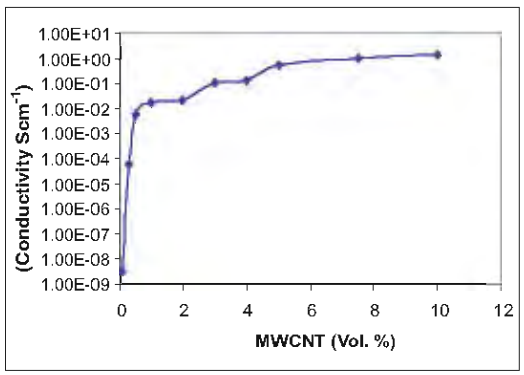


Fig. 3.7: Effect of dispersion conditions on the flexural properties of the CNT/Phenolic composites with 2 vol% CNTs dispersed in the resin

Preparation of CNT/PMMA and CNT/PS composites

The use of multi-walled carbon nanotubes (MWCNT) as reinforcing material for thermoplastic polymer matrices polymethyl methacrylate (PMMA) and polystyrene (PS) has been studied. As-prepared MWCNT from CVD technique were ultrasonically dispersed in toluene and subsequently dispersed in PMMA and PS. Thin polymer composite films were fabricated by solvent casting. The effect of



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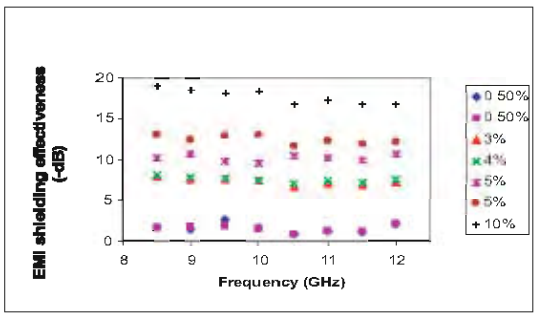


b

Fig. 3.8 : (a) Electrical Conductivity and (b) EMI Shielding Effectiveness of MWCNT - PMMA composites with different CNT content

MWCNT content on the mechanical and electrical properties of the nanocomposites was investigated. Results showed an improvement in electrical conductivity from insulating to conducting with increasing MWCNT content. MWCNT network showed a classical percolating network behaviour with a low percolation threshold. These composites shows percolation threshold at 0.5 vol% (Fig. 3.8 a) and EMI shielding effectiveness of 20 dB (Fig. 3.8 b)

Development of carbo-graphite sponsored by DMSRDE, Kanpur

Green coke was prepared, characterized and mixed (dry and wet) with 0, 10, 20 of finely ground and purified natural graphite (NG). The mixtures were molded into blocks using isostatic press which were characterized and carbonised to 1000, 1400 and 2500 °C. The bulk density of the carbonised blocks (dry mixed) increased from 1.7 to 1.75 gcm^{-3} with NG addition at 1000 °C where it remained constant around 1.82 gcm^{-3} at 1400 °C and 1.87-1.91 gcm^{-3} at 2500 °C. The compressive strength and electrical resistivity of the dry mixed block at HTT of 1400 °C changed from 1030 to 1385 kg cm^{-2} and 3.0 mΩcm to 2.3 mΩcm respectively, with increase in NG content to 20%. The bulk density and compressive strength were found to be better for wet-mixed GC-NG material than those of dry-mixed material. Two imported samples of carbographite supplied by DMSRDE were characterized in detail and it was found that the sample no. 2 possessed better properties including oxidation resistance compared to the sample no. 1. The interim progress report of the project was prepared and submitted to DMSRDE Kanpur. A patent for the improvement in the properties of the special graphite by suitable modification has been applied for.

C Polymeric and Soft Materials

Ferroelectric Liquid Crystal

Of all the interesting materials emerging from the field of nanotechnology, materials continue to attract immense research interest. The size dependent properties of metal nano particles are unique as they have both bulk and molecular metal characteristic, hybrid organic and inorganic materials have emerged as a class of electronic and optical materials with a number of potential applications. Nano composites consisting of inorganic nano particles and functional polymers have shown promises of various applications such as light emitting diodes and photovoltaic devices. Over a number of years, liquid crystals have been the subject of intense research because of its applications in flat panel displays, spatial light modulators, optical antennas etc.

Ferroelectric liquid crystals are well known for their good optical contrast, low threshold voltage, memory effect etc. But a closer look shows that all these characteristic properties have a scope for further improvement as they are limited by one or other factors. One of the methods discovered in NPL recently involves doping of ferroelectric liquid crystals (FLCs) with gold nanoparticles, which brings out a phase of FLCs with enhances optical contrast and yields a much lower threshold voltage with memory effect independent of the thickness of the sample cell. The doping procedure is shown to enhance the FLC materils original properties and reveals the significant interction of nanoparticles with FLC materials.

The gold nano particles doped FLC material has been investigated for its optical properties. Five-fold increase in optical tilt is obtained in the doped FLC case at an applied bias of mere 0.1 V. Adding gold nanoparticles in

FLC brings memory in the cell unlike the case of pure ferroelectric liquid crystal (as shown in Fig. 3.9).

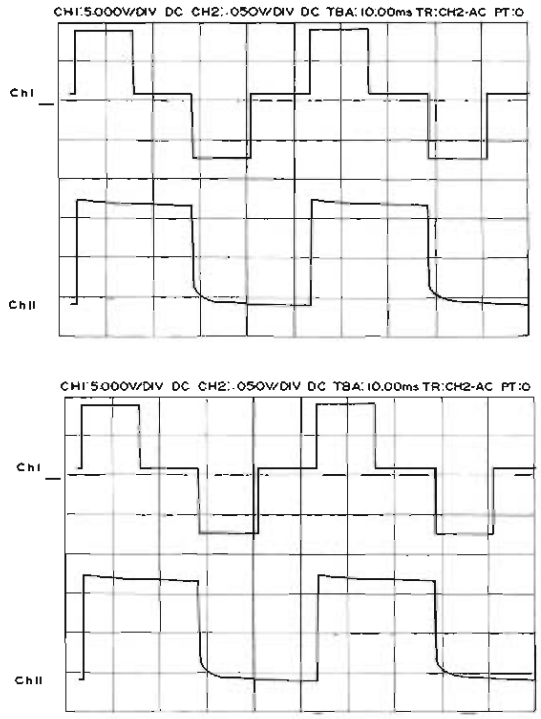


Fig. 3.9: Optical response of (a) pure Felix 17/100 and (b) Au NP doped Felix 17/100, in 3 μm cell at 20 V and 25 Hz. CH1:[5.000 V/DIV] shows driving square voltage and CH2:[0.050 V/DIV] shows its optical response, outside mark on Y-axis (voltage axis) shows zero voltage level for respective channels. TBA shows the time scale per division (10.00 ms) on X-axis, which is same for both channels.

The enhanced intrinsic field created in the sample because of nano gold particles attributed to the high tilt and strong memory effect. The interaction of the collective electron wave from the photon of incident light traversing through FLC molecules probably bring out the observed extraordinary results. These enhanced electro-optical properties could thus pave way for nano-composite FLCs to be utilized in devices from with reduced threshold voltage and much better optical contrast. The detail dynamic studies of the effect of nano-gold particles in FLC media are being carried out.

Conducting Polymers

Copolymers of aniline with substituted aniline were synthesized by taking copolymers in specific ratio sothat the copolymerization retains the conductivity of the parent polymer. The thermal stability of the copolymer doped with specific dopant was found to be 280-290 °C which was well suited for an industrial requirement for which Reliance Industries showed interest. TG-Mass studies of the conducting Polyaniline and its analogue was carried out at 300 °C and the results indicated the absence of benzidine.

PEDOT-ferrite and copolymer of (EDOT+Aniline) ferrites were synthesized sothat the resultant polymer composite possess both the electrical and magnetic properties. Thermo-magnetic measurements were carried out to determine the curie temperature of the nano ferrite particles encapsulated in conducting polymer matrix. Proposed coordination of ethylenedioxy thiophene moieties with ferrites resulting in the formation of conducting polymer complex is as shown below in Fig. 3.10.

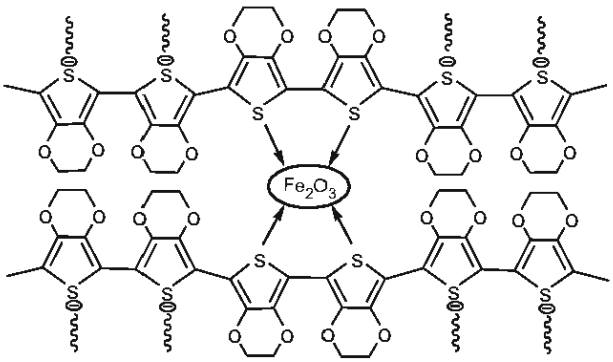


Fig. 3.10: Formation of conducting polymers complex

The electrochemical polymerization of aniline with EDOT was carried out on Pt electrode in protonic acid solution by potentiostatic technique at a potential of 0.8 V or cyclic voltammetry technique by cycling the

potential between 0.2 V to 0.8 V vs SCE at a scan rate of 20 mV/sec. The growth behaviour of copolymer is shown in Fig. 3.11.

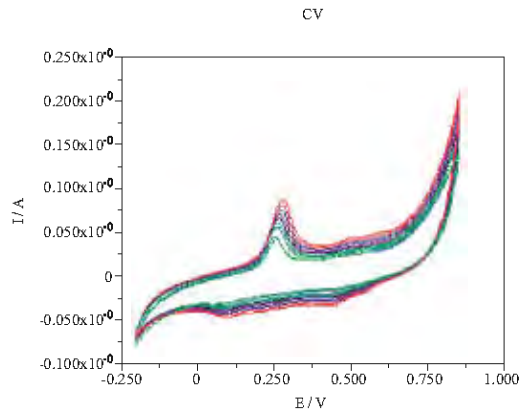


Fig. 3.11 : Growth behaviour of aniline and EDOT in DBSA medium on cycling the potential between 0.2 V to 0.8 V on platinum electrode at a scan rate of 20 mV/sec

Organic Light Emitting Diodes

During the period 2006-2007, R&D was carried out towards the development of Small Molecular Organic LEDs. Device life time testing was main focus of our work. Phosphorescent materials like $Ir(ppy)_3$ has been studied as a electro luminescent material. The devices parameters have been optimized. The devices were fabricated on the pre-patterned and pre-cleaned indium tin oxide (ITO) coated glass substrates via thermal evaporation of the materials. The cleaned ITO substrates were treated to oxygen plasma under reduced pressure for 5 min. A thin film (50 nm) of -NPD, 0.4 % doped with F_4-TCNQ, which works as hole transport layer was deposited on ITO. Then $Ir(ppy)_3$:CBP (30 nm) was deposited over F_4-TCNQ:-NPD. Subsequently 7 nm of BCP and 20 nm of Alq_3 were deposited on $Ir(ppy)_3$:CBP. Here BCP and Alq_3 work as hole blocking and electron transporting materials. Finally LiF(1 nm)/Al(200 nm) cathode was deposited on Alq_3. All the depositions were carried out be thermal evaporation of the materials in vacuum at about $4x10^{-6}$ Torr. After preparation the device was transferred to glove box that resulted exposure of the sample to the ambient. In the glove box the sample was sealed with glass cap using UV epoxy. A maximum efficiency of 28.9 cd/A was achieved at 2.45 mA/cm^2. Device had a continuous running life-time of 400 h at 28 °C.

The I-V-L characteristics of the device are shown in Fig. 3.12.

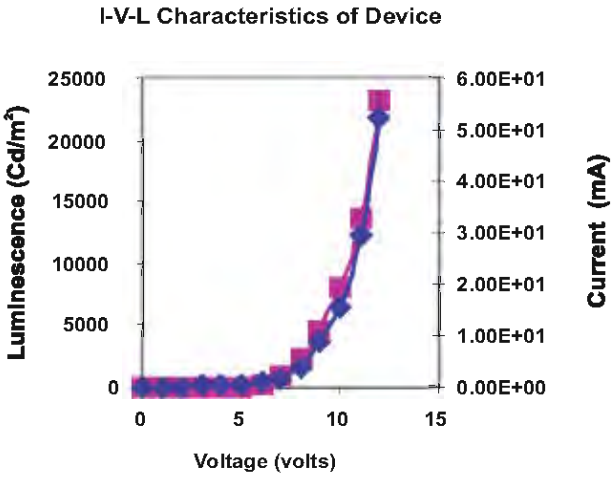


Fig. 3.12 : I-V-L characteristics of the OLED device

Cholestrol biosensor

Cholesterol biosensor based on N-(2-aminoethyl)-3-aminopropyl-trimethoxysilane self-assembled monolayer.

Cholesterol oxidase (ChOx) has been covalently immobilized onto two-dimensional self-assembled monolayer (SAM) of N-(2-aminoethyl)-3-aminopropyl-trimethoxysilane (AEAPTS) deposited on the indiumtin oxide (ITO) coated glass plates using N-ethyl-N0-(3-dimethylaminopropyl) carbodiimide and N-hydroxysuccinimide (EDC/NHS) chemistry. These ChOx/AEAPTS/ITO bioelectrodes are characterized using contact angle (CA) measurements, UVvisible spectroscopy, atomic

force microscopy (AFM), electrochemical impedance technique, and Fourier transform infrared (FTIR) technique. The covalently immobilized ChOx-modified AEAPTS bioelectrodes are used for the estimation of cholesterol in solution using UVvisible technique. These cholesterol sensing bioelectrodes show linearity as 50 to 500 mg/dl for cholesterol solution (Fig. 3.13), detection limit as 25 mg/dl, sensitivity as 4.499 x 10^{-5} Abs $(mgdl)^{-1}$, Km value as 58.137 mg/dl (1.5 mM), apparent enzyme activity as 1.81 x 10^{-3} U cm^{-2}, shelf life of approximately 10 weeks, and electrode reusability as 10 times.

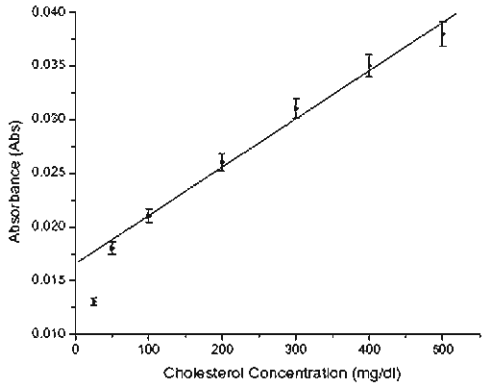


Fig. 3.13 : UVvisible absorbance curve as a function of cholesterol concentration.

Sol-gel based cholesterol biosensor

Cholesterol oxidase (ChOx) and cholesterol esterase (ChEt) have been covalently immobilized onto tetraethylorthosilicate (TEOS) solgel films. The tetraethylorthosilicate sol-gel/ChEt/ChOx enzyme films thus prepared have been characterized using scanning electron microscopic (SEM), UVvis spectroscopic, Fourier-transform-infrared (FTIR) spectroscopic and amperometric techniques, respectively. The results of photometric measurements carried out on tetraethylorthosilicate sol-gel/ChEt/ChOx reveal thermal stability up to 55 °C, response time as 180 s, linearity up to 780 mg/dl (12 mM), shelf life of 1 month, detection limit of 12 mg dl^{-1} and sensitivity as 5.4×10^{-5} Abs./mgdl.

DNA biosensor

Polypyrrole-Polyvinyl sulfonate based DNA biosensor

Double-stranded calf thymus (dsCT)DNA was electrochemically entrapped into polypyrrole-polyvinyl sulfonate (PPy-PVS) films deposited onto indium tin oxide (ITO) coated glass plates. These dsCTDNA entrapped PPy-PVS/ITO films were characterized using cyclic voltammetry, UV-visible, Fourier transform infrared (FTIR), scanning tunneling microscopy (STM), and electrochemical impedance measurements. Attempts were made to use these dsCTDNA entrapped PPy-PVS/ITO films for detection of 2-amino anthracene (0.001 6 ppm) and 3-chloro phenol (0.055 ppm) (Fig. 3.14) revealed a response time of 30 s and a shelf life of approximately 25 weeks when stored under desiccated conditions at 25 °C. The addition of salts such as Ca^{2+}(250

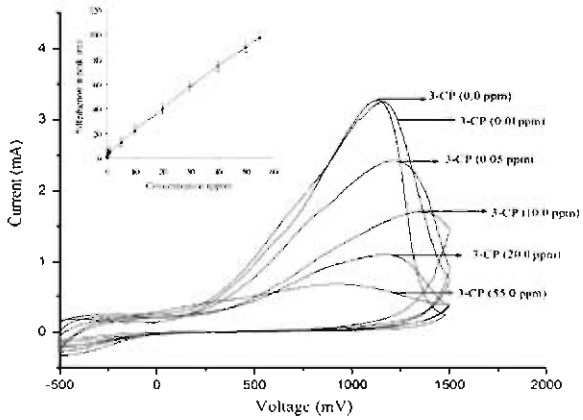


Fig. 3.14 : Typical CVs obtained for dsCTDNA entrapped PPy-PVS films showing a decrease in the peak height of guanine oxidation for increasing concentration of 3-CP at a scan rate of 20 mV/s in phosphate buffer (0.05 M, pH 7.0). The inset shows a linear plot of percentage peak area reduction as a function of concentration of 3-CP (0.055 ppm)

ppm), Mg^{2+}(200 ppm), Cl-1560 ppm), and Na^{+}(150 ppm) ions contained in water does not affect the observed amperometric response of the disposable dsCT-DNA entrapped PPy PVS film-based electrochemical biosensor.

Organic Inorganic Hybrid Nanocomposites for Sensing Application

The following nanocomposite thin films of conducting polymer and metal oxide nanoparticlea have been fabricated successfully using vacuum evaporation technique. The as grown thin was found to sensitive for the gas sensing application

Fabrication and Characterization of Polyaniline ZnO Hybrid Nanocomposite Thin Films

Polyailine (PANI) - ZnO nanocomposite thin film have been successfully fabricated on glass substrates by using vacuum deposition technique. The as-grown PANI-ZnO nanocomposite thin films have been characterized using analytical techniques. X-ray diffraction of as-grown film shows the reflection of ZnO nanoparticles along with a broad peak of PANI. The surface morphology of nanocomposite films has been investigated using scanning electron microscopy and atomic force microscopy. The hypsochromic shift in UV absorption band corresponding to π-π^* transition in polymeric chain of PANI and a band at 504 cm^{-1}due ZnO nanoparticle has been observed in the FTIR spectra. The hydrogen bonding between the imine group of PANI and ZnO nanoparticle has been confirmed from the presence of the absorbance band at 1151 cm^{-1} in the FTIR spectra of the nanocomposite thin films.

Aniline Formaldehyde condensate-tungton oxide nanocomposite thin film for the detection of NOx gases.

The nanocomposite of aniline formaldehyde condensate (AFC)-WO_3 was synthesized by in situ chemical polymerization in acidic medium and its thin film has been fabricated successfully using vacuum deposition technique on Platinum inter digitated electrodes deposited on glass substrate. X-ray diffraction of as grown film shows the reflection of WO_3 and H_2O. WO_3 along with broad peak of AFC. The surface morphology of nanocomposite films investigated using scanning electron microscopy reveals the uniform distribution nanosized WO_3 embeded in polymer matrix. The NOx gas sensing characteristics of prepared AFC-WO_3 thin films were studies by measuring the change in resistance with time (as shown in Fig. 3.15). The sensor was operated at room temperature showing a response time of 15 second and recovery time of 5 minute.

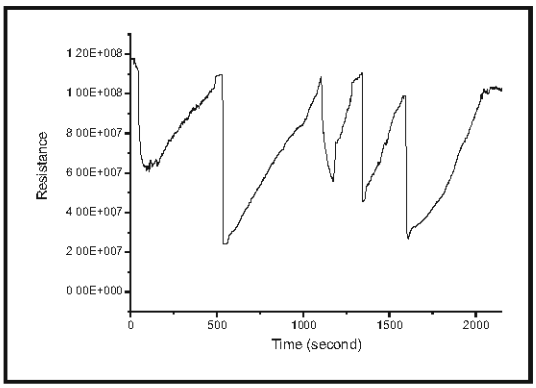


Fig. 3.15 : NOx gas sensing characteristics of prepared AFC-WO_3 thin films

Hybrid cross-linked polyaniline WO_3 nanocomposite thin film using thermal vacuum deposition technique for NOx gas sensing

The nanocomposite thin film of cross-linked polyaniline (derived from polyaniline and aniline formaldehyde condensate (AFC) i.e., CLPANI) and WO_3 has been fabricated using vacuum thermal evaporation technique.

X-ray diffraction pattern of as grown film shows the broad reflection of polymer along with the mixed reflection of nonhydrated and hydrated WO_3 particles. The uniform dispersion of WO_3 nanoparticles in CLPANI network has been investigated using scanning electron microscopy. The broadness in the absorption band at 320 nm corresponds to PANI and AFC-WO_3 nanocomposite confirming the cross-linking between the polymer units. The NOx gas sensing characteristics of vacuum deposited CLPANI -WO_3 thin films have been studied (Fig. 3.16) by measuring the change in resistance with respect to time. The sensor was operated at room temperature, which could extend the shelf life of the sensor. The response time of 15 second and recovery time of 5 minute have been achieved.

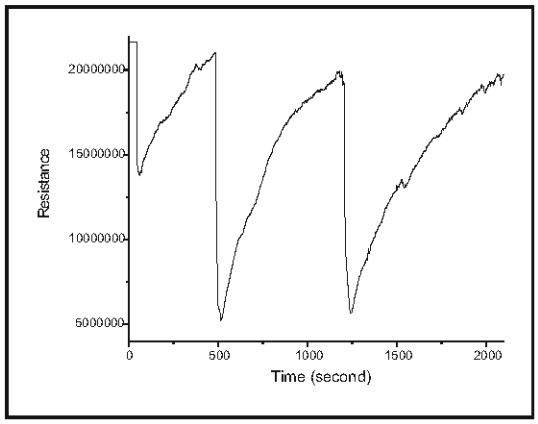


Fig. 3.16 : Resistance vs Time for CLPANI-WO_3 on the exposure of NOx

ICPs based Biopolymer-metal oxide nanocomposites for sensor probes

The current prospective of material research has been devoted to reformation of technologies in cheaper and eco-friendly manners. The electrically conducting polymers (ICPs) based nanocomposite materials are widely used in the solar cells, sensors, electronic shielding, environmental sensitive membranes, etc. as a principal component. Currently, I am engaged in the synthesis of electrically conducting-redox biopolymer-metal oxide nanocomposite for the chemical, gas and biosensor applications. Bio-based polymers have unique physiochemical properties and make attractive an excellent electroactive redox environmental friendly biocompatible material through wet chemical routes. These nanocomposites have mesopores that is controlled by thermal curing or by in situ process. The development of mesopores on the materials provides significant extension by creating large surface areas for the interaction of analytes. It is observed that such materials have advocate electrical and ion conducting features that provide unique physical signals for the detection of analytes. Hence, nanocomposites of biopolymer ICPs could be used as semiconductor, superionic conductor, ion sensitive semiconductor field-effect transistor (ISFET) probes for the fabrication of electronic sensor devices.

Organic Photovoltaic Devices

To develop improved materials for organic solar cells fundamental investigations were carried out in a potential conjugated polymer viz. poly (3-hexylthiophene) (P3HT) that finds applications as electron donor in donor-acceptor interpenetrating bulk heterojunctions, the most efficient combination used globally in the development of organic solar cells. In fact, an **innovative** work was carried out in P3HT by way of studying the effect of interface layer, curing temperature and **polarization** on its charge transport behaviour in the configuration ITO/PEDOT:PSS/P3HT/Au diode structure. Some unique features were observed in these investigations. After spin depositing P3HT films were cured at different temperatures viz 80, 100, 120 and 140 °C, respectively. It was found that the best possible J-V behaviour in P3HT was obtained at ~120 °C. Further, it was found that

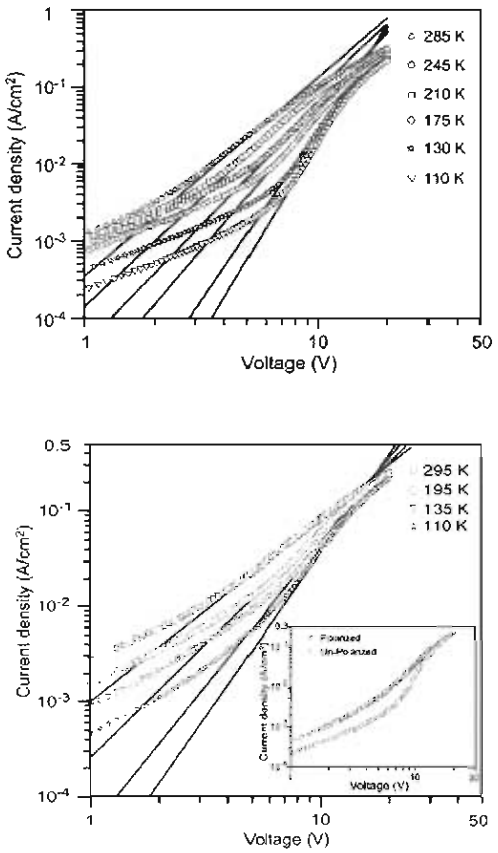


Fig. 3.17 : (a) J-V curves for unpolarized case and (b) for polarized case

incorporation of PEDOT:PSS interface layer enhances the hole injection into P3HT and switches the conduction from ohmic to space charge limited conduction. Subsequently the J-V behavior of P3HT was studied at different temperatures in the range 110-295 K with no-polarization (Fig. 3.17 a) and under polarization (Fig. 3.17 b) of the films prior to conductivity measurements. Symbols represent the experimental data and solid lines represent the theoretical plots at different temperatures. The values of calculated transport parameters are H_b=5.9x10^{17} cm^{-3}, Nv=2x10^{17} cm^{-3}, Tc=450 K and E_a ~39 meV for unpolarized case whereas the values of the same parameters for the polarized case are H_b=5.3x10^{17} cm^{-3}, Nv=2x10^{17} cm^{-3}, Tc=270 K and E_a~ 23 meV. Inset in Fig.3.17b shows the observed J-V characteristics of the polarized and unpolarized samples at 110 K.

From these parameters it is seen that the polarization effect in P3HT results in i) decrease in T_c from 450 K to 270 K, ii) decrease in H_b from 5.9x10^{17} to 5.3 x10^{17}, iii) making traps shallower i.e. that the characteristic depth reduces from 39 meV (unpolarized case) to 23 meV (polarized case). All these effects of hole transport were attributed to trap model having traps distributed exponentially in space. In essence, this work is an important fundamental contribution on the charge transport aspect of P3HT that may result in the development improved devices, especially organic solar cells.

Automation Group

Developed the several computer controlled systems like:

Fully Computer controlled Coaxial Microcalorimeter set-up (a primary standard setup) for the measurement of power in the frequency range 10 MHz to 20 GHz all the instruments, required for measurement and control, have been successfully interfaced with the computer using Visual BASIC-5.0 language.

Electronic circuitry for 89C51 microcontroller based water pollution monitoring system for taking data from developed 8 different BOD sensors using embedded technology along with the interface circuit with Keithley Instruments Inc 6½ digit multimeter Model 2700. This 6½ digit multimeter when interfaced with computer gives resolution of 0.01nA. The program for 89C51 is written in 89C51 assembly language and the program for online data acquisition and graph plotting on the screen is written in Visual BSAIC-5.0 language. This system has been developed in collaboration with Institute of

Genomics and Integrative Biology (IGIB), (CSIR) Mall Road, University of Delhi and Central Pollution Control Board (CPCB), Karkar Dooma Court, Delhi. Rigoroustesting of the same is going on in CPCB, Delhi.

Brought the liquid helium plant in order by studying it's electronic and electrical circuitry from the manual and sequentially checking them, correcting the faults after locating them and if found necessary replacing the old electronic circuit with new developed modified ones. The helium plant is functioning satisfactorily.

Developed an electronic circuit around 89C51 for controlling the very old existing MLW-MK-70 bath. For the measurement of temperature of the bath one industrial platinum resistance thermometer (Pt-100) has been employed and the data acquisition from thermometer has been done using 4½ digit ADC. This way a resolution of 0.01°C is obtained. The controlling of the power has been done by controlling the firing angle by a developed firing angle control circuitry and a triac. The instructions for controlling the firing angle are given by the 89C51. In the bath a special provision for creating the varying environment has also been incorporated. The complete circuit has been tested and is functioning satisfactorily.

The program for controlling the electronic circuit, which will be controlling the MLW-MK-70 bath, has been developed in 89C51 assembly language and is working satisfactorily.

Developed an analog electronic circuitry for PID controller to compare it with the digital PID controller (i.e. to compare hardware control circuit with the software controlled system).

Helped several scientists in bringing their systems in operation.

D Liquid crystal materials and devices

Design, Development and Fabrication of Array Sensor Chip For Biological Applications

Micropatterning of biological molecules (proteins, immunoglobulins, peptides) onto various surfaces using soft lithographic techniques

Patterning of biomolecules with micron and submicron resolution on to different solid surfaces is central to the development of advanced biosensors, fundamental studies of cell biology and tissue engineering. All round efforts are being made to develop simple techniques for patterning of biomolecules with high resolution. Soft lithography techniques (microcontact printing of self-assembly forming thiols and silanes and microfluidic networks and devices) have witnessed a tremendous growth in recent years for forming two dimensional patterns of functional biomolecules suitable for binding primary and secondary antibodies to fabricate advanced biosensor chips.

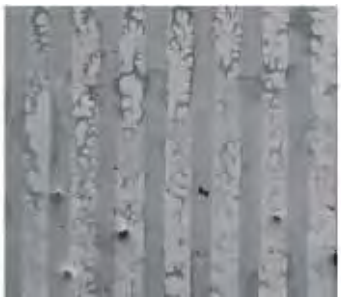
A simple techniques based on microcontact printing of hexadecane thiol (HDT) and polyethylene glycol-thiol (PEG-thiol) has been used to create pattern structure on gold-coated substrate exhibiting high hydrophobicity and high hydrophillicity, respectively. The hydrophobic regions strongly support the adsorption of proteins while the hydrophilic regions strongly resist the adsorption of proteins.

Fig. 3.18 shows the SEM pictures of HDT, HDT & PEG and fibronectin deposited regions of HDT. It is clearly seen from the above figure that fibronectin is selectively deposited on HDT coated regions while there is very little

deposition of the protein on the PEG-coated regions. This will form the template for the deposition of primary and secondary antibodies.

SEM of: HDT (50X),

HDT & PEG thiol(50X)



Deposition of fibronectin on HDT

Fig. 3.18 : SEM of HDT, HDT & PEG and fibronectin deposited on HDT

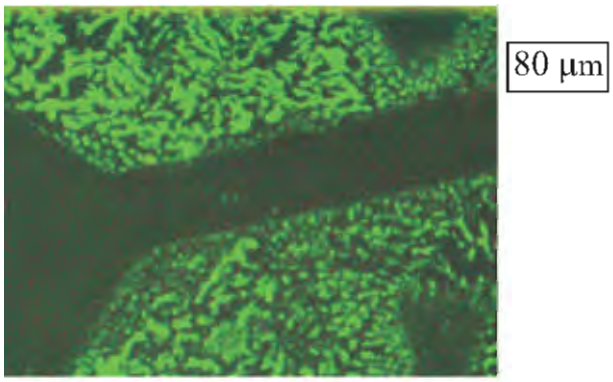


Fig. 3.19: Fluorescence micrographs of selectively deposited BSA_FITC conjugated molecules on HDT coated regions.

The pattern hydrophobic and hydrophilic regions have been further utilized to selectively deposit bovine serum albumin (BSA) tagged with FITC dyes. The following Fig.3.19 shows the selective deposition of BSA-FITC conjugated molecules as seen under a fluorescence microscope. These experiments would form the basis to fabricate fluorescence based array biosensors for various biological applications.

Micropatterning of Alignment Layers To Produce Pattern Liquid Crystal Displays

A new technique has been developed to produce patterned liquid crystal displays showing homeotropic and planar orientation with a few micron resolution in the same azimuthal plane. The technique is primarily based on microcontact printing of alignment layer of OTS to produce homeotropic alignment to the specified region of the substrate and formation of planar orienting layer by self-assembly technique in the remaining region of the substrate. Fig. 3.20 shows the homeotropic alignment in the selected regions shown by dark lines and the remaining region shows no preferred alignment of liquid crystals. It is quite clearly seen from this figure that there is no variation in the intensity of dark lines on rotating between crossed polarizers.

Fig. 3.21 shows the homeotropic and planar orientation in the selected regions. The homeotropic alignment (dark strips) showed no variation in the intensity on rotating between cross polarizers while the planar regions showed

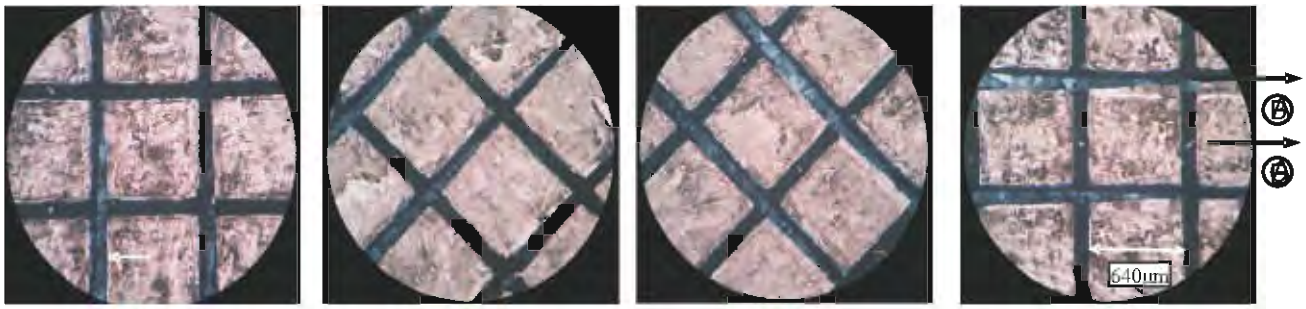


Fig. 3.20 : Photographs showing Homeotropic alignment (B) of a liquid crystal cell rotated clockwise between cross polarizers from 0^0 to 135^0 at an interval of 45^0. Uncoated area shows no preferred alignment (C).

dark and bright regions at intervals of 45° due to birefringence of liquid crystalline material.

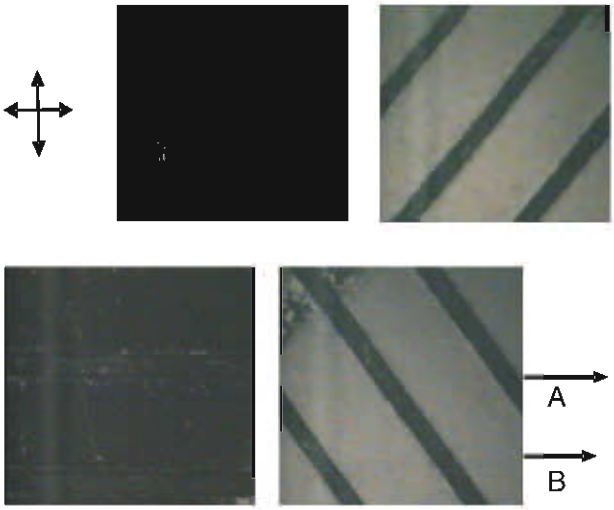


Fig. 3.21: Photographs showing Planer alignment (A) as well as Homeotropic alignment (B) of a liquid crystal cell rotated clockwise between cross polarizers from 0^0 to 135^0 at an interval of 45^0.

The planar alignment of liquid crystals takes place only on the area having bilayer of APTES & cinnamoyl moieties. Area patterned with OTS showed homeotropic alignment of liquid crystals. Alignment direction is governed by the polarization direction of the UV-light and can be varied locally. These two independent techniques have been combined to produce samples showing both homeotropic as well as planer alignment of liquid crystals in a single cell. This has given rise to the possibility of creating new storage liquid crystal displays. The technique may also be used to produce patterned liquid crystal displays. Both the alignments have been found to be stable with time and temperature.

Development of self-cleaning coatings on glass substrates and design of coating equipment.

Sun-Shielding & Self Cleaning Coating on Window Glass

An equipment have been designed for obtaining thin films of metal oxides by sol-gel dip coating technique. The equipment described here is cheap as compared to the conventional coating equipment. Further its operation is simple, as adjustment of coating parameters can be done by simple knob operation. This equipment gives thin film coating on both sides of the substrate simultaneously. Uniform film thickness can be obtained on large area substrates up to 1 m x 1 m with the equipment reported here.

The coating solution is partially hydrolyzed metal alkoxide solution with catalyst. The composition of different constituents is adjusted in such a manner that the solution can be reused for coating up to six months if stored under sealed conditions. The solid films obtained from

this solution are scratch proof and are stable under various environmental conditions.

Simple glass window panes coated with films using the said technique blocks up to 30% if IR radiations and allows up to 80% of the visible part of the spectrum. These films absorb UV radiations to excite electrons from the valence band to the conduction band. Valence band electrons converts helps in dissociating the organic matter which make the window pane dirty while valence band holes helps adsorb OH groups on the surface thereby making the surface superhydrophillic. Both these properties are very important from architectural point of view. Such glass used as window pane reduces the heating and cooling cost of the building also their cleaning require little labour and less detergents which saves on the cleaning costs.

इलेक्ट्रॉनिक पदार्थ

ELECTRONIC MATERIALS

इलेक्ट्रॉनिक पदार्थ

इलैक्ट्रॉनिक पदार्थ प्रभाग इन पदार्थों पर आधारित व्यापक श्रेणी के नवीन पदार्थों और विभिन्न उत्पादनों व साधनों में अनुसंधान और उन्हें विकसित करने में संलग्न है और जिसका उद्देश्य इंडस्ट्री को वाणिज्यिक उपयोग के लिए प्रौद्योगिकी को हस्तांतरित करना है पदार्थों की श्रेणी में विद्युत संदीप्तिशील पदार्थ, प्रकाश वोल्टीय पदार्थ और इलैक्ट्रोक्रोमिक पदार्थ से विभिन्न प्रकार के नैनो संरचित पदार्थ तक उच्च ताप अतिचालक पदार्थ, उन्नत सिरेमिक पदार्थ और पालिमेरिक पदार्थ शामिल हैं। इन पदार्थों को सघन और तनु फिल्म प्रकार के साथ साथ वृहद प्रकार का इस्तेमाल करते हुए उत्पाद विकसित किए गए। इसके अतिरिक्त, इस प्रभाग की मुख्य गतिविधियां सतह और नैनो संरचना का अभिलक्षणन और अध्ययन है । प्रभाग में वर्ष 2006 और 2007 के दौरान निम्न गतिविधियों में अनुसंधान एवं विकास कार्य किए गए।

संदीप्तिशील पदार्थ और साधन

यह ग्रुप सघन और नैनो आकार के अकार्बनिक फॉसफर्स और संबद्ध साधनों को विकसित करने में संलग्न है। प्रदीप्त और संदीप्त के जीवन काल के मापन हेतु काल विघटित स्पैक्ट्रम विज्ञान के लिए प्रयोगात्मक सुविधाओं का सृजन तथा Ce डोप्ड 4AG फॉसफर्स को विकसित करने के कार्य के साथ साथ नीले LED के साथ संयोजन में ठोस विद्युत के लिए उपयुक्त नए अवनत रूपांतरण फॉसफर्स आदि इस ग्रुप के मुख्य विशिष्ट कार्य हैं।

पदार्थों की प्लाज़्मा प्रक्रिया

PECVD तकनीक द्वारा सूक्ष्म/नैनो क्रिस्टलीय सिलिकॉन फिल्म का निक्षेपण, कार्बन (DLC) फिल्म की तरह सिलिकॉन समावेशित डायमण्ड और फिल्टरित कैथोडिक वैक्यूम द्वारा निक्षेपित चतुष्फलकीय अक्रिस्टलीय कार्बन फिल्में इस ग्रुप की मुख्य गतिविधियां हैं ।

सिलिकॉन प्रकाश वोल्टीय

सोलर सैल पर सरंध्र सिलिकॉन परतों और सूक्ष्म विन्यास सतहों से युक्त कम कीमत वाली अपरावर्ती आवरण (विलेप) की खोज, सोलर सेल की गतिशील विशेषताएं और सोलर सेल की शंट और क्रमिक प्रतिरोधों की गणना की नई पद्धति के विकास के साथ साथ ग्लूकोज़ अनुभूति के लिए एक गतिहीन इन्ज़ाइम रिएक्टर हेतु सिलिकॉन में सूक्ष्म वाहिका (माइक्रो चैनल) की संरचना और सरंध्र (Porous) सिलिकॉन का विकास इस ग्रुप की मुख्य गतिविधियां रही हैं ।

नैनो संरचित पदार्थ और साधन

तीव्र स्विच गतिक युक्त सभी सोलिड स्टेट वैद्युतक्रोमिक साधनों का विकास, फोटो फिज़िकल, अवसंरचनात्मक और रूपात्मक गुणों पर रेडॉक्स डोपिंग का प्रभाव और नवीन पॉलिमर वैद्युत साधनों हेतु P3HT और P30T मैट्रिक्स के dc वैद्युत चालकता का अध्ययन, गैस सैंसर्स अनुप्रयोगों के लिए नैनो क्रिस्टेलाइन टिन आक्साइड पाउडर्स के गुणधर्मों पर पृष्ठ सक्रियक (Surfactants) के प्रभाव का अध्ययन और उपक्रम, Cd:Se प्रणाली के कैपड मोनो डिस्पर्स्ड (समापकीर्ण) नैनो पार्टिकल्स का अध्ययन इस ग्रुप के मुख्य कार्य हैं ।

उच्च ताप अतिचालकता, उन्नत सिरेमिक (मृत्तिका–शिल्प) और प्रकाशिक थिन फिल्म

यह ग्रुप विभिन्न ऑक्साइड पदार्थों के अनुसंधान और विकास में लगा हुआ है । अतिचालक ट्यूब्स, टेप्स और संशोधित विशिष्टताओं सहित संधियों (जोड़) का विकास, बीटा अल्युमिना के माइक्रोवेव सिंटरिंग की तरह उन्नत सिरेमिक पदार्थों पर कार्य, गैस सैंसर्स के लिए सघन आक्साइड फिल्म और बायो–सैंसर्स से प्राप्त सोल–जेल, और फाइबर प्रकाशिक संप्रेषण प्रणाली के लिए संकीर्ण बैंडपास फिल्टर्स की तरह तनु फिल्म प्रकाशीय परत का विकास, चालक पॉलीमर परत के साथ साथ प्लास्टिक लैंस पर अपरावर्ती परत आदि पर कार्य इस ग्रुप की महत्वपूर्ण गतिविधियां रही हैं ।

सतही अध्ययन और नैनो संरचनाएं

इस ग्रुप के कार्यों को नई सीमाओं तक आगे ले जाने के लिए एक नई हीटरोपिटेक्सियल (Heteroepitaxial) प्रयोगशाला का निर्माण किया गया है । TOP/TOPO आवरण युक्त नैनो पार्टिकल्स के आकृति मूलक संयोजनात्मक, संरचनात्मक और आकृति मूलक पहलुओं का अध्ययन एक महत्वपूर्ण गतिविधि रही है । Si (5512) सतह पर उप एकपरत क्षेत्र व्यवस्था में Sb के अवशोषण पर व्यापक UHV का भी अध्ययन किया गया है ।

ELECTRONIC MATERIALS

The Division of Electronic Materials has been engaged in research and development of a wide range of novel materials and various products and devices based on these materials, with the aim of transferring the technology to industry for commercial exploitation. The materials range from electroluminescent materials, photovoltaic materials and electrochromic materials to nanostructured materials of various types, high temperature superconducting materials, advanced ceramic materials and polymeric materials. The products developed utilize these materials in thin and thick film form as well as in bulk form. Moreover, the study and characterization of surfaces and nanostructures is a major activity in this division. During 2006-07 the R & D work in the division was carried out under the following activities:

LUMINESCENT MATERIALS AND DEVICES

This group has been engaged in the development of inorganic phosphors in bulk and nano form and related devices. Creation of experimental facility for time resolved luminescence spectroscopy for measurement of fluorescence and phosphorescence lifetimes and work on developing Ce doped YAG phosphors as well as new down conversion phosphors suitable for solid state lighting in conjunction with blue LED are the main highlights of the work.

PLASMA PROCESSING OF MATERIALS

The deposition of micro/nanocrystalline silicon films by PECVD techniques, deposition of silicon incorporated diamond like carbon (DLC) films and tetrahedral amorphous carbon films deposited by filtered cathodic vacuum arc technique have been the main activities of the group.

SILICON PHOTOVOLTAICS

The group's main activities have been the investigation of low cost antireflection coatings consisting of porous silicon layers and microtextured surfaces on solar cells, the development of new methods of calculating the shunt and series resistances of solar cells and the dynamic characteristics of solar cells/panels, as well as the development of a porous silicon and microchannel structure in silicon for an immobilized enzyme reactor for glucose sensing.

NANOSTRUCTURED MATERIALS AND DEVICES

The development of novel all solid state electrochromic devices with fast switching kinetics; studies of the effect of redox doping on photo-physical, structural, and morphological properties and dc electrical conductivity of P3HT and P3OT matrices for novel polymer electronic devices; the preparation and studies of the effects of surfactants on the properties of nanocrystalline tin oxide powders for gas sensor applications; and studies of capped monodispersed nanoparticles of the Cd:Se system, constituted the main work undertaken by the group.

HIGH TEMPERATURE SUPERCONDUCTIVITY, ADVANCED CERAMICS AND OPTICAL THIN FILMS

This group is engaged in R & D on various oxide materials. Development of superconducting tubes, tapes and joints with improved characteristics; work on advanced ceramic materials like the microwave sintering of beta alumina, thick oxide films for gas sensors and sol-gel derived biosensors; development of thin film optical coatings like narrow bandpass filters for fibre optic communication systems and antireflection coatings on plastic lenses as well as conducting polymer coatings, have been the major activities of the group.

SURFACE STUDIES AND NANOSTRUCTURES

A new heteroepitaxial laboratorty has been created to carry forward the work of this group to new frontiers. A major activity has been the study of the compositional, structural and morphological aspects of TOP/TOPO capped CdSe nanoparticles. An extensive UHV study of the adsorption of Sb, in the sub-monolayer coverage regime, onto the Si(5 5 12) surface has also been carried out.

Luminescent Materials and Devices Group

This group is engaged in developing phosphors with special emphasis on nanophosphors for applications such as solid-state lighting using blue LED, thin film photoluminescence (PL) and electroluminescence devices, plasma display panel and long persistence phosphors. A new experimental facility for time resolved luminescence spectroscopy has been created with Edinburgh Instruments FLSP920 combined steady state Fluorescence and Phosphorescence lifetime spectrometer (Fig. 4.1). The spectrometer employs time correlated single photon counting technique for lifetime measurement. The sample is repetitively excited

Fig. 4.1 : Combined steady state Fluorescence and Phosphorescence lifetime spectrometer.

using a pulsed light source (ns flash lamp or s Xe flash lamp). Scanning over many pulses, the resultant decay curve viewed on a semilogarithmic scale, indicates the exponential /multiexponential or complex lumines-cence decay kinetics. A representative luminescence decay curve is shown in Fig. 4.2. The spectrometer is being used for groups working in fields related to luminescence apart from in-house R & D work.

Thin film nanophosphors e.g., ZnS doped with Cu, ZnO, $Zn_{1-x}Mg_xO$ have been prepared

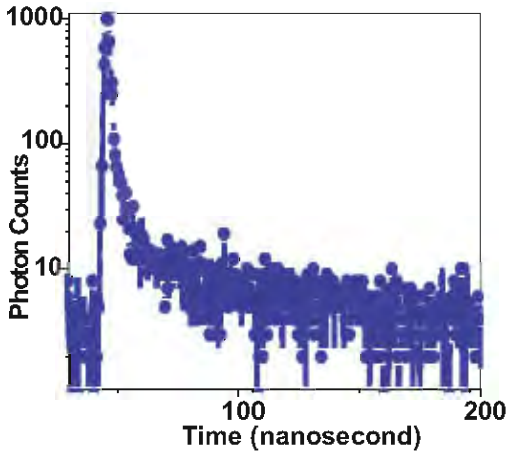


Fig. 4.2 : Decay curve of ZnMgO nanophosphor

under varying processing conditions. Correlation of structural, optical and photoluminescence properties as a function of dopant concentration and quantum size effect has been studied. The group is developing existing (YAG:Ce^{3+}) as well as new down conversion phosphors suitable for solid state lighting in conjunction with blue LED. Nanophosphor of YAG:Ce^{3+} with varying concentrations of Ce^{3+} was synthesized for estimating optimum Ce^{3+} concentration.

Fig.4.3 shows the photoluminescence emission spectra for different Ce^{3+} concentrations, when excited by 450 nm blue light. Aluminate phosphors doped with rare earth in bulk and nano form were synthesized by solid state reaction and auto combustion method, they are excitable by commercial blue LED light and emit in the green and orange. Nitride phosphor ($Sr_2Si_5N_8$: Eu^{2+}) was synthesized by Carbothermal Reduction & Nitridation (CRN) method. The phosphor is excitable by commercial blue LED light & emit in the red.

In order to get complete and full colours in dark, long persistence phosphors (LPP) emitting in primary colours of Green, Blue and Red are very important. The group has already

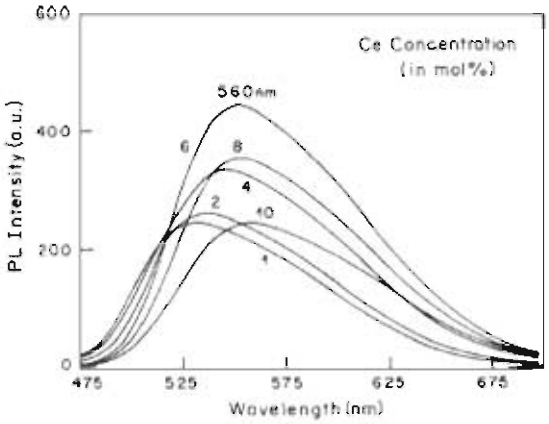


Fig. 4.3: Variation in PL spectrum of YAG:Ce with Ce concentration

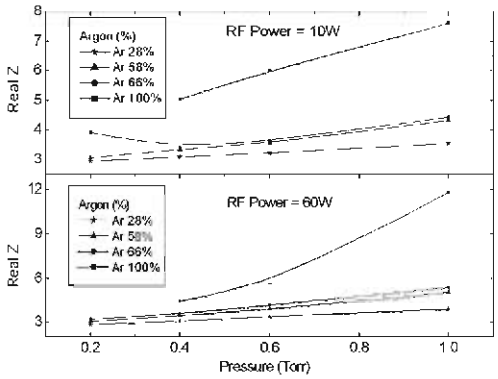


Fig. 4.4: Impedance of SiH_4+ Ar plasma measured as a function of chamber pressure at a fixed consumed RF power of 10 W and 60W for various Ar partial pressures.

developed Green and Blue LPP of persistence time about ten hours. A process to prepare Red light emitting long decay/persistence phosphor excitable with ambient light has been developed. Red emitting LPP was made using different hosts like $(Ca,Zn)TiO_3$, $(Ca,Zn)TiSiO_3$ and Y_2O_2S. The persistence time for red LPP was about two hours. Efforts are going on to improve brightness and persistence time. The DP has filed a patent for, "A Process for Preparation of Metal Oxides with dopants in lower valence state by Combustion Synthesis Technique in nanowire form", in which a modified process has been disclosed to prepare nanocrystalline metal oxides. The DP is interacting with industry (M/s SAMTEL India Ltd.) on a collaborative project on "Development of next generation Plasma Display Panel Technology and 50" High Definition (HD) TV Prototype" in which the group is responsible for synthesis of phosphors for Plasma Display Panels.

Plasma Processed Materials Group

The PPMG group was involved in deposition and characterization of micro/nano crystalline silicon films as a function of various process parameters in a plasma enhanced chemical vapour deposition (PECVD) system for photovoltaic and other optoelectronic applications. In-situ impedance probe analyzer has been used to evaluate the electrical parameters of plasma discharge generated using gaseous mixture of argon and silane in a radio frequency (RF) PECVD technique. The impedance of plasma and consumed power in the plasma as a function of incident power and pressure has been monitored. The results indicate that more RF power is utilized during the plasma discharge of silane and argon mixture which leads to higher plasma density. The same

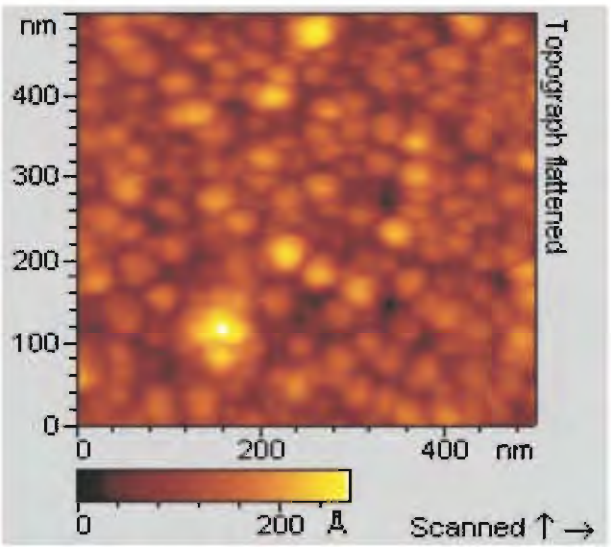


Fig. 4.5 : AFM image of a representative nc-Si:H film deposited by PECVD technique

plasma conditions as in Fig. 4.4 were used to deposit nanocrystalline silicon films. The electrical behaviour of the plasma and process parameters were optimized for the deposition of nanocrystalline silicon thin films. When the applied power was increased, the nanocrystalline phases embedded in amorphous matrix of silicon change. AFM micrographs (Fig. 4.5) show that these films contain nano-crystallites of 20-100 nm size. It has also been observed that nano crystallites in these films enhanced the optical band gap and electrical conductivity. The crystalline fraction in these films was varied from 30% to 80 % with the variation of deposition pressure from 2 to 8 torr. There is an optimum pressure of 4 torr where the maximum growth of nano-crystalline phases was observed. It was found that films deposited under certain set of process parameters show high values of dark conductivity ($\sim 10^{-3}\ \Omega^{-1}cm^{-1}$) with high photoconductivity. A process has also been developed to deposit photoluminescent nanostructured silicon thin films.

The deposition of Si incorporated diamond like carbon (Si-DLC) films using PECVD on various substrates (silicon wafer, glass, metals and plastic) over large area (15.0 x 15.0 cm^2) has been carried out (Fig. 4.6). A novel methodology was applied to achieve high adhesion, involving a-Si:H as an adhesive layer, silicon incorporated a-C:H bulk layer and pure a-C:H surface layer. These films were deposited using SiH_4 and C_2H_2 gas mixtures at different ratios. EDX measurements showed that there is variation in silicon to carbon ratio as function of gas feed ratio of SiH_4 and C_2H_2. Dilution of these gases was also performed using argon. The main objective was to obtain diamond like properties and good substrate adhesion, particularly for non carbide forming substrates for tribological applications in industry.

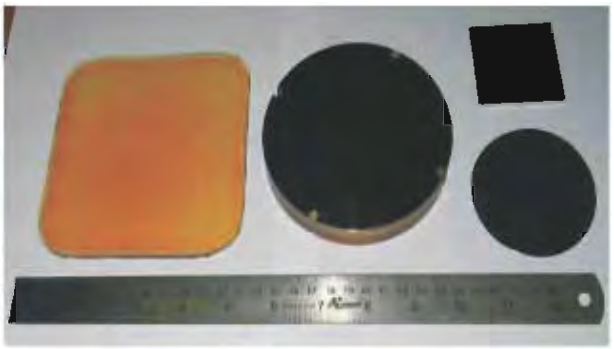


Fig. 4.6 : Si-DLC films on glass and metals

The stress measurements of undoped ta-C films have been carried out using X-ray technique. The results of photoluminescence, XPS, XAES and Raman have been thoroughly analyzed. Residual stress of 0.09 - 0.71 GPa, optical bandgap of 2.4 - 2.7 eV and sp^3 content 80-90 % have been obtained. Modifications in the set-up to enhance the deposition rate and advance the incoming ion beam further have been made. The modified arc system for producing a new form of amorphous carbon thin film having nanoparticle inclusion has also been conceived and designs involving both the cathodic jet carbon arc (CJCA) and anodic jet carbon arc (AJCA) techniques have been made.

Silicon and Silicon Devices Group

The group has been investigating low cost and effective antireflection coatings (ARC) on solar cells, e.g. porous silicon (PS). To know the potential of PS a model calculation was made and the increase in cell short-circuit current J_{sc} after application of an ARC was calculated to be about 37%. The effect of orientation on the growth rate and optical properties of PS layers grown on p-Si wafers was investigated, on <100>, <110> and <111> oriented wafers. The PS ARC of thickness 70 nm showed increase ~26% in J_{sc}. This work is important from the

point of view of large scale production of large area mc-Si terrestrial SPV cells where PS is used as ARC.

A new method of measurement of series resistance R_s and shunt resistance R_{sh} of a silicon solar cell was developed. It enables determination of values of R_{sh} and R_s with the intensity of illumination, is very convenient to use and has been applied to silicon solar cells having finite values of R_{sh}. It has been found that R_{sh} is independent of intensity but R_s decreases with both the intensity of illumination and the junction voltage.

Texturization of mc-Si in alkaline or acidic solution was studied, with carefully chosen compositions of chemical components [$HF:HNO_3:H_2O$] and temperature. The reflectivity of these acidic textured surfaces were measured by a spectrophotometer and it was found that the solution $HF:HNO_3:H_2O$ :: 10:1:4 gives lowest reflectivity of ~ 10%. However, this is not good enough and usually Si_3N_4 coating is applied by plasma enhanced chemical vapour deposition (PECVD) method (not a low-cost process) to suppress the reflectivity further. Growth of PS on the textured surface yields lowest reflectivity of about 4-6% in the wavelength range 400-1000nm (Fig. 4.7).

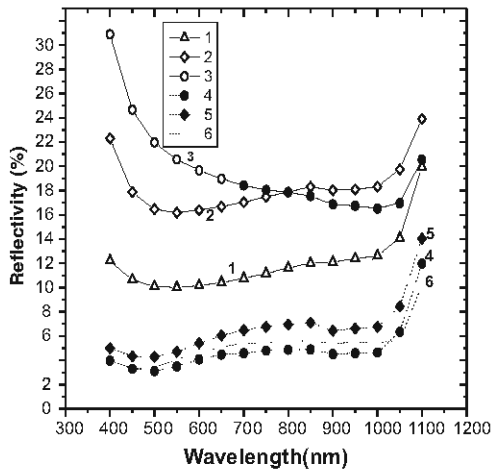


Fig. 4.7 : Reflectivity data for Si surfaces textured with various solution compositions, and for textured surfaces with PS grown on them for various times.

Solar cell panels are interfaced with external load through an electronic power conditioner and a battery to supply uninterrupted power to the load at the desired power rating. To design an efficient and reliable power conditioner, a thorough understanding of both the static and dynamic characteristics of the cell/panel is necessary. To study the dynamic characteristics that have not received much attention, the impedance spectroscopy (IS) technique has been applied to an induced n-p-p^+ structure (created by deposition of semitransparent Al and Pd layers on the two side of a p-Si wafer), developed earlier to measure the lifetime in silicon, in order to understand the device structure, underlying physics and role of interfaces in determining the lifetime values. It appears that the properties of the aluminium or palladium layers, or both, are affected in the ambient, influencing the interfacial properties (either the Al/Si or Pd/Si interface, or both) of the induced n-p-p^+ junction structure (Fig. 4.8).

Silicon surfaces covered with PS provide

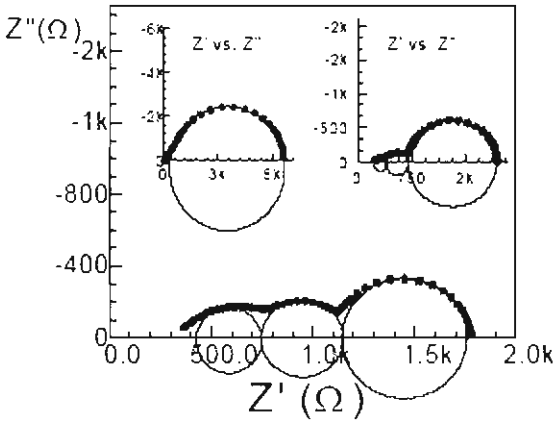


Fig. 4.8 : Impedance spectra of a n-p-p^+ structure, under vacuum (left), after breaking vacuum (right) and after long atmospheric exposure (bottom).

large enhancement in surface area and thus a vast increase in enzymatic turnover when compared to non-PS samples. In order to increase the surface area further, the PS layer has been grown on microchannels on oxidized silicon wafers. PS thus grown had micro- as well nanometric pores. This structure is most desirable for application in immobilized enzyme reactor (Fig. 4.9) for glucose sensing because microstructures are required for rapid flow of fluid and nanostructures for increase in

Fig. 4.9 : Micro Enzyme Immobilized Reactor (μIMER) for glucose sensing.

surface area. This structure has been embedded between two glass plates and two holes were made on the upper glass slide for injection of liquid glucose and for placement of Clark type oxygen electrode to pickup monatomic oxygen ions and generate a current in the nA-μA range, depending on the concentration of glucose in the unknown sample.

Nanostructured Materials and Devices

Electrochromic devices

Novel ionogels encompassing an ionic liquid encaged in an inorganic matrix were synthesized by sol-gel chemistry. The ability of these highly conducting ionogels (~10^{-2} S cm^{-1} at 25 °C) to act as liquid electrolytes inspite of their solid form has been exploited in inorganic electrochromic devices based on nanostructured tungsten oxide (WO_3) and Prussian blue (PB) electrodes. These devices exhibit extremely fast switching kinetics and render the electrolyte to be the best and only candidate for the realization of fast all solid state electrochromic devices. The active electrode area of the device was 4 cm × 8.5 cm and the device colors / undergoes a 90 % drop in transmittance in 2 s and bleaches / experiences a 90 % enhancement in transmittance in 0.8 s. Such rapid switching behaviour has seldom been reported before for solid-state inorganic electrochromic devices.

Conducting Polymers

The effect of redox doping on photo-physical, structural, and morphological properties and dc electrical conductivity of P3HT and P3OT matrices has been examined. The dc conductivity is predominantly governed by Mott's 3-dimensional variable range hopping (3D-VRH); however, below 40 K tunneling seems to dominate. A slight deviation from 3D-VRH to 1D-VRH is observed with an increase in doping level. This deviation is attributed to the induced expansion in crystallographic lattices due to insertion and intercalation of dopant species in between ππ stacks and to the

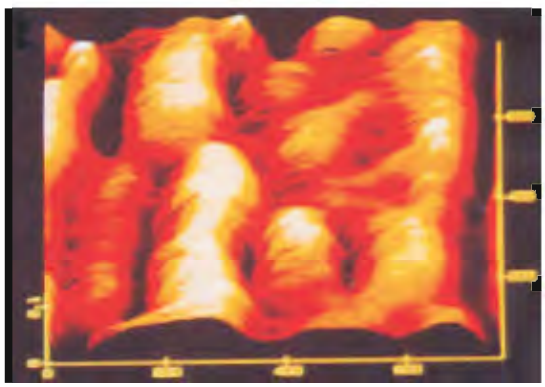


Fig. 4.10 : AFM image in nm showing periodic nanostructuring of P3OT-Fe matrices when P3OT-Fe nanocomposite films were grown under applied magnetic field.

formation of discrete conducting domains separated by undoped regions of polymer matrices. A cost effective chemical synthesis and single step magnetic patterning of iron nanoparticles (size ≈ 100 nm) in a semiconducting P3OT polymer matrix is shown in Fig. 4.10. A large enhancement (~90%) in magneto-resistance in $La_{0.82}Sr_{0.18}MnO_3$ (LSMO) layers by incorporating a P3OT polymer layer in between them has been observed. This enhancement originates from the magnetic field induced spin-polarized carrier injection from the manganite to the semiconducting polymer layer and is found to be temperature dependent. The possibility of the formation of efficient electron-conducting percolative network in an efficient hole conducting polymer matrix has been explored. This work has demonstrated, for the first time, the formation and characterization of a viable percolative network of SWCNTs through self-assembly during solution evaporation. These co-aggregates can be regarded as nanoscopic pn-heterojunctions, which may serve as valuable models for photo-induced electron-transfer processes in solid-state devices.

Nanocrystalline materials and gas sensors

Nanocrystalline tin oxide powder was prepared using hydrosol /hydrothermal technique. The effect of various surfactants addition on the particle size and grain morphology was investigated. The gas sensitivity of the derived sensors were investigated for various gases like ethanol, acetone, TMA, DMA, ammonia, NOx, CO, LPG and CNG. A systematic study was made on morphology, structure and the sensor properties of thick films achieved by powders prepared by various chemical routes and a comparison was made with the commercial WO_3 powder. Synthesis of II-VI chalcogenide CdS, ZnS powder was undertaken using various chemical routes like reverse micelle, solvothermal and hydrothermal, under a variety of synthesis conditions. 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.

Capped monodispersed nanoparticles

A variety of approaches have been considered to arrest the growth of particles of desired size, in a chemical precipitation method. TOPO capping to arrest the growth of CdSe particles was employed. A change in the ratio of Cd:Se during the precipitation conditions produced particles of different diameters. Lower Cd/Se ratios result in the large size particle regime with high quantum yield, whereas higher Cd/Se ratios were found to produce particles of smaller size. The crystallite sizes were measured by the blue shift of the absorption edge with respect to bulk CdSe and were found to be about 14.0 and 5.0 nm, respectively. The quantum confinement effect becomes apparent when the semiconductor crystal size is smaller than the bulk Bohr diameter of the CdSe exciton, about 11.2 nm. Different crystallite sizes less or greater than the Bohr diameter of the CdSe exciton were used in order to study the size quantization effects of CdSe nanocrystallites upon its interaction with different amines. The interaction of aliphatic (triethyl amine) and aromatic amines (p-phenylene diamine (PPD), aniline) with CdSe quantum dots of smaller (~ 5 nm) and larger (~ 14 nm) sizes has been studied. It has been found that steric factors play a role in the quenching abilities of different amines. Smaller CdSe quantum dots facilitate

better surface coverage and thus higher quenching efficiency of amines. The quenching efficiency in general follows the trend: PL quenching (PPD) >> PL quenching (TEA)> PL quenching (aniline). Heterogeneous quenching of amines due to the presence of accessible and inaccessible set of CdSe fluorophores is indicated. PPD owing to its lowest oxidation potential (~ 0.26 V) has been found to have higher quenching efficiency as compared to other amines like TEA & aniline having oxidation potentials ~ 0.66 and > 1.0 V respectively. The changes in the emission properties and lifetime values of CdSe quantum dots arising from the interactions with different amines are greatly influenced by a combination of oxidation potential of amines and crystallite sizes.

High Temperature Super-conductivity, Advanced Ceramics and Optical Thin Films

The High Temperature Superconducting Materials & Devices group has been engaged in the development of $(Bi,Pb)2Sr_2Ca_2Cu_3O_{10+x}$ (Bi-2223) bulk tube/rod current leads for high current transport. Bulk tube current leads carrying critical currents of 1000 A and more at 77 K and 0 T have been developed. Work on joining a pair of such tubes with a superconducting joint is in progress. An improved method for making Bi-2223 rods of small diameter in the range of 2 to 3.5 mm and length in the range of 100 to 150 mm, which have applications in HTS low current magnets and cryogenic electronic circuits has been developed. A method for joining Ag- clad mono filamentary Bi-2223 tapes has been developed. The joint is superconducting with a negligible change in Tc of the tape before joining and of the joint portion. The joint carries transport current not less than 85% of that of the tapes before joining at 77 K, in self field. Work in the direction of development of multi filamentary (7 and 13) Ag-clad Bi-2223 wires using wire in tube (WIT) method is in progress. Fig. 4.11 shows the cross-sectional scanning electron micrograph of these filaments, containing good

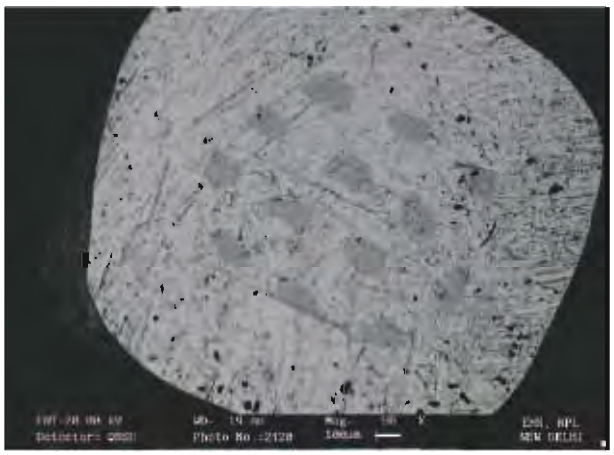


Fig. 4.11: Cross-sectional (trans-verse) SEM photograph of multi-filamentary wires showing number of filaments

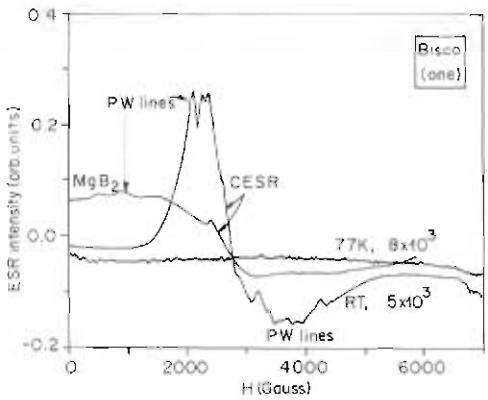


Fig. 4.12 : ESR spectra of Bi-2223 showing vanishing of CESR & PW lines in superconducting state.

density of calcined powder. To understand the nature of pairing and in search of effective pinning centers, conduction electron spin resonance (CESR) studies (Fig. 4.12) were carried out, which have strongly suggested the prime role of exchange interactions in pairing. Studies of MgB_2 (Tc~39 K) at liquid helium temperature are in progress.

In the area of **Advanced Ceramics,** under

externally funded projects microwave sintering of beta alumina prepared by zeta process was carried out at different temperatures and compared with samples from conventional sintering (Fig. 4.13). For a project on the development of thick oxide film gas sensors, the effect of Pb incorporation, operating

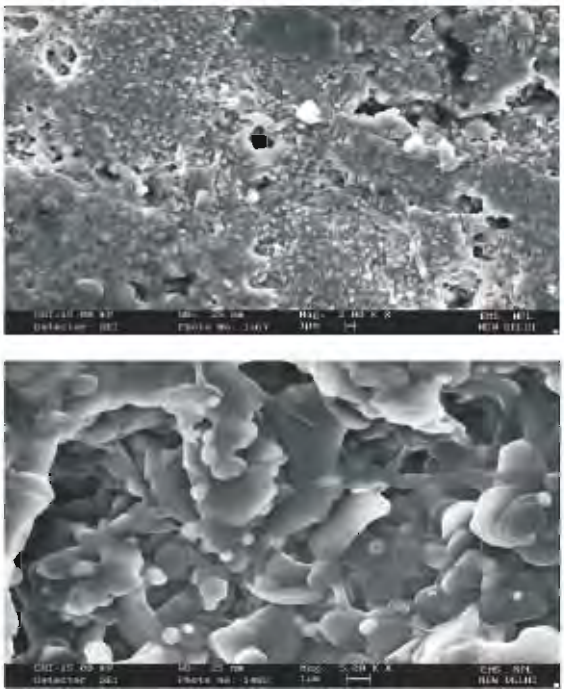


Fig. 4.13 (a), (b) : Micrograph of beta" alumina microwave sintered at (a) 1400 °C (b) 1600 °C

temperature, morphology and sensitivity were studied and the project concluded successfully. Under a new project, work was initiated on the development of a bio-element entrapped optical biosensor transducer for water pollution monitoring and its optical response under different excitations was studied. Standardized SiO_2 composition was used to prepare SiO_2 sol that was coated on a glass substrate to achieve a porous zero gel film, which was heated and its density and porosity were measured. A Nova control impedance analyzer was procured and successfully installed.

In the area of **Thin Film Optical Coatings,** two cavity narrow bandpass filter coatings (Fig. 4.14), comprising about 35 layers deposited by reactive e-beam evaporation, were successfully developed with centre wavelengths in the 1450-1650 nm range, bandwidth about 19 nm and off-

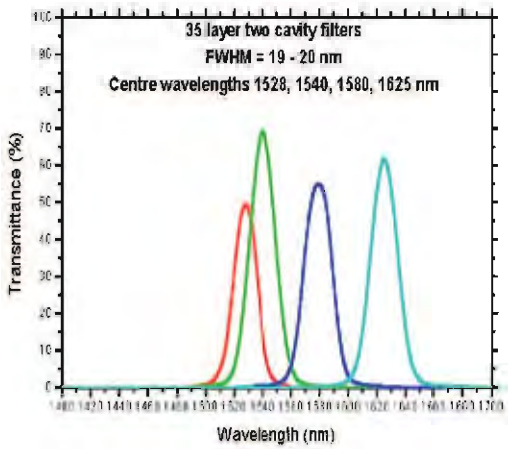


Fig. 4.14: Transmittance vs wavelength characteristics of some typical narrow bandpass filters fabricated in NPL

band transmittance < 0.5%, for potential use in CWDM applications for fibre optic communication systems. A home-made deposition system for deposition of polymeric films by plasma polymerization using liquid precursors was successfully made operational. Processes were developed for making the surfaces of polycarbonate substrates wettable, as well as hard scratch-resistant, and the a 4 layer

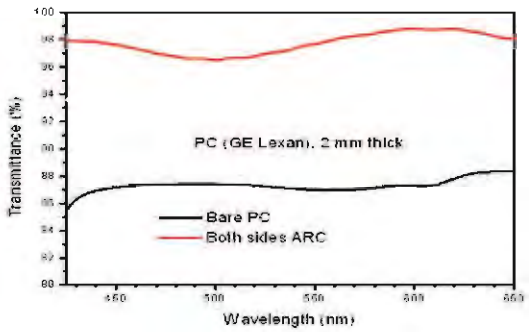


Fig. 4.15: Transmittance characteristics of polycarbonate substrates with antireflection coating deposited by plasma polymerization process at NPL

antireflection coating comprising TiO_2 and SiO_2 films of specified thicknesses was deposited successfully, to develop a process for optical coatings on plastic ophthalmic lenses (Fig. 4.15). Polymeric conducting films were deposited using thiophene as monomer and iodine as dopant, and the patterned underlying ITO layer and top gold layer deposited in a home-made sputtering system. Manual ellipsometric determination of the optical constants and thicknesses of thin films was also carried out for several users.

Surface Physics and Nanostructures

CdSe coreshell structure and morphological studies were a major activity of this group. The promising technological applications of colloids of CdSe nanoparticles in solid state devices is hampered due to issues related to their stoichiometry, agglomeration effects and coreshell relationship. Due to the short inelastic mean free path of core-level electrons, X-ray photoelectron spectroscopy is the most reliable method for analysis at the nanometer depth scale, and in conjunction with layer by layer ion beam erosion it can provide valuable information regarding distribution of elements along the depth of the sample. In this work, we address the issue of synthesis of CdSe nanoparticles and probing them by XPS and conventional techniques such as like transmission electron microscopy (TEM) and X-ray diffraction (XRD). Cd/Se input precursor ratio is varied to form colloidal TOP/TOPO capped CdSe nanoparticles. An optimum input precursor ratio is determined where stoichiometric yield, efficiently capped smallest sized (5 nm) CdSe nanoparticles with superior optical, structural and morphological properties are obtained. Electron diffraction and deconvolution of XPS-core-levels enables the identification of the different compositional

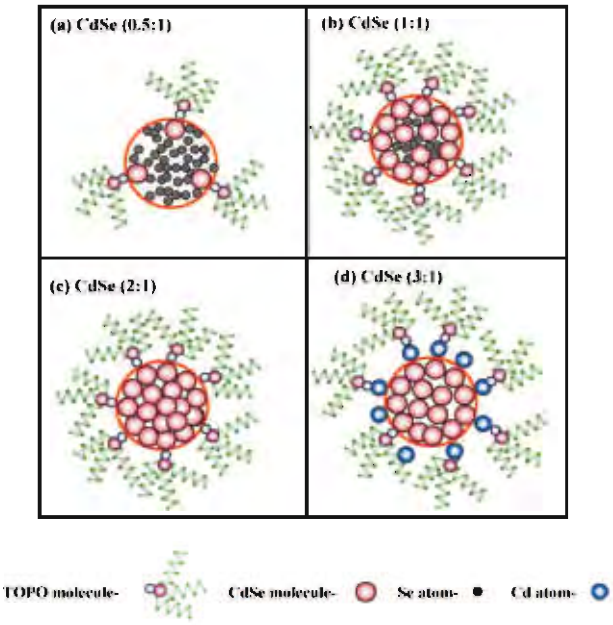


Fig. 4.16 : Adsorption induced faceting and superstructural phase diagram of the Sb/Si (5 5 12) interface

regimes of CdSe nanocrystallites. For non-optimal precursor ratios, the presence of Cd- and Se-related oxides is observed. This multi-technique approach has enabled us to pictorially model the compositional, structural and morphological aspects of TOP/TOPO capped CdSe nanoparticles (Fig. 4.16).

The planar high index Si(5 5 12) surface consists of trenches formed by the several proximal surface planes, that can be employed

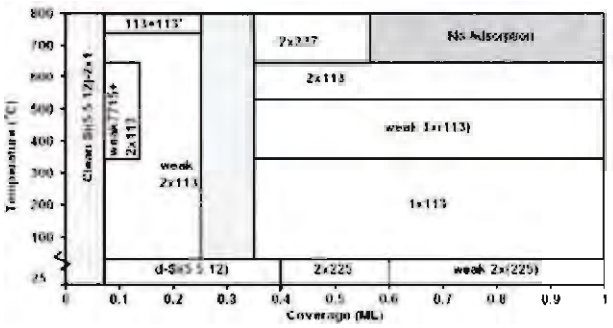


Fig. 4.17 : Schematic representation of various superstructural phases formed by steering the kinetic parameters.

as templates for the adsorption of low dimensional nanostructures. This paper reports the results of an extensive UHV study of the adsorption of Sb, in the sub-monolayer coverage regime, onto the Si(5 5 12) surface. The evolution of the surface phases, surface morphology and electronic structure is monitored by Auger Electron Spectroscopy (AES), Low Energy Electron Diffraction (LEED) and Electron Energy Loss Spectroscopy (EELS). A careful control of substrate temperatures and Sb coverages formed at a low flux rate of 0.06 ML/min enable us to extract a complete adsorption phase diagram (Fig. 4.17) of the important interface, for the first time. The phase diagram clearly demonstrates the conversion of the large Si (5 5 12) unit cell into facets of planes of smaller (2 2 5), (3 3 7) and (1 1 3) base units. The study also reveals the formation of various superstructural phases formed by steering the kinetic parameters.

पदार्थ अभिलक्षणन

MATERIALS CHARACTERIZATION

पदार्थ अभिलक्षणन

विविध प्रकार के उन्नत पदार्थों का पर्याप्त मात्रा में, थिन फिल्म्स और नेनो पदार्थ (जिसमें विभिन्न मॉरफोलोजी होते हैं) का विभिन्न तकनीकों के द्वारा संश्लेषण और चरित्र–चित्रण हमारी प्रयोगशाला का नियमित क्रिया–कलाप बन चुका है । इन पदार्थों का अभिलक्षणन शुद्धता, तत्वों के संगठन, अशुद्धता का मूल्यांकन, संरचनात्मक व्याख्या, क्रिस्टलाइन रूप की पहचान, सतह एवं अंतर सतह का अभिलक्षणन और क्रिस्टल की खामियों की जानकारी को सुनिश्चित करने के लिए आरंभ किया गया है । पदार्थों का अभिलक्षणन विभाग उन्नत अभिलक्षणित तकनीकों से सुसज्जित है । पदार्थों के अभिलक्षणन कार्य से हटकर यह समूह विभिन्न प्रकार के जैविक और अजैविक पदार्थों के पिघलाव एवं घोल विकास विधि द्वारा लगभग सटी क्रिस्टल के विकास में जो प्रौद्योगिक रूप से महत्वपूर्ण है में व्यस्त है योजना, तैयारी और प्रमाणित मानक पदार्थों का प्रचार जो एक इंटर प्रायोगिक सहयोगी कार्यक्रम के अंतर्गत आता है इस विभाग का एक दूसरा महत्वपूर्ण क्रिया कलाप है । पदार्थों की अभिलक्षणन सुविधाओं को एन पी एल समूह के बहुत से आर और डी तथा उसी प्रकार बहुत से दूसरे खोजी संस्थानों उद्योगों को प्रदान किया गया है । इस अवधि के दौरान कुछ महत्वपूर्ण आर एण्ड डी कार्यकलापों को निम्न प्रकार से किया गया है –

(1) योजनाबद्ध कार्यक्रम एरोसोल और रेडिएशन (आई सी ए आर बी–06) में प्रेक्षण प्लेटफार्म पर भागीदारी जैसे भूमि निर्धारित क्षेत्र, ओ आर वी सागर कन्या तथा वायुयान पर समुद्री मोबाइल पर्यटन (एस के–222 बी ओ वी क्षेत्र एवं एस के 223 अरब सागर क्षेत्र) भारतीय अंतरिक्ष अनुसंधान संगठन (आई एस आर ओ) परियोजना के अंतर्गत चलाए गए हैं । दिल्ली की प्रयोगशाला में ऐरोसोल के आकार तथा द्रव्यमान वितरण के अतिरिक्त, भौतिकी–रासायनिक पैरामीटरों ससंबंद्ध निलंबित विविक्त पदार्थ (एस पी एम) के अध्ययन का कार्य भी किया ।

(2) पारा टोल्वीन सल्फोनिक एसिड (पी टी एस ए) पर ई पी आर अध्ययन किया गया जिसमें पोलीनीलीन, नेनो क्रिस्टलाइन $COFe_2O_4$ तथा टर्नरी ऑक्साइड ग्लास मिलाया गया । फेरो फ्लूड आधारित लघु आकार के इलेक्ट्रिक पॉवर जनरेटर मशीन का विकास किया तथा इसके लिए पेटेंट के लिए आवेदन प्रस्तुत कर दिया गया है । एक्स आर डी तकनीक का प्रयोग विभिन्न पदार्थों में मौजूद विभिन्न रूप का पता लगाने के लिए किया गया । माइक्रो स्ट्रकचरल जांच का कार्य विभिन्न विधियों, पाउडर का प्रयोग करके तथा एस ई एम तथा टी ई एम तकनीकों का प्रयोग करते हुए भारी पदार्थों पर जमा पतली परत पर किया गया ।

(3) एन पी एल के विभिन्न ग्रुपों तथा अन्य संस्थानों / उद्योगों से प्राप्त विभिन्न प्रकार के उन्नत पदार्थों का एफ टी आई आर, ई पी आर, एक्स आर डी, एस ई एम तथा टी ई एम तकनीकों का प्रयोग करते हुए अभिलक्षणन किया गया है । इस वर्ष के दौरान, मोनो एलिमेंटल सोल्यूशन पर सी आर एम के नए बैच तथा पीड़ानाशक रिलीज किए गए ।

(4) अरैखिक ऑप्टिकल (एन एल ओ) जैव, अजैव तथा अर्द्ध अजैव सिंगल क्रिस्टल की संवृद्धि तथा अभिलक्षणन अरैखिक ऑप्टिकल तथा रैखिक डोपेंट का प्रयोग करते हुए मेल्ट तथा सोल्यूशन संवृद्धि विधियों का प्रयोग करते हुए किया गया । इन क्रिस्टलों के उच्च रिसोल्यूशन एक्स रे विवर्तन (एच आर एक्स आर डी) के अध्ययनों ने एस एच जी दक्षता तथा उत्कृष्ट क्रिस्टलाइन परफेक्शन में वृद्धि को दर्शाया है । विभिन्न तापमानों में तापानुशीतन करके Ni/Si पद्धति का इंटरफेशियल व्यवहार का अध्ययन एस आई एम एस का प्रयोग करके किया गया है ।

MATERIALS CHARACTERIZATION

Synthesis and characterization of various kinds of advanced materials using various techniques in the form of bulk, thin films and nano materials possessing different morphologies have become a regular activity of our laboratory. Characterization of these materials is undertaken 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. Materials characterization division is well equipped with advanced characterization techniques. Apart from materials characterization work, this group is also engaged in growth of nearly perfect crystals of different inorganic and organic materials of technologically importance by melt and solution growth method. Planning, preparation and dissemination of certified reference materials under an inter laboratory collaborative programme is another important activity of this division. Materials characterization facilities are provided to various R&D groups of NPL as well as to other research organizations/industries. Some of the important R&D activities pursued during this period are:

(i) Participated in campaign on aerosols and radiation (ICARB-06) 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, carried out under ISRO project. Study of suspended particulate matter (SPM) for physico-chemical parameters at Delhi were also carried out apart from size and mass distribution of aerosols.

(ii) EPR studies were carried out on para-toluene sulphonic acid (PTSA) doped polyaniline, nanocrystalline $COFe_2O_4$ and ternary oxide glasses. Ferro fluid based small size electric power generator device has been developed & a patent has been filed for this. XRD technique was used to identify the different phases present in the variety of materials. Microstructural investigations were carried out on thin films deposited by using different methods , powder and bulk materials using SEM and TEM techniques.

(iii) A large variety of advanced materials received from different groups of NPL as well as other institutes/industries have been characterized using FTIR, EPR, XRD, SEM and TEM techniques. During this year new batches of ten CRMs on mono elemental solutions and pesticides were released.

(iv) Growth and characterization of non linear optical (NLO) organic, inorganic and semiorganic single crystals have been carried out using melt and solution growth methods using non NLO and NLO dopants. High resolution X-ray diffraction (HRXRD) studies of these crystals revealed enhancement in SHG efficiency and excellent crystalline perfection. The interfacial behavior of Ni/Si system by annealing at different temperatures has been studied using SIMS.

Analytical Chemistry

Analytical chemistry section carried out work related to metrology in chemistry, characterization of materials for its purity, physical and chemical composition of atmospheric aerosols. Testing of a large variety of materials e.g. various parameters in poly aluminium chloride (PAC) and Alumina ferric samples used for the cleaning of water. The evaluation of indelible ink is done, which is used in the electoral process by Election Commission of India. Testing of metal & alloys and graphite brushes (used in aircraft motors etc.) are done on regular basis. These type of test facilities are used by the industries, government agencies and institutions for regulatory purposees. The facilities utilized for trace metal analysis of materials are Flame Atomic Absorption spectrometer (FAAS), Graphite Furnace Atomic Absorption spectrometer (GFAAS), Spectrophotometer etc. The Gas Chromatographic techniques have been utilized for evaluation of gaseous samples from different sources for Green House Gases (GHGs), trace gas impurities in samples from security agencies, and pollutants viz. CO, NO-NO_2 - NO_x, CO_2 using respective gas analysers for environmental studies viz. related to studies for sponsored projects. The group had participated in EANET rainwater and CCQM-K52 CO_2 in synthetic air, gas analysis key comparisons during this year. Suspended particulate matter (SPM) and its chemical composition apart from aerosol size and mass distribution by Anderson and quartz crystal microbalance (QCM) for APN-Health project; and material synthesis for nano ZnO through wet-chemical route has also been done. Writing of DP's ISO-17025 documents for peer is continuing.

The group participated in the ISRO-GBP sponsored "Integrated Campaign for Aerosols, Gases & Radiation Budget" (ICARB) program through the measurements of aerosols, trace gases and radiation at NPL, New Delhi in the month of March to May 2006. Fig. 5.1 represents the monthly mean aerosol number-size distribution. Fig. 5.2 shows the average daytime variation of aerosol mass distribution as obtained by quartz crystal microbalance (QCM).

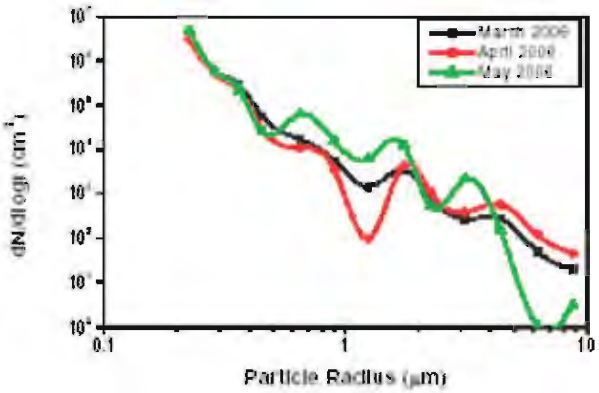


Fig. 5.1: Monthly mean aerosol number-size distribution

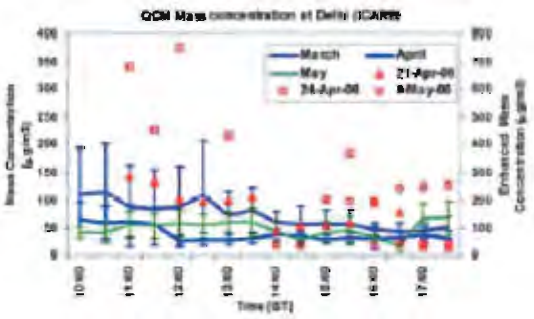


Fig. 5.2 : The average daytime variation of aerosol mass distribution

In this year, sponsored project work viz. SEI-Swedish related to physico-chemical characterization of dry & wet precipitation, and ISRO GBP work related to biomass burning & special campaigns were also carried out during this period. Fig. 5.3 shows the burning field where the biomass study was carried out.

The section had completed two sponsored projects from ISRO-GBP viz. 'Study of biomass

Fig. 5.3 : The burning field where the biomass study was carried out.

burning and related trace gas emission using IRS-P3 satellite data', (ISRO-GBP sponsored project of NRSA Hyderabad) and 'Study of Atmospheric Aerosols, Radiation & Trace Gases under ISRO-GBP Road Campaign' (ISRO-GBP sponsored project of PRL Ahmedabad). An integrated campaign on aerosols and radiation budget (ICARB-06) 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 under ISRO. NPL participated in land (Delhi, Darjeeling and Port Blair) & synchronous to sea cruises. Study for suspended particulate matter (SPM) for physico-chemical parameters were carried out apart from size and mass distribution of aerosols by Anderson and quartz crystal microbalance (QCM), by our group at NPL Delhi. These simultaneous measurements were first of its kind. It had provided extensive database 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. Studies by the group for methane emission measurements have been carried out in Karnal, Haryana during July-October 2006 with integration of GIS/ RS tools for up scaling. Acid deposition work at Delhi has been continued under Swedish sponsored project. Collaborations with Tezpur univ. Assam (DST), TIET Patiala (DST), with RASD for APN-health (APN) and Biomass burning EF (DST), have been continuing.

EPR & IR Spectroscopy

Electron Paramagnetic Resonance (EPR/ESR) Spectroscopy is a very sensitive and sophisticated technique used for identification and characterization of paramagnetic centres/ point defects/ impurities in different substances. Such centres produced during different preparation/experimental processes may play important role in controlling the properties of the materials/devices and therefore detailed investigations about them becomes beneficial for optimising the process parameters or properties of the materials. FTIR spectroscopy gives information about the vibration and rotation of molecular groups in a material which is mainly used to determine the concentration of the impurities and their bonding with the host material.

EPR Spectroscopy was used to understand the charge conduction mechanism in para-toluene sulphonic acid (PTSA) doped polyaniline. A single narrow line EPR signal obtained was assigned to polarons formed during doping process. The increase in conductivity at higher doping levels inspite of decrease in polaron concentration was attributed to the enhanced mobility of charge carriers through interchain transport. PTSA doping seems to be less effective for enhancing electrical conductivity as compared to HCl doped polyaniline as observed earlier.

FTIR spectra of para-toluene sulphonic acid (PTSA) doped polyaniline conducting polymers were also analysed in 4000-400 cm^{-1} region to reveal different bonding groups,

oligomeric units of the polymeric chain and nature of doping ions in doped polymeric salts. PTSA ions help in cross linking of polymeric chains through week hydrogen bonding which may enhance mobility of charge carriers through interchain transport.

Chromium ions doped tetramethyl ammonium cadmium chloride, diammonium hexa-aqua magnesium sulphate and ammonium lithium sulphate single crystals grown by slow evaporation method were characterized by EPR and optical spectroscopic techniques under the collaborative work with Physics Department, University of Allahabad, Allahabad. The purpose of these studies was to use EPR spectroscopy technique for revealing the structural details of technologically important single crystals. Results reveal that cromium ions are doped substitutionally and form distorted octahedrons in the lattice.

Free radical concentration in the kernal of different pulses namely lentil, moong green, urad black, white gram and black gram was estimated alongwith expanded uncertainty by EPR spectroscopy. All sources of errors involved in recording the EPR spectrum were identified and optimised. These studies presented the method for selecting uncertainty components and evaluation of expanded uncertainty. Such investigations help in establishing measurement capability and quality for acceptability of measurement data.

EPR study of nanocrystalline transition metal doped ferrite was continued in collaboration with X-ray group of our Division. Nano crystalline cobalt ferrite ($COFe_2O_4$) was prepared and samples Synthesized were annealed at different temperatures 100 °C to 900 °C for one hour to understand the effect of annealing in terms of variation in particle size and formation of super paramagnetic particles. EPR measurements have exhibited the formation of superparamagnetic particles in these as prepared and annealed samples. Further work is in progress.

EPR study of microstructure of many ternary oxide glasses depending upon composition was made under collaborative project with Physics Department, M.D. University, Rohtak. Glass systems with composition $xCoO.(0.30-x)M_2O.70B_2O_3$ (M=Li, K) were prepared with x varies in the range of 0.00 x0.15 containing 1.0 and 2.0 mol % of V_2O_5. Results suggest that hyperfine spectra of vanadium ions are not observed when amount of CoO exceeds a certain value. The $3d_{xy}$ orbital in the vanadium ion expands and the tetragonal distortion around the vanadium ion increases with the increase in $CoO:M_2O$ ratio. The dc conductivity decreases when Li_2O is replaced by K_2O keeping the concentration of CoO and B_2O_3 constant. Addition of CoO to the sample induces "blocking effect" on the overall mobility of alkali ions and reduces conductivity on increasing $CoO:M_2O$ ratio.

The development of FTIR spectro-photometric standards of transmittance at normal and oblique angles from 0 to 60 using quartz, fused silica and opal glass is in progress in the spectral range 2.5 m to 5.0 m. Work on development of IR diffuse reflectance and transmittance standards is also continued. Apart from this IR calibration of thermovision cameras and polystyrene films from various outside industries and other agencies were made and EPR, FTIR & FT Raman spectroscopic characterization facilities were provided to different NPL research groups and outside users.

X-ray Analysis

X-ray diffraction is widely used for crystalline phase analysis and determination of crystalline structure. It is used to determine the size of the unit cell along with other structural parameters. Characterization of materials regarding crystalline phase and crystallied size, and elemental analysis were carried out for more than 600 samples received from various group of NPL and outside institutions and industries by using X-ray diffraction and X-ray fluorescence methods. Materials from almost all the groups of NPL who are working on development of materials are being analysed using powder X-ray diffractometer (PXD) techniques.

Nano-structured thin films of PZT in thickness range 80-120 nm have been prepared on Si/Pt substrates by RF magnetron sputtering at CGCRI, Kolkata.. Samples were annealed in air at 600-700 °C. Both the as grown and post-annealed samples were characterized by Glancing Angle X-ray Diffraction technique. X-ray diffraction showed the interface of ferroelectric Pervoskite phase, the degree of crystallinity improved by anealing. The interface stresses developed during film deposition and also during annealing were measured by High Resolution Double Crystal X-ray Diffraction method. The interface stresses increased in the case of annealed sample from $3X10^{9}$ dynes/sq.cm to $1X10^{10}$ dynes/sq.cm.

Electric power generator has been developed using ferrofluid. The principal is based on law of electricity generation. The coefficient of friction of the magnets motion is tremendously reduced to 0.0008 using ferrofluid bearing as shown in Fig. 5.4. A ferrofluid bearing lubricant is provided between the magnets and substrate for ultra low frictional movement. This unique property of magnets levitation by ferrofluid is exploited for making the power generator device. A fluctuating alternating current has been produced and rectified by using bridge circuit for providing continuous power source.

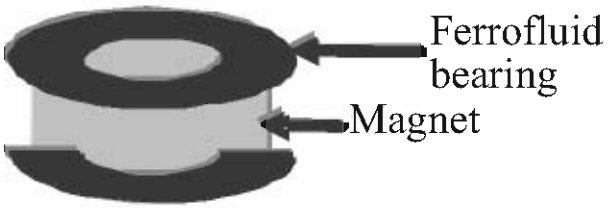


Fig. 5.4 : The magnetic fluid ring formation with poles of the permanent magnet

Ferrofluid are the technologically advanced nano magnetic materials. The devices based on these are changing with spectacular pace. Basically ferrofluids are colloidal dispersion of nanosize ferro-ferrimagnetic particles of size 2-10 nm. It is stable against gravitational as well as magnetic field gradient. Selection of host liquids depends on the type of applications. The magnetic particles are typically covered with surfactants or a dispersing agent. The surfactants coating keeps magnetic particles at a distance to overcome the forces of attraction caused by Van-der Waal forces and magnetic interaction.

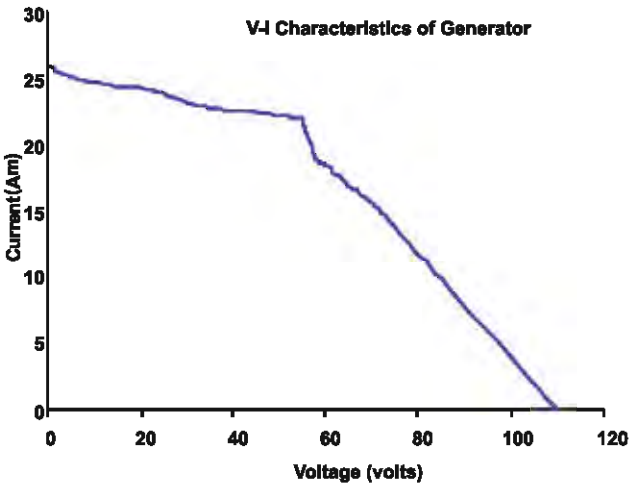


Fig. 5.5 : V-I characteristic of the device with varying load.

Fig. 5.5 shows the V-I characteristics of the device with varying load. The observed output power is maximum for the good impendence matching of the coils in the device and the output load.

Fig. 5.6 : Laboratory model of a ferro-fluid based electric power generator.

The device used for the electric power generation includes ferrofluid bearings, magnets, copper coils, holder to shaft, rotating shafts, fan, base plate and device housing of size 15.0 × 25.0 cm. The shaft connected to base is to make an inner bearing race. A small lab model of the device is shown in Fig. 5.6. In the normal environment conditions and at the wind speed of 4 m/s the device is able to generate 1.2-Watt power. The calculated efficiency of the system is 24%.

Boron nitride nanotubes (BNNT) are of significant interest to the scientific and technical communities for its unique and important properties for structural and electronic applications. Boron nitride nanotubes possess a very high modulus (~1TPa), chemical and thermal stability and also uniform band gap of 5.5 eV.

Boron nitride nano-tubes were synthesized by high energy ball milled for about 50-100 hour using a high energy planetary ball mill and subsequently annealed at 950-1300 °C in nitrogen atmosphere for about 5 hours. All the samples were characterized by using powder X-ray Diffraction technique. X-ray diffraction pattern indicated pure hBN phase along with some diffraction peaks of W and W_2B_5 coming from the WC container during ball milling operation.

Research on nanomaterials has gained considerable attention in recent years as these materials may exhibit properties that can be very different from their properties at the normal scales and therefore have high potential for novel applications. Zinc oxide is one of the most important nanomaterial due to its wide area of applications. Nanocrystalline zinc oxide powders were prepared by wet chemical methods. The synthesized nanomaterials were characterized for crystal structure and morphology.

XRD analysis of nano-crystalline ZnO thin films (prepared by IITD) by sol-gel method with different precursor materials and by rf sputtering were carried out. Single phase, crystalline films of ZnO with hexagonal structure were obtained. The rf sputtered film showed a high degree of preferred orientation along the c-axis. The preferred orientation and crystallite size of the sol-gel prepared films were found to vary with the concentration of the sol. These results were further correlated with the microstructure analysis.

Ga_3Se_4 is binary semiconducting compounds represented by general equation $A_3^{III}B_4^{VI}$. No PDF data file of this compound is available with ICDD. Therefore, to establish the

powder data, this compound has been synthesized using spec. pure elements. The stoichiometric proportion of the material was filled in the sealed and evacuated quartz capsule and heated slowly in the rocking furnace at the rate of 150 °C / hr to achieve temperature 1000 °C. The temperature kept for 8 hours to ensure complete miscibility of the elements in the molten state and the capsule was also rocked inside the furnace for 4 hours. The temperature of the ampoule was lowered from 1000 °C to room temperature by switching off the furnace. The ingot was ground to powder in agate pestle and mortar. Powder X-ray diffraction (XRD) raw data of the specimen was recorded at room temperature using, Bruker axs Model D8 Advance, Powder X-ray diffractometer (PXD) with CuK_α incident radiation of wavelength λ=1.5418 Å. The PXD was operated at 40 kV, 40 mA tube rating with fixed divergence, antiscattered, receiving and detector slits 1mm, 1 mm, 0.10 mm, and 0.6 mm respectively. The XRD data evaluated and indexed using the software. We received the mixture of sharp and broad diffraction peaks. The sharp peak reflections were found appears with even indices and broad with mixed indices. The whole pattern was identified as δ-Ga_3Se_4. This material was again sealed in the evacuated quartz capsule and annealed at 500 °C over a period of 200 hrs. To obtain single polycrystalline phase of Ga_3Se_4 at room temperature, the stiochiomeric proportion of the elements sealed in the evacuated quartz capsule and quenched in water from 1000 °C. The whole process is in progress.

Electron Microscopy

Transmission electron microscope (TEM) at NPL is utilized as the central facility for the characterization of materials. Different types of samples in the form of thin films and powders prepared by various techniques have been received from different groups of NPL working on the development of new materials. These samples have been characterized for their particles shape, size, distribution of particles, phase identification etc., using transmission electron microscopy technique. Some of the samples analyzed are given here. Silicon nano particles, cobalt ferrite, Ferrofluid nanoparticles, graphitized CNT, ZnO, CdSe thin films (Fig. 5.7).

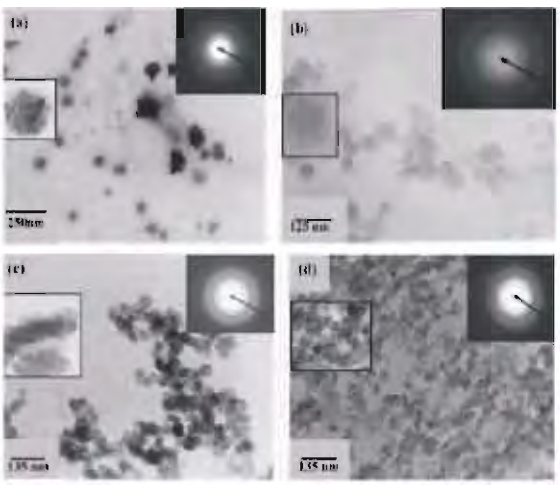


Fig. 5.7 : TEM micrographs and SAED patterns (inset) of CdSe nanocrystals with different precursor Cd/Se ratios: (a) 0.5:1, (b) 1:1, (c) 2:1 and (d) 3:1. The insets on the left hand side of (c) and (d) represents the magnified portion of the selected areas.

Biosensor materials like NdF3(CH), NdF3:Tb, TbF3(Pr) and Pr(acac)ETOS in powder form. InSb thin films deposited at 250°C using electron beam evaporation technique, thermally evaporated Gold thin films. Al_2O_3 thin films prepared at various gas pressures of Ar and O_2 for different timings and deposition rates were also characterized using our TEM.

A systematic study on characterization of annealed amorohous Si specimens coated with a thin layer of Aluminum on it has been

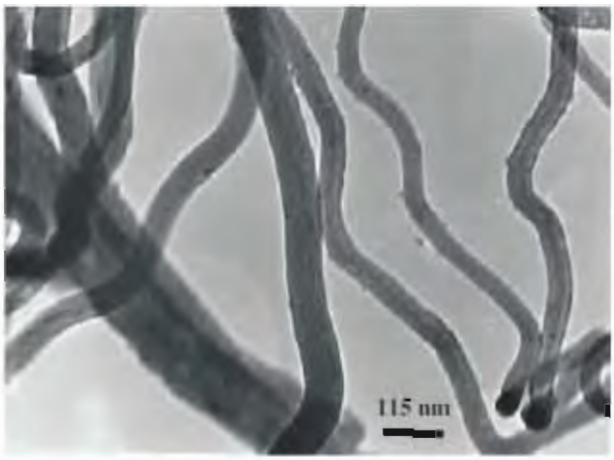


Fig. 5.8 : TEM bright field image of thermally evaporated ZnO nanowires

carried out using TEM. Effect of variable pressure on growth and photoluminescence of thermally evaporated nanostructured ZnO has been studied in detail in Fig. 5.8. About 60 samples were received from the various groups of NPL working on the development of new and advanced materials.

Scanning Electron Microscopy and Energy Dispersive Spectroscopy is another central facility of the laboratory which is extensively used by various R & D groups of NPL, other scientific R & D institutes and Industrial organizations for characterization of materials for surface microstructure and chemical compositional measurement. Some of the materials characterized by using SEM are Al alloys, Al-Mg alloy samples spray formed and tensile fractured, Mg- RE alloys, SiC Oxidised, Carbon Nanotubes with Ni, Co and Y as catalysts and grown by different techniques, carbon paper nanotube composites, Resin based nanotube composites, C60/Au/Si films, Carbon Brushes ZnO, SnO_2 and CdS powders, ZnS nano particles with Mn as dopant, Metal doped PS+PANI Composites, Polyaniline with Lectate TEOS Polymeric films, metal doped polyaniline films, PVA+Conducting Polymer+Soft ferrite Composites, Oxidase coatings, metal doped polymer films, polymer powders and films with and without enzyme and DNA, Microwave sintered Beta Alumina samples and Cr doped PLZT (Fig.5.9) prepared & annealed at different conditions and temperatures.

Fig. 5.9 : SEM micrograph of Cr doped PLZT

A total of 472 samples have been examined by SEM and EDS for surface microstructure and compositional analysis. SEM and EDS facility is also used by the industry for carrying out different type of testing and analysis work.During the period different samples were received from industry for particle size, shape, surface structure, fracture analysis, thickness and chemical compositional analysis. Some of the industries for which SEM/EDS analysis were carried out are M/s. Oriental Carbon and Chemicals Ltd., New Delhi, M/s. Ranbaxy Laboratories, SAS Nagar Mohali and Gurgaon M/s. Samtel Color Limited, M/s. NRCY, Dirang, Arunachal Pradesh, M/s. MNIT, Jaipur. Ghazibad, U.P.

Indian Reference Materialds

Preparation and Dissemination of Certified Reference Materials and Chemical Metrology

Release of New Certified Reference Materials

National Physical Laboratory (NPL) is coordinating a CSIR Network project on Upgradation 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 laboratories of the country are working in this project as a partner institutes. This year, ten new CRMs have been prepared and certified, out of which 6 are the CRMs of mono elemental solutions and remaining 4 are the pesticides. CRMs of pesticides were prepared and purified to the purity of + 99% at Indian Institute of Chemical Technology, Hyderabad. The concentration of the materials had been certified on the basis of its round robin testing at partner laboratories in accordance to ISO 35. The certified values are reported with the uncertainty in measurement at a confidence level of 95%. (k=2). These CRMs were released by Dr. Robert Kaarls, Chairman, Consultative Committee on Amount of Substance and secretary CIPM along with Dr. G.J. Gyani, Secretary General, Quality Council of India on December 13, 2006. Following are the details of the CRMs released:

a) Mono elemental Solutions:

1. Lead Solution (BND 105.01) - concentration 5.01 ± 0.04 mg/L
2. Cadmium (BND 205.01) - concentration 5.00 ± 0.04 mg/L
3. Zinc (BND 1205.01) - concentration 5.00 ± 0.04 mg/L
4. Iron (BND 1305.01) - concentration 5.00 ± 0.04 mg/L
5. Copper (BND 1405.01) - concentration 5.01 ± 0.04 mg/L
6. Cobalt (BND 2205.01) - concentration 5.01 ± 0.04 mg/L

b) Pesticides:

1. Chlorpyriphos (BND 1701.02) - Purity $99.08 \pm 1.28\%$
2. Isoproturon (BND 2001.02) - Purity $99.10 \pm 1.4\%$
3. Fenvalerate (BND 3101.01) - Purity $99.09 \pm 0.94\%$
4. Cypermethrin (BND 3201.01) - Purity $99.09 \pm 0.82\%$

Some of the important users of these CRMs are the laboratories Defence, Power, Petroleum, Bureau of Indian Standards, National Test House, State Pollution Control Boards, Public Health sectors and accredited laboratories of National Accreditation Board of Testing and Calibration Laboratories (NABL). Society is also being benefited by improvement in the quality of life by monitoring and control of quality of water, industrial produces, environmental and health parameters by the use of CRMs directly and indirectly. It also helps the industries in quality assurance and quality control of the industrial and agricultural products to meet the requirement of WHO.

Works on the preparation of following new CRMs in different areas are at final stage of release:

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. It is proposed to certify the concentration of C, Si, Mn, P, S, Cr and Ni. These materials are under round robin testing for certification.

ii) α-Alumina

A new XRD standard of -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 for its certification.

Dr. Robert Kaarls, Secretary Comite International des Poids et Measures (CIPM) and Chairman consultative Committee on Amount of Substance (CCQM) and Mr. G.J. Gyani, Secretary General Quality Council of India releasing certified reference materials of six mono elemental solutions and four pesticides on December 13, 2006. On their right are Dr. A.K. Agrawal, Coordinator, Certified Reference Material Programme and Dr. Vikram Kumar, Director NPL seen in the picture.

Crystal Growth & Characterization

Growth and Characterization of Nonlinear Optical (NLO) organic, inorganic and semiorganic single crystals

Due to the unlimited capacity of data storage, processing and communication, NLO materials are expected to play a major role in the technology of photonics. The reactive -bonds available in certain organic compounds with NLO properties can be engineered by the incorporation of suitable functional groups to the host material for tailored made applications. In view of this, in the recent past, with the collaboration of various institutes like Anna Universtity, Chennai (CAP-14), SSN College of Engg., Chennai (CAP-18), Annamalai University, Annamalai Nagar, CAT, Indoor, LASTEC, Delhi etc., we have carried out the growth and characterization of variety of organic NLO crystals like benzimidazole, hippuric acid, 8HQ, L-alanine, L- alaninium maleate (LAM), methyl p-hydroxybenzoate (p-MHB), L-lysine monohydrochloride dehydrate (L-LMHCl), 3-methoxy 4-hydroxy benzldehde (MHBA), Dimethyl amino pyridinium 4-nitrophenolate 4-nitrophenol (DMAPNP), L-arginium percholate (LARPCL), L- histidinium perchlorate (LHPCL), L-Asparaginium Picrate (LASP), inorganic crystals like TGS, ADP, KHP, thiourea based semiorganic crystals like cadmium thiourea acetate (CTA), tristhiourea zinc sulphate (ZTS), tristhiorea zinc chloride (ZTC) etc. by slow evaporation solution growth technique (SEST) and a recently developed novel method, the so called Sankarnarayanan-Ramasamy (SR) method to grow along the desired direction needed for the fabrication of devices, without any wastage of material during growth. These crystals have been characterized by various instrumentation methods with a main emphasis on the crystalline perfection by High-resolution X-ray diffractometry (HRXRD) to see various aspects like (i) growth conditions/thermal environment, (ii) additives with very littlie quantities, (iii) dopants with wide range of concentrations, (iv) ability of accommodation of dopants interstitially by the lattice in a view to enhance the NLO properties

and (v) correlation between crystalline perfection and nonlinear efficiency like second harmonic generation (SHG) etc. A few important results are mentioned below.

Effect of thermal environment on the crystalline perfection of Benzimidazole single crystals grown by VBT (vertical Bridgman technique) and SEST (slow evaporation solution technique) methods has been demonstrated by HRXRD. It was shown that due to entrapment of solvent inside the crystal, a very low angle boundary has been observed in SEST specimen whereas in VBT specimens thermal stresses lead to large no. of low angle boundaries. However, on thermal annealing by slow cooling or heating rates these were annealed out. Growth and characterization of benzimidazole

Single crystal grown by the Sankaranarayanan-Ramasamy method has been carried out. HRXRD studies revealed excellent crystalline perfection.

Affect of nylon thread used to hang the seed crystal for growing bulk crystals of SEST grown L-alanine has been demonstrated. Nylon thread lead to the formation of low angle grain boundaries which is a very useful finding for crystal growers.

Enhancement in the crystalline perfection by organic dopants having different structures on ZTS, ADP and KHP single crystals grown from aqueous solutions have been demonstrated by HRXRD. In theses studies, it was clearly demonstrated that some organic additives/dopants which are able to form complexes with the unavoidable impurities present in the solution form a less adsorbing layer on the surface of the crystal and helps not only to improve the crystalline perfection but

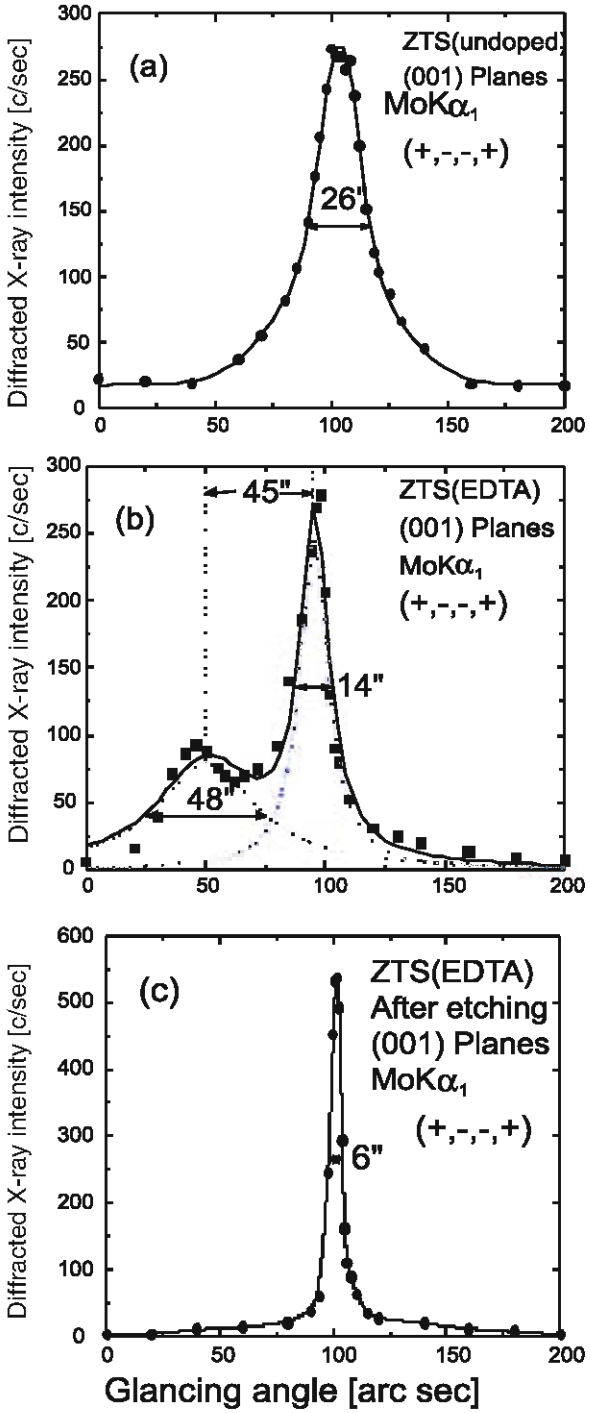


Fig. 5.10 : High-resolution X-ray diffraction curves recorded for ZTS single crystals: (a) undoped, (b) as-grown EDTA added, showing a satellite peak (indicating the complexating layer with impurities) and (c) after etching the surface layer showing the enhancement of crystalline perfection due to EDTA additive.

also to promote the fast growth of the crystals as metastable zone width due to these dopants was found to be increased considerably (Fig. 5.10).

Very recently we have grown and characterized some organic (Benzimidazole), inorganic (ADP) and semiorganic (ZTS) crystals doped with non NLO like KCl, Mn, Oxalic acid and NLO like urea and Nmethyl urea were grown and characterized. Due to these dopants, considerable enhancement in SHG efficiency was observed. Some interesting correlation between crystalline perfection and SHG efficiency was also observed.

Growth and Characterization of semiorganic Zinc Thiourea Chloride (ZTC) NLO single crystals has been carried out. After designing and fabrication of suitable glassware apparatus, using a seed ZTC single crystal grown by SEST method, large single crystal in a predetermined unidirection 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.

In collaboration with CAT, Indore, Cr doped and Mg-Cr codoped crystals grown at CAT were characterized for possible applications as photorefractive devices and optical waveguides. Phase identification was done using the powder XRD technique. The crystalline perfection was monitored using high-resolution XRD. These studies revealed that the overall crystalline perfection is better in doped crystals due to the reduction in Li vacancies aroused due to evaporation of Li during growth process.

Surface and Interface characterization using SIMS

Measurement and analysis of the intensity and mass of the ions, atomic or molecular, that de-sorb from the surface due to primary ion bombardment forms the basis of Secondary Ion Mass Spectrometry (SIMS). This is distinguished from other surface analysis techniques by its extreme sensitivity and its ability to detect all elements, including hydrogen. It can be used in static mode (for minimum damage), dynamically (for determination of concentration profiles), and for chemical imaging.

Characterization of surface and interface of solid materials using Secondary Ion Mass Spectrometry (SIMS) is a very rare facility in India, particularly for users from academic institutions or industries. This is because the only other such facilities are not easily accessible, as they are installed in strategic laboratories. NPL has the unique position of offering this facility to any user, including R & D institutions, Universities or relevant industries.

Morphological and interfacial investigations at Ni/Si system

The interfacial behavior of Ni/Si system by annealing at different temperature has been studied in the present work. Nickel was deposited on silicon substrate (100) using electron gun evaporation at 10^{-8} torr vacuum. The enhancement of intermixing and silicide formation as a result of annealing at Ni/Si systems at temperature 350^{0} C and 500^{0} C at 10^{-6} torr vacuum for 1 hr have been studied. The formation of crystalline metal silicide is confirmed and phases identified by grazing

incidence X-ray diffraction (GIXRD) studies while AFM have been used to study the change in morphology. In SIMS depth profiling, the aim is to determine the local composition of the material as a function of its depth beneath the original surface. Attempts were made to determine the interface width following ASTM norm by measuring the difference between the maximum and the minimum atomic concentration of Si and Ni and then taking the difference in the depth position at 84% or 16% of the above concentration values. The depth profiles of Ni/Si interface show trace of oxygen at the interface due to which there is a sudden increase in the Ni concentration at the interface which does not allow us to calculate the true interface width (Fig. 5.11). But the depth resolution of these three sets of data could be calculated taking Si intensity as base data. The depth resolution can be taken as a qualitative measure of the mixing width and were calculated to be 13.5, 23.5 and 25.5 nm respectively. The trend in increase in depth resolution in the three cases definitely shows the trend in the mixing behaviour of Ni/Si interface due to annealing at different temperatures.

The above investigations suggest that there

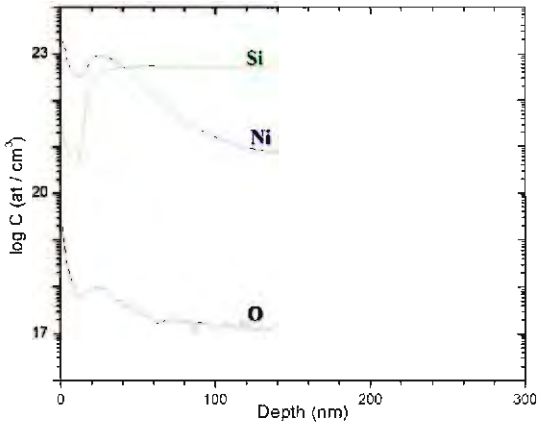


Fig. 5.11 : SIMS depth profile of Ni/Si annealed at 350 °C

exists a strong interface mixing at Ni(20nm)/Si system due to annealing at temperature 350 °C and 500 °C for 1h. The silicide formation starts at 350 °C where some mixed phases exist. The occurance of Ni_3Si_2 phase is strange in the 350 °C annealed case but it is possibly related to the nucleation controlled mechanism resulting from the reaction of Ni_2Si phase with NiSi phase under long annealing time. The stable NiSi phase was found at 500 °C. SIMS technique was applied to measure the interface width, which increases with increasing temperature. Atomic force microscopy has revealed noticeable morphological changes upon silicidation.

रेडियो तथा वायुमण्डलीय विज्ञान

RADIO AND ATMOSPHERIC SCIENCES

रेडियो तथा वायुमण्डलीय विज्ञान

रेडियो तथा वायुमंडलीय विज्ञान प्रभाग के कार्यकलापों में एन पी एल की दो प्रमुख प्रयोगशाला परियोजनाएं शामिल हैं – 'रेडियो भौतिकी अनुप्रयोग' तथा 'वायुमंडलीय पर्यावरण में परिवर्तन'

चालू वर्ष के दौरान रेडियो भौतिकी तथा अनुप्रयोगों पर प्रमुख प्रयोगशाला परियोजना के अंतर्गत 'एफ' – क्षेत्र पैरामीटरों के लघु तथा दीर्घकालीन प्रामुक्ति के मॉडल के लिए दो उपगमनों पर कार्य किया गया है । पहले उपगमन में 'एफ' – क्षेत्र पैरामीटरों के विशिष्ट फ्रीक्वेंसी तथा भू चुम्बकीय इंडेक्स ए पी में सौर फलक्स पर उनकी निर्भरता की जांच करने के लिए बहु परिवर्तन विश्लेषण का प्रयोग किया गया है । दूसरे उपगमन में सन स्पॉट संख्याओं के 12 मासिक माध्य (मीन) सहित समान पैरामीटरों के मासिक मध्यिका (मीडियन) के द्वितीय क्रम के सहसंबद्ध गुणांक का प्रयाग किया गया है । द्वितीय उपगमन में एच एफ संचार अनुप्रयोगों के लिए एफ–क्षेत्र पैरामीटरों के दीर्घकालीन प्रामुक्ति (प्रीडिक्शन) में अधिक उपयोगी पाया गया है । एक और अध्ययन में यह भी पाया गया है कि भूमध्य रेखा के निकट ExB या h'F का देहली मान (threshold values) का प्रयोग 'स्प्रेड–एफ / सिंटिलेशन के 'नाइट टू नाइट' के होने के प्रामुक्ति (प्रीडिक्शन) के लिए किया जा सकता है । आयन सोंद डाटा में भारत में पूर्व में आए प्रमुख भूकम्पों का रुझान देखने के लिए एक अध्ययन किया गया है । F_2 के असंगत व्यवहार के रूप में 1967 के कोयना भूकंप के दो दिन का पूर्वानुमान सिग्नल वास्तविक भूकंप आने से दो दिन पूर्व विभिन्न लोकेशनों पर पांच आयनसोंद स्टेशनों के डाटा में नोट किया गया था । बादलों के विभिन्न अभिलक्षणों द्वारा उत्पन्न 10–70 GHz फ्रीक्वेंसी पर बादलों के क्षीणन के तीन स्टेशनों पर अनुभव किया गया । वीएलएफ अभिग्राही (रिसीवर) पर आधारित एक लेब व्यू (Lab VIEW) का डिजाइन किया गया तथा अंटार्कटिका में स्थायी वी एल एफ़ स्टेशन स्थापित करने के एक कदम के रूप में कार्य कर रहा है ।

'वायुमंडलीय पर्यावरण में परिवर्तन' पर प्रमुख प्रयोगशाला परियोजना के अंतर्गत चालू वर्ष से CH_4 के प्रेक्षणों NMHC तथा बेनजीन को राष्ट्रीय भौतिक प्रयोगशाला कैम्पस से नियमित मॉनीटरिंग करने के लिए पैरामीटरों के रूप में शामिल किया गया है, जबकि सतह पराबैंगनी विकिरण के प्रेक्षणों, ओजोन तथा नाइट्रोजन के ऑक्साईड, ऐरोसोल के कॉलम मापों, ओजोन तथा जल वाष्प का प्रेक्षण कार्य जारी है । सिंधु–गंगा नदी के मैदानी इलाकों के ऊपर वायुमंडल के सतह पर तथा शीर्ष पर एरोसोल विकिरण प्रणोदन के पूर्वानुमान पर एक योजनाबद्ध प्रयास प्रारंभ किया गया है । कानपुर के ऊपर प्रणोदन दक्षता कर पूर्वानुमान लगाया गया है तथा थार के मरुस्थल से उत्पन्न होने वाला अपवादिक धूल भरी आंधी के द्वारा दिल्ली तथा नैनीताल में वैश्विक विकिरण का प्रणोदन का भी अवलोकन किया गया तथा परिमाण को मापा गया । भारतीय अंतरिक्ष अनुसंधान संगठन (आईएसआरओ) के अंतर्गत 'शिप–बोर्न' प्रेक्षणों के परिणाम के रूप में कार्यकलापों का समन्वय किया गया ग्रीष्म तथा शीत मानसून के संक्रमण अवधि के दौरान बंगाल की खाड़ी तथा अरब सागर के ऊपर ओजोन तथा सी ओ (CO) के संबंध पर भी अध्ययन किया गया है । उष्ण कटिबंध क्षोभ सीमा तापमान के निचले क्षेत्र पर मानसून से संबंधित 'मेसोस्केल कंवेक्शन सिस्टम' के प्रभाव को भी नोट किया गया है । दार्जिलिंग से ओजोन की सतह पर लगातार मानीटरिंग करने से इस क्षेत्र में मानी गई उच्च मिश्रण अनुपातों को उत्पन्न करने में लम्बी रेंज के परिवहन की अधिकता के प्रमाण भी प्राप्त हुए हैं । एक अन्य अध्ययन के हिस्से के रूप में स्ट्रेटोस्फियर ऊंचाई पर ओजोन के घटते हुए रूझान को सैद्धांतिक मॉडेल में अनुभव किया गया है । इस डिवीजन द्वारा सी एस आई आर नेटवर्क कार्यक्रम के एक हिस्से के रूप में एन आई ओ, गोवा में एक नए वायुमंडलीय मॉनीटरिंग स्टेशन को भी स्थापित किया गया है ।

RADIO AND ATMOSPHERIC SCIENCES

The activities of the Radio and Atmospheric Sciences Division comprise two Major Laboratory Projects of NPL namely 'Radio Physics and Applications' and 'Atmospheric Environment Change'.

Under the Major Laboratory Project on 'Radio Physics and Applications', during current year two approaches to model short and long term predictions of F-region parameters have been attempted. The first one uses multi-variant analysis of F-region parameters to examine their dependence on solar flux at a specific frequency and the geomagnetic index Ap. The other one uses second order correlation coefficient of monthly median of the same parameters with 12 monthly mean of sunspot numbers. The second approach is found more useful in long term prediction of F-region parameters for HF communication applications. In another study it is also found that, near magnetic equator, threshold values of ExB or h'F can be used for prediction of night-to-night occurrences of Spread-F/scintillations. A study has been initiated to look for precursor of past major earthquakes in India in ionosonde data. A two day precursor signal of the 1967 Koyna earthquake in the form of anomalous behaviour of foF2 has been noted in data of five ionosonde stations at different locations two days before the actual event. Cloud attenuation at frequencies 10-70 GHz caused by different cloud characteristics has been deduced for three stations. A LabVIEW based VLF receiver has been designed and operated at Antarctica as a step to establish a permanent VLF station there.

Under the Major Laboratory Project on 'Atmospheric Environment Change' observations of CH_4, NMHC and Benzene have been added from the current year as parameters for regular monitoring from NPL campus, while earlier observations of surface ultraviolet radiation, ozone and oxides of nitrogen, column measurements of aerosols, ozone and water vapor have been continued. A systematic effort on estimation of aerosol radiation forcing at surface and at top of the atmosphere over the Indo-Gangetic plains region has been initiated. While forcing efficiency over Kanpur has been estimated, the forcing of global radiation at Delhi and Nainital by a rare dust storm event that originated from Thar Desert has been also observed and quantified. As an outcome of ship-borne observations under the ISRO coordinated activity, the relationship of ozone and CO over the Bay of Bengal and Arabian sea during summer and winter monsoon transitions has been studied. Influence of monsoon associated mesoscale convection system on the lowering of tropical tropopause temperature has been noted. Continuous monitoring of surface ozone from Darjeeling has given evidence of dominance of long range transport in producing the measured high mixing ratios at this site. As part of another study, the observed declining trend of ozone at stratospheric heights has been theoretically modeled. A new atmospheric monitoring station has been established at NIO, Goa by this Division as part of a CSIR Network Program.

Radio and Atmospheric Sciences Division

The activities of the Radio and Atmospheric Sciences Division comprise two Major Laboratory Projects of NPL. The first one named 'Radio Physics and Applications' deals with improving the characterization of ionized and non-ionized media, employing models and observations in both the upper and the lower atmosphere, studying ionospheric irregularities and their causes, providing predictions for some space weather parameters, and impact on applications of various radio frequency bands, e.g., fixed & mobile communication links, naval communication, satellite data transmission, navigation, global position fixing and also some studies in space physics. The long term objective of this set of studies and associated instruments & networked facility development is to acquire for the country a near real time high precision ionospheric predictions capability for strategic applications by various agencies. The second Major Laboratory Project named 'Atmospheric Environment Change' covers observations and modeling to understand long and short term changes in ambient radiation and composition of various minor constituents including aerosols in lower and middle atmosphere and their impact. Regular and some campaign mode studies of strengths of their ambient concentrations, their sources & sinks, their long range transport and transformation and various impact assessment are part of this. The 'Centre on Global Change' and the 'South Asian Regional Research Centre' of ICSU's START Programme for regional studies in Global Change that promote capacity building in the Indian region for coordinated multi-agency multi-disciplinary national and international programs are also operated as a constituent of this Major Laboratory Project

Radio Physics and Space Applications

Upper Atmospheric Studies

Ionospheric Modeling for short and long term predictions of F-region parameters

The equatorial and low latitudinal F-region ionosphere is highly dynamic and unpredictable because of various geophysical operative mechanisms. In the present study, two HF prediction models for short and long term are developed for equatorial and the low latitude F-region ionosphere. In the first model, Multivariant (MV) analysis for the dependence of F-region parameters, foF2 and M(3000)F2 on solar 2800 MHz flux (F10.7) and geomagnetic index Ap is performed. In the second model, second degree (SD) correlation coefficients of the monthly median foF2 and M(3000)F2 with 12 monthly mean sunspot numbers (R12) are determined. Using the hourly values for about half a solar cycle from Delhi (28.6°N, 77.1°E) digital ionosonde, MV correlation coefficients, separately for quiet (Ap<25) and disturbed (Ap > 25) periods, for foF2 and M(3000)F2 are obtained for every month over 24 local times (LT) with daily F10.7 and Ap simultaneously. Similarly SD correlation coefficients are obtained for each of the 24 LT for each of the 12 months and for all the 14 stations covering a geographic latitude range of about 0° to 45° N. These coefficients for each hour for all the twelve months are then used by the computer based MV and SD models to predict ionospheric hourly foF2 and hmF2 values for a given inputs such as month, F10.7, Ap and R12 as the case maybe. Modeled output of foF2 and hmF2 values, calculated on short and long term basis, are then compared with the observed data over Delhi and IRI model. Performance of MV and DS models are examined by comparing it with measured values of foF2 and hmF2 and IRI

model and they are found to be in good agreement. As an example comparison of MV model, foF2 and hmF2 values with observed and IRI values at Delhi as measured on Mar27-Apr2, 2001 are shown in Fig. 6.1 Over all, on short and long term basis, MV modeled values are showing best correlation with the observed one even during the magnetic storm periods whereas SD model is useful for providing long term predictions for HF communication applications.

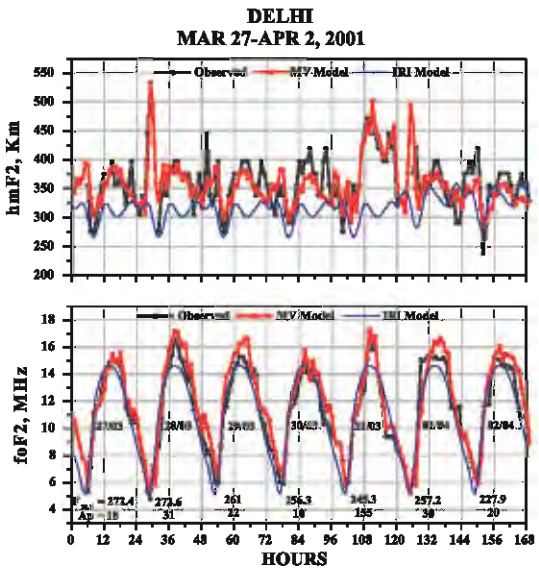


Fig. 6.1 : Comparison of modeled hourly foF2 and hmF2 values

Equatorial and low latitude spread F irregularity characteristics over the Indian region and their prediction possibilities

To study the occurrence characteristics of equatorial spread-F irregularities and their latitudinal extent, simultaneous digital ionosonde data (January to December 2001) from Trivandrum (8.2° N), Waltair (17.7° N) and Delhi (28.6° N) and 4 GHz scintillation data from Sikandarabad (26.8° N) and Chenglepet (10.4° N), and 250 MHz scintillation data from Bhopal (23.2° N) for equinox period are analysed. It is noted that during equinox and

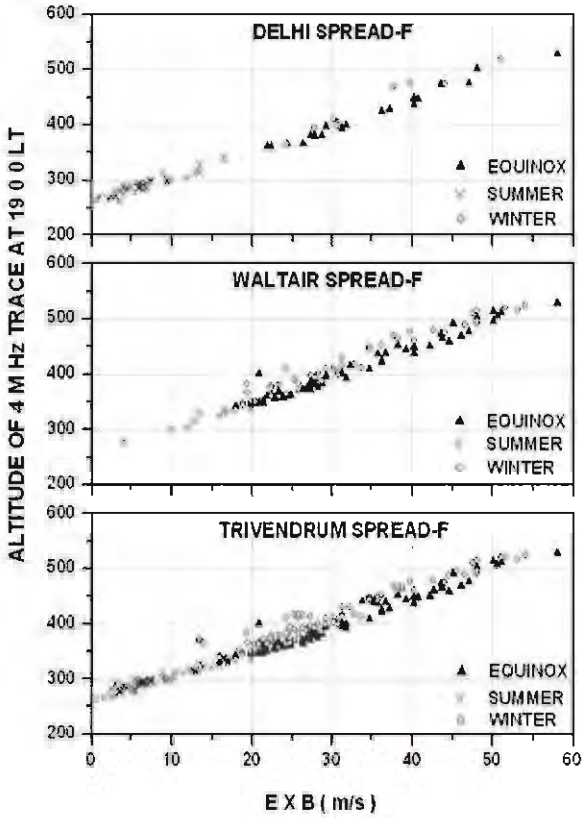


Fig. 6.2 : Seasonal plots of ExB drift and h'F values over the magnetic equator on those nights when Spread-F is observed over Trivandrum, Waltair and Delhi.

winter months their occurrences at higher latitude station are always conditional to their prior occurrences at lower latitudes indicating their association with the generation of equatorial plasma bubble and associated irregularities. To gain forecasting capability, night-to-night occurrences of spread-F/scintillation at these locations are examined in relation to post-sunset rise of h'F and upward ExB drift velocity over the magnetic equator using Trivandrum ionosonde data. It is noted that except the summer months, the spread-F at Trivandrum, Waltair and Delhi are observed only when equatorial ExB (h'F) is more than about 15 m/s (325km), 20 m/s (350km) and 25 m/s (375km) respectively. Fig. 6.2 shows the seasonal variations of ExB drift and h'F

thethreshold values over the magnetic equator required for the onset of Spread-F over Trivandrum, Waltair and Delhi during 2001. With these threshold values their corresponding success rate of predictions are more than 90 %, 50% and 15 % at the respective locations. However GHz scintillation, near equator are observed only when ExB (h'F) is more than 15 m/s (325 km) and for low latitude, the same should be 30 m/s (400 km) with success rates of prediction of about 90% and 30% respectively. Thus near magnetic equator threshold values of ExB or h'F can be used for the prediction of night-to-night occurrences of spread-F/scintillations.

Ionospheric Precursors observed at low latitudes around the time of Koyna Earthquake

On December 11, 1967 at 05:21 LT, an immense earthquake of magnitude 6.7 on Richter Scale struck Koyna, the Indian province of Maharashtra. Its epicenter was located at geographic latitude 17.37°N and longitude 73.75°E with depth of about 3 km (Fig. 6.3).

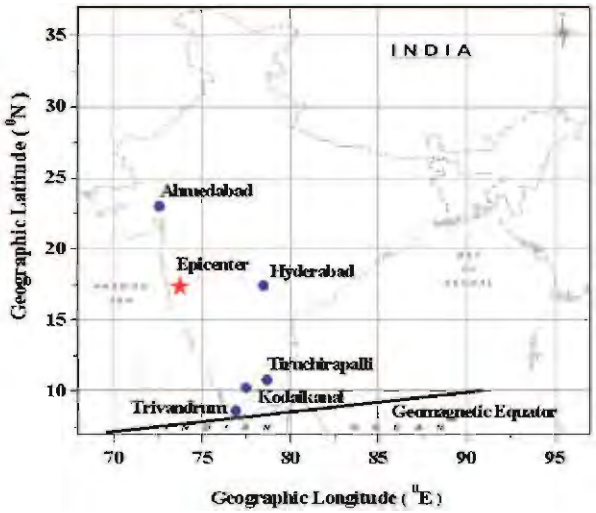


Fig. 6.3 : The star mark shows the geographical position of epicenter of the earthquake while the filled blue circles show the locations of observing ionosonde stations.

The behavior of F2- region of ionosphere is examined over the equatorial and low latitudinal region ionosphere around the time of Koyna earthquake period using the ionospheric data, Hyderabad (located close to the earthquake epicenter) Ahmedabad, Trichirapulli, Kodaikanal and Trivendrum. The upper and lower bound of Interquartile range (IRQ) are constructed to monitor the variations in foF2 other than day-to-day and diurnal pattern for finding the seismo-ionospheric precursors. Anomalous electron density variations are observed between post midnight hours to local pre-noon hours at each station. These anomalies are strongly time dependent and appeared a couple of days before the main shock. Hence the observed anomalies (which are more than the usual day-to-day variability) over all stations are likely to be associated with this imminent earthquake (Fig. 6.4) since it was a geomagnetic quiet period. The possible mechanism to explain these anomalies is the effect of seismogenic electric field generated just above the surface of earth within the earthquake preparation zone well before the earthquake due to emission of radioactive particles and then propagated upward, which perturbs the F-region ionosphere.

Martian Ionosphere

Electron density profile measured by the radio science experiment on Mars Global Surveyor (MGS) were studied for the variability in the density and height of the primary peak of the Martian ionosphere. The variability showed anomalous behavior from the expected photochemically formed layer. These behaviors are explained on the basis of solar wind interaction, which seems to have affected even the lower regions of Martian ionosphere.

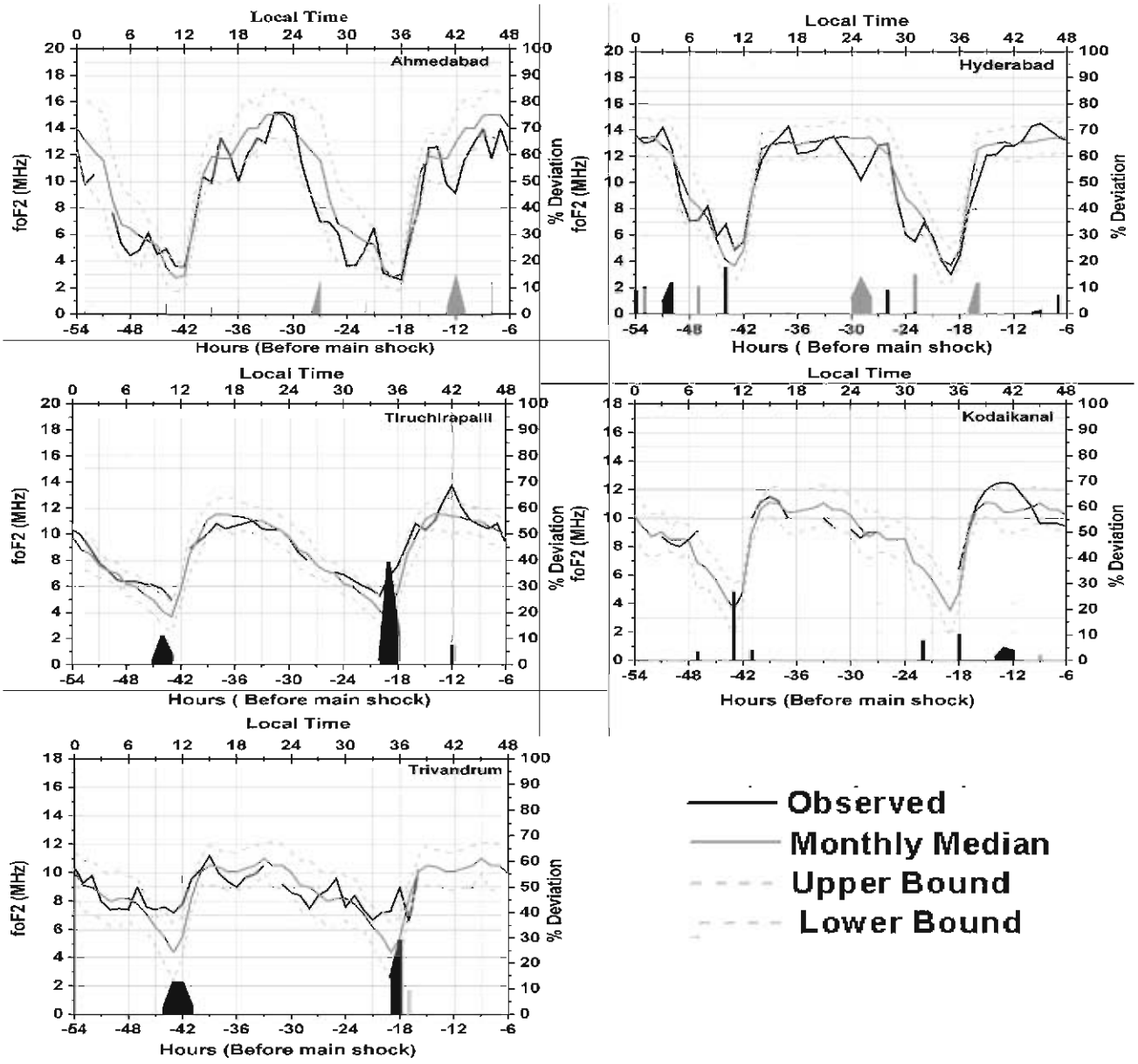


Fig. 6.4: Local time precursory variations in foF2 at the five observing ionosonde stations.

TROPOSPHERIC COMMUNICATIONS

Cloud characteristics for radio applications

Microwave and millimeter wave frequency bands are in demand for requirement of larger bandwidth for various applications of radio systems. In India microwave frequencies are already in use for communication/broadcasting purposes and millimeter wave frequencies will be in use in near future extensively for radio and remote sensing applications. But cloud attenuation and cloud noise temperature, both, lead to degradation in the performance of microwave communication and radar propagation. Though the effects of rain on radio wave are more than cloud but the occurrence of cloud is more frequent than rain. The cloud morphology particularly in relation to radio wave propagation over different geographical

region of India is therefore very essential and important. In view of this, systematic studies on cloud occurrence morphology over different geographical locations in India have been undertaken. In this study, cloud characteristics and cloud attenuation over three more stations are presented. Based on low level cloud coverage observations, cloud occurrences frequency over Mumbai (19.07°N, 72.51°E), Nagpur (21.06°N, 79.03°E) and Ahmadabad (23.04°N, 72.38°E) situated in Indian tropical west coast, central plain and semi arid region of western India in different months during daytime and nighttime has been deduced. The low-level cloud over Mumbai, Nagpur and Ahamedabad has been found to occur for many days and nights and particularly in the months of June, July, August and September. The specific attenuation of radio wave due to clouds at various frequencies 10 GHz, 18 GHz, 32 GHz, 44 GHz and 70 GHz over the aforesaid three stations also been deduced.

Atmospheric Environment and Global Change Studies

Long-term time series measurements including calibration of critical atmospheric parameters:

Land based measurements at Delhi: Continuous measurements of ozone (surface and columnar), NO_x ($NO+NO_2$), THC (CH_4 + NMHC), VOCs (Volatile Organic Compounds), mass concentration of PM2.5 and aerosol number-size distribution along with various meteorological parameters have been carried out at NPL. Salient features of the studies are as follows:

Surface ozone: Continuous measurement of surface ozone has been made at NPL since 1997 to till date. Temporal variation in surface ozone during 1997-2006 is shown in the Fig. 6.5.

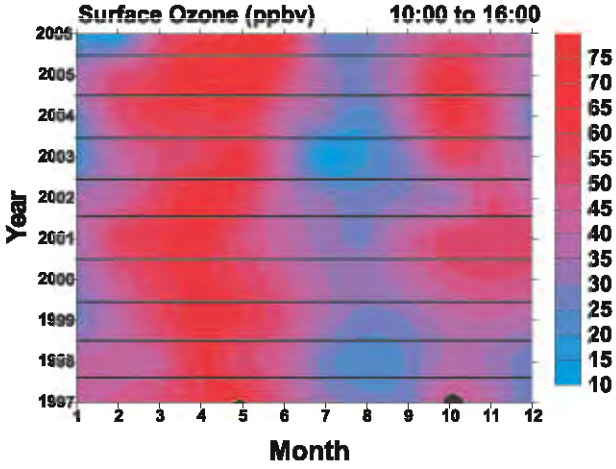


Fig. 6.5: Seasonal variation in ozone concentrations in summer, autumn, monsoon and winter seasons.

During the measurement period, concentration levels of surface O_3 at NPL shows the periodicity of 3 to 4 years. In summer (March-June) months, the average surface O_3 levels during the peak sunlit period (10:00 to 16:00 hours) vary between 45 to 80 ppbv, whereas the levels are comparatively low and vary between 35 to 65 ppbv during autumn (Oct-Nov) months. But in winter (Dec-Feb), the O_3 levels vary from 15 to 40 ppbv, whereas in monsoon months the levels are even low in comparison to the above seasons and vary between 10 to 35 ppbv.

Since NW side of the present site is surrounded by agricultural areas (IARI, PUSA Campus), a exposure plant response index AOT 40 (Accumulated exposure Over Threshold 40 ppb) has been calculated.

$$AOT\ 40 = \sum_{i=1}^{n} ([O_3] - 40)i \qquad \text{for } [O_3] > 40 \text{ ppb}$$

where $[O_3]$ is hourly averaged O_3 concentration; 40 is threshold value of O_3.

Results (Fig. 6.6) show that most of the time during the measurement period, the AOT 40 values are exceeding by 2 to 3 times than the

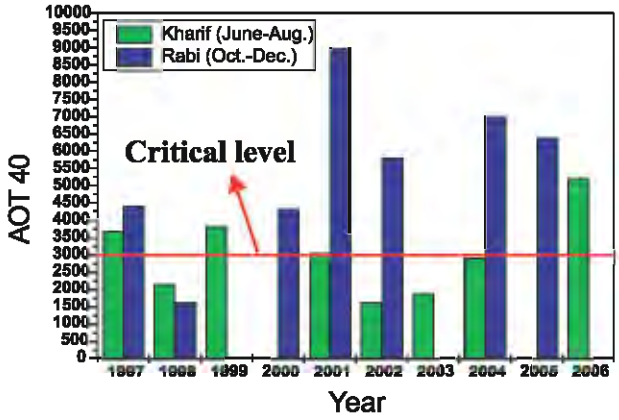


Fig. 6.6: AOT 40 for Kharif (June-August) and Rabi (October-December) periods of different years during 1997-2006.

critical level. But, in the year 1998 the AOT 40 values are well below the critical level during both the crop seasons.

Oxides of Nitrogen:

Continuous measurements of oxides of nitrogen NOx ($NO+NO_2$) have been made since June, 2002 at NPL, New Delhi.

Fig. 6.7 shows that the monthly average value of NOx varies between 2.5 to 60 ppb. It attains maximum value during post-monsoon and winter months. The values are found minimum during summer and monsoon seasons.

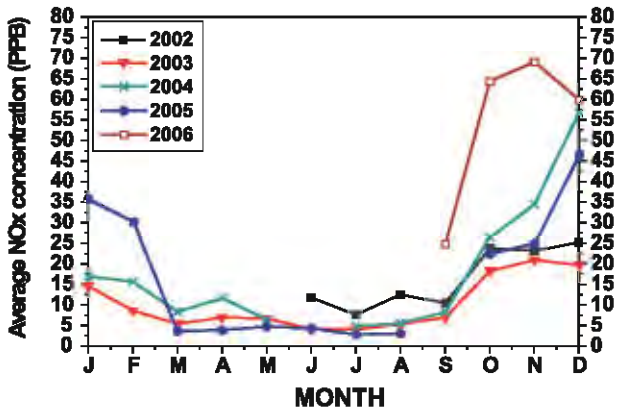


Fig. 6.7 : Monthly average NOx concentrations during 2002-2006

Methane and Non-Methane Hydrocarbon and Volatile Organic Carbon:

Non-Methane Hydrocarbons (NMHC) play an important role in global scale tropospheric photochemistry. NMHC influence the concentration of NOx and OH radical, which in turn control the concentration of photochemically and climatically active trace gases such as methane and CO. Measurements of Methane (CH_4) and Non-Methane Hydrocarbon (NMHC) and Benzene (C_6H_6) have been carried out since August, 2006 at NPL.

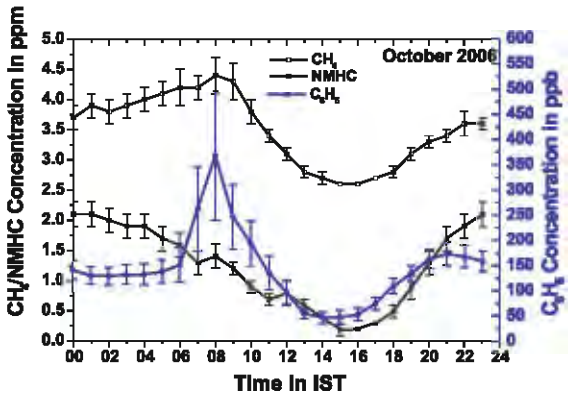


Fig. 6.8 : Diurnal variations of Methane, Non-Methane Hydrocarbon and Benzene

The monthly average concentration of CH_4 during October, 2006 varies between 2.6 to 4.4 ppm and NMHC varies between 0.2 to 2.1 ppm, whereas the average concentration of C_6H_6 is found to be between 48 to 370 ppb at NPL (Fig. 6.8).

Aerosol radiation interaction and Aerosol Radiation forcing

The study of the aerosol radiation interaction was continued using the data generated at NPL and the data obtained from Kanpur AERONET station. The aerosol forcing was obtained at the surface and at the top of the atmosphere (TOA) for the Kanpur station in the

Indo Gangetic Plain. The average surface forcing changed by -23 W/m^2 and TOA forcing changed by -11 W/m^2 during dust event days as compared to the non-dusty days (pre-monsoon season). The average aerosols forcing efficiency at the wavelength 500nm is found to be -46±2.6 W/m^2 and -17±2.5 W/m^2 at surface and TOA, respectively during dust storm period April-June, 2005 over the IG Plains (Fig. 6.9).

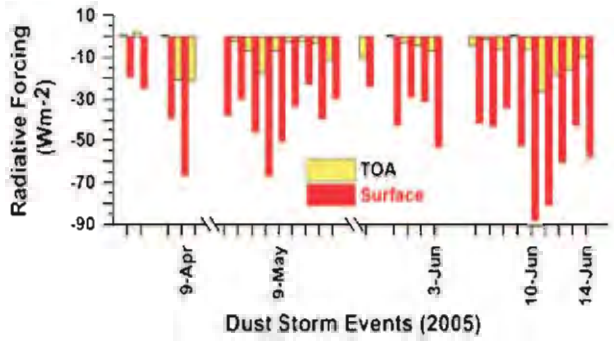


Fig. 6.9 : Aerosol Radiation Forcing at the surface and TOA at Kanpur

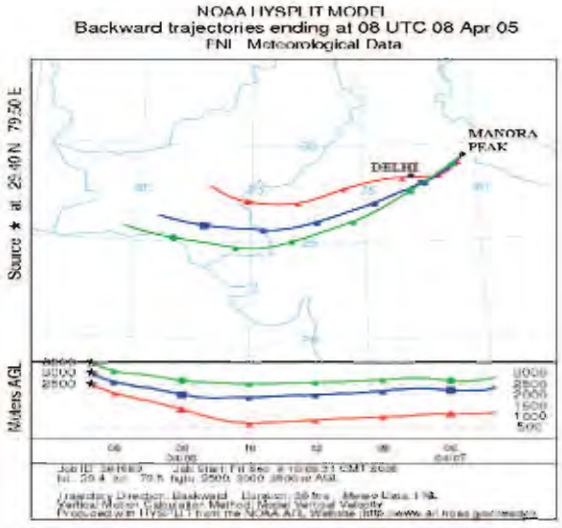


Fig. 6.10 : HYSPLIT, 36 hours back trajectories for Manora Peak station for dusty day.

A rare dust event originated from Thar Desert of northwest India and the Margo Desert of southern Afghanistan on April 6, 2005, affected the Indo-Gangetic plains in the northern India and parts of adjacent higher altitudes. With the help of MODIS satellite imagery, HYSPLIT backward trajectory, momentum flux derived from NCEP/NCAR reanalysis data and the ground based observations of AOD and radiation flux at Delhi and Manora Peak the dust event originating on April 6, 2005 was studied in detail (Fig. 6.10). It caused a reduction in global radiation (400-100nm) ~34% and doubled the AOD value at Manora peak. AOD at Delhi increased to three times and heavily reduced the Erythemal dose.

Bay of Bengal Moonsoon Experiment (BOBMEX): Sagar Kanya ship cruise (SK223):

In order to study the transport of aerosols over Bay-of Bengal and Arabian Sea and their characteristics and to gain deeper insight some of the processes controling the summer moonsoon, NPL participated in the ISRO-GBP led Integrated Campaign for Aerosol gas and Radiation Budget (ICARB) campaigns organized on board ship cruise Sagar Kanya during March 18 to May 10, 2006 as its cruise SK223 and at land stations Delhi and Darjeeling. The cruise Track is given in Fig. 6.11. During this cruise, preliminary measurements were made of GHGs like ozone, N_2O, CH_4, aerosols (chemical composition and size distribution, optical depths) and radiations etc.

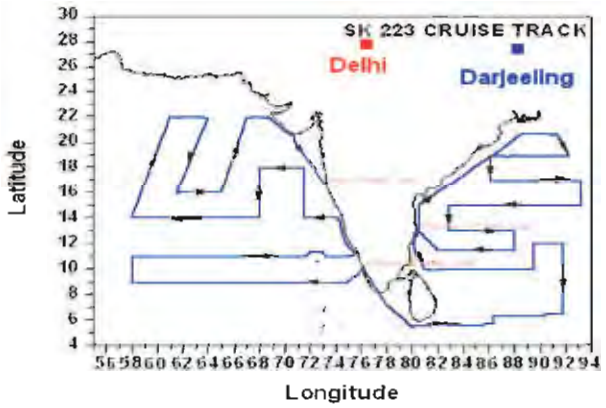


Fig. 6.11 : NPL Participation in the ICARB Field campaign March to May 2006.

(i) Relationship of Ozone and Carbon Monoxide over Bay of Bengal and Arabian Sea during summer and winter Monsoonal Transitions:

To understand the characteristic of surface ozone and carbon monoxide and their relation over Bay of Bengal and Arabian Sea during monsoonal transitions i.e., October-November, 2004 (SK212) and March-May, 2006 (SK223), coordinated observations were made in campaign mode on board ORV Sagar Kanya. During both the periods, surface ozone shows large variation with lesser concentration (5-40 ppbv) as compared to earlier reported results. Carbon monoxide shows higher concentration (100-200 ppbv) during October-November, 2004 compared to that of March-May, 2006 (50-150 ppbv). Back trajectories calculation shows that air mass has been originated either from India or Indian Ocean during March-May 2006, whereas, air mass during October-November, 2004 has been originated either from South East Asia or from India.

(ii) Influence of monsoon associated mesoscale convection systems on The tropical tropopause region:

GPS sondes were launched on board Sagar Kanya along with radiosondes flights at several coastal stations of Bay of Bengal. Analysis of GPS sonde and Radiosonde data collected during BOBMEX have shown that extremely low tropopause temperatures (LTT) occur over Indian tropical region including Bay of Bengal during monsoon and post monsoon seasons. Tropical mesoscale convection systems (TMCS) are generally considered as one of the causative mechanisms for the appearance of such cold tropopause. The association between occurrence of TMCS and spatial distribution of temperature and water vapour in upper troposphere and lower stratosphere (UTLS) region over eastern tropics was studied. Radiosonde /GPS sonde temperature observations, satellite observations of OLR and cloud top temperature (CTT) are used along with the ECMWF reanalysis of temperature, specific humidity (SH), relative humidity (RH) and wind fields at these height levels.

The ECMWF re-analysis of temperature at 100mb level shows that the area of low tropopause temperature (LTT) appears prominently over the Indian tropics during monsoon months. The air in the vicinity of LTT appears to be close to saturation. The area of low OLR, which indicates enhanced convection, is embedded with high clouds with top temperatures of 193 K to 213 K. An examination of areas of low OLR and LTT, though, yields a close association in the spatial occurrence of these two phenomena, the two areas, generally, appear to be spatially separated. When there are multiple low OLR areas, the area of LTT appears in between such areas, though LTT areas may partially overlap with some of the OLR areas. Present observations; show that the cooling at the tropopause level might have been produced by multiple convection events.

Study of Surface Ozone behaviour in Eastern Himalayas at Darjeeling (27.01° N, 88.25° E)

Characteristics of surface ozone, monitored continuously at Darjeeling (27.01°N, 88.25° E, msl: 2196 meter) in the Eastern Himalayas for the period of 2004-2007, are examined. The annual average volume mixing ratio of surface ozone at Darjeeling is 45 ppbv, with a range from 20 to 130 ppbv. Such high surface ozone mixing ratios are rarely observed at other sites in India. The relative importance of horizontal transport from surrounding regions, long-range transport, vertical transport and local

photochemistry in controlling surface ozone levels are assessed based on additional observations, along with seven-day backward trajectories from the HYSPLIT4 model and output from the MATCH-MPIC model. The horizontal advection from the surroundings is ruled out since the surface ozone in the surroundings of Darjeeling is also of the order of 45 ppbv. On the whole, it appears that long-range transport is of primary importance in producing the high mixing ratios observed at Darjeeling.

Theoretical Explanation of low stratospheric ozone over Indian Sub-continent

A height wise trend analysis of ozone using Umkehr data over Delhi and Pune showed a decline in ozone at stratospheric heights which is a serious concern as it shields the earth's biosphere from harmful ultraviolet radiation. An attempt is made to find the theoretical reason for the stratospheric ozone depletion. Since minor constituents show variation with Quassi Biennial Oscillation (QBO), trend in minor constituents like water vapour, methane, NOx is recalculated by taking QBO into account and then this change is incorporated in minor constituents in the photochemical model to explain the depletion.

The existing time regressive model is generalized to include any periodic oscillations like ENSO, QBO, Solar cycle etc. Trend analysis of tropospheric ozone is done using ozonesonde over various Indian stations namely Delhi, Pune and Trivandrum.

Instruments and Facility Development Activities

Atmospheric Laboratory at NIO, Goa under CMM-0009 Network Project:

CO, CO_2, Multigas calibrator, SODAR and radiation measurements experiments have been setup and made operational at NIO, Goa.

Lab-VIEW based VLF receiver for IPY

A software VLF receiver for monitoring VLF signals at Antarctica during the 26th Indian Antarctic expedition undertaken in Jan-Mar 2006 period has been designed and developed. Also, this expedition is meant to provide a ground work for the installation of a permanent VLF monitoring station at Larsemann Hills, is the new Indian Antarctic station. In addition, the scope of VLF monitoring station at Antarctica is relevant in the light of ongoing International Polar Year (IPY) program which envisages a global scientific participation to understand the sun-earth relation vis-a-vis the large scale global linkages to highly energetic solar events through observations at polar regions. One special aspect will be to study the Inter-Hemispherical conjugates and dissimilarities displayed by the two polar ionospheres to large solar events. Fig. 6.12 shows a typical solar flare effect seen on VLF record during the 26th Antarctica expedition at Larsemann Hills station.

Some important aspects of the software receiver developed at NPL is that the PC based

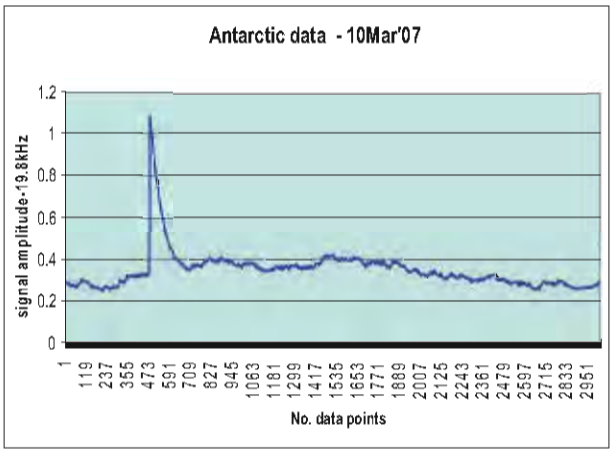


Fig. 6.12 : VLF record showing a solar flare effect

receiver is configured using National Instruments (NI) LabView software and the NI 4472 dynamic signal analyzer DAQ card with 24 bit, 8 channel simultaneous aquisition capability at 102.4 kHz maximum sampling per channel.

The software receiver is configured for multiple VLF signal acquisition (amplitude only) with input sensitivity ~ 5 μv, dynamic range 90db.

One of the important aspect is that the receiver implements Fourier spectral domain averaging with digital filter modules to condition the input VLF signal. Fig. 6.13 shows the LabVIEW software-receiver front panel displaying the spectrum of the VLF beacon signal at 19.8 kHz transmitted from Australia - well resolved using the band pass filter with a pass band 18.5 kHz 21.2 kHz.

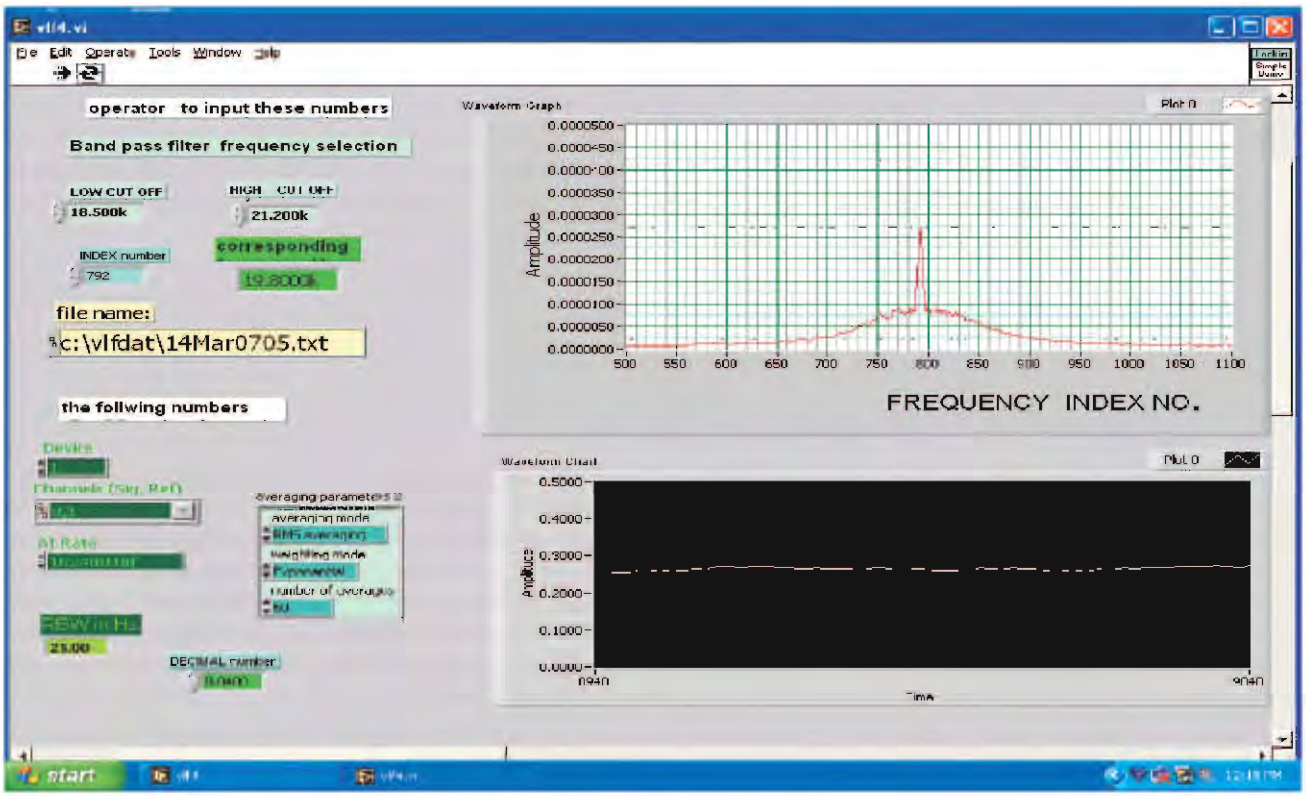


Fig. 6.13 : LabVIEW software-receiver front panel

अतिचालकता तथा निम्नतापिकी
SUPERCONDUCTIVITY AND CRYOGENICS

अतिचालकता तथा निम्नतापिकी

विभाग का ध्यान अतिचालकता की खोज में है। पॉलीक्रिस्टलाइन एम जी बी टू के पर्याप्त नमूनों को चारों ओर से आर्गन एनीलिंग कन्डिशन दाब पर तैयार किया गया। संरचना/माइक्रो संरचना के विस्तृत भौतिक गुणों (TEM) चुम्बकीय क्षेत्र की प्रतिरोधकता [$\rho(T, H)$], थर्मोइलेक्ट्रिक शक्ति S(T), थर्मल कंडक्टविटी κ (T) और चुम्बकीय करण का अध्ययन इन नमूनों में किया गया। विभिन्न नेनो कणों को MgB_2 पॉलीक्रिस्टल में मिलाया गया जैसे–n-TiO_2 गुण दोष विवेचन विद्युत घनत्व (J_c) प्रदर्शन को बढ़ाने के लिए मिलाया गया । 20 K से नीचे चुम्बकीय क्षेत्र लूप में नीचे गिरती तत्वों के प्रवाह का अवलोकन इन पदार्थों में उच्च (J_c) को दर्शाता है। इन यौगिकों में चुम्बकीय अवयवों को अध्ययन करने के लिए रूथेनो क्यूप्रेट फेरोमेग्नेटिक सुपर कंडक्टर पर एक्स पी एक्स अध्ययन किया गया। Mn का पॉलीक्रिस्टल पर्याप्त नमूना $(Y,Gd)Ba_2(Cu_{1-x}Mn_x)_3O_{7-\delta}$ ($x \leq 0.02$) and $YBa_2(Cu_{1-x}Mn_x)_3O_y$ ($0 \leq x \leq 2\%$) को तैयार किया। इसमें थर्मल कंडक्टिविटी और थर्मो इलेक्ट्रिक पावर और रैखिक उष्ण विस्तार (α) की खोज की गई। Mn विस्थापन अनेक महत्वपूर्ण बनावट जैसे κ (T) में कूबड़, S(T) का चिन्ह परिवर्तन, और रैखिक उष्ण विस्तार में परिवर्तन को प्रभावित करता हुआ पाया गया । इसके अतिरिक्त Sb ने $La_{2/3}Ba_{1/3}Mn_{1-x}Sb_xO_3$ को विस्थापित किया और मैग्नेटाइट को तैयार किया गया और संरचनात्मक मैग्नोट्रांसपोर्ट और जन्तु शरीर रचना शास्त्र संबंधी अध्ययन को कुचालक धातु जैसे उसमें परिवर्तन को अध्ययन करने के लिए किया गया।

SUPERCONDUCTIVITY AND CRYOGENICS

The focus of the division has been on basic research in superconductivity. Polycrystalline bulk samples of MgB_2 were synthesized under ambient pressure argon annealing conditions. Detailed physical properties study of structure/micro-structure (TEM), resistivity under magnetic field [$\rho(T,H)$], thermoelectric power S(T), thermal conductivity $\kappa(T)$ and magnetization were carried out in these samples. Different nano particles were added to MgB_2 polycrystalline, e.g. nano-TiO_2, to enhance the critical current density (J_c) performance. Observation of flux avalanches in the magnetization field loops below 20 K indicate high J_c in these materials. XPS studies were carried out on Rutheno-cuprate ferromagnetic superconductors to study the magnetic component in these compounds. Polycrystalline bulk samples of Mn substituted $(Y,Gd)Ba_2(Cu_{1-x}Mn_x)_3O_{7-\delta}$ $(x \leq 0.02)$ and $YBa_2(Cu_{1-x}Mn_x)_3O_y$ $(0 \leq x \leq 2\%)$ system were synthesized. Investigations of thermal conductivity (κ) and thermoelectric power (S), and linear thermal expansion (α) have been carried out in them. Mn substitution is found to effect several interesting features like hump in $\kappa(T)$, sign change of S(T) and jump in the coefficient of linear thermal expansion. In addition, Sb substituted $La_{2/3}Ba_{1/3}Mn_{1-x}Sb_xO_3$ manganites were synthesized, and structural, magneto-transport and morphological studies were carried out to study the insulator-metal (I-M) like transitions in them.

Physical properties of MgB_2 Superconductor

We report synthesis, structure/micro-structure, resistivity under magnetic field [ρ(T)H], thermoelectric power S(T), thermal conductivity κ(T) and magnetization of ambient pressure argon annealed polycrystalline bulk samples of MgB_2, processed under identical conditions. The compound crystallizes in hexagonal structure with space group P6/mmm (Fig.7.1). Transmission electron microscopy (TEM) reveals electron micrographs showing various types of defect features along with the presence of 3-4nm thick amorphous layers forming the grain boundaries of otherwise crystalline MgB_2. Superconductivity at 38K is corroborated by magnetic susceptibility χ (T), resistivity ρ(T) (Fig.7.2), thermoelectric power S(T) (Fig.7.3), and thermal conductivity κ(T) measurements (Fig.7.4). The power law fitting of ρ(T) give rise to Debye temperature (Θ_D) at 1400 K which is found consistent with the theoretical fitting of S(T), exhibiting Θ_D of 1410 K and carrier density of 3.81 x $10^{28}/m^3$. Thermal conductivity κ(T) shows a jump at 38K, i.e., at T_c, which was missing in earlier

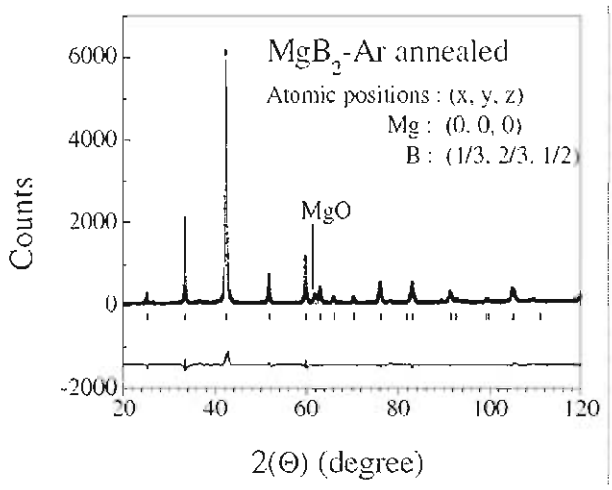


Fig. 7.1: XRD of Argon annealed MgB_2 sample

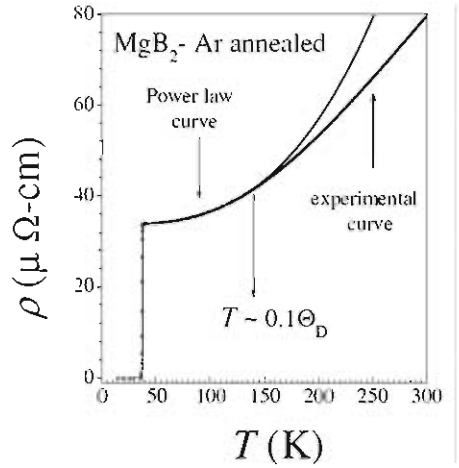


Fig. 7.2: ρ versus T of Argon annealed MgB_2 sample

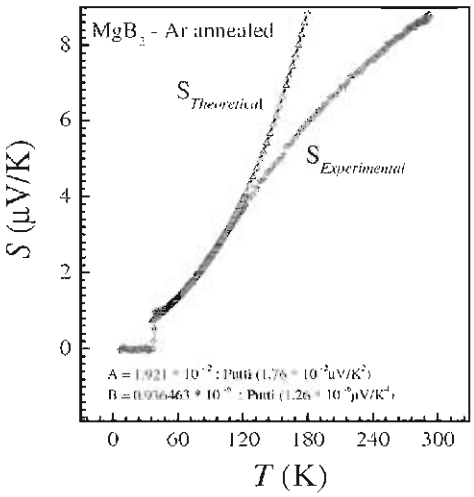


Fig. 7.3: S versus T of Argon annealed MgB_2 sample

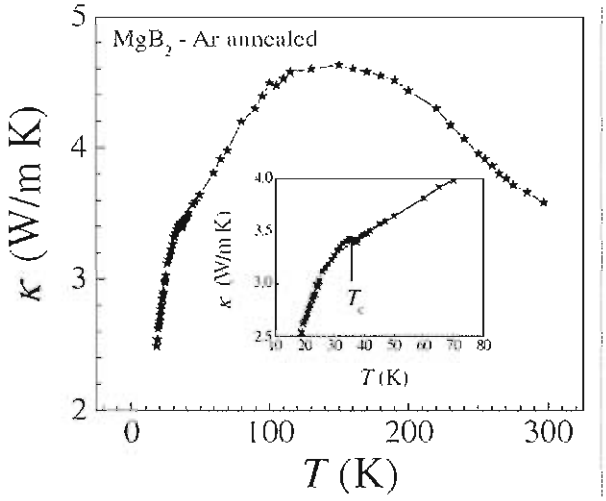


Fig. 7.4: κ versus T of Argon annealed MgB_2 sample

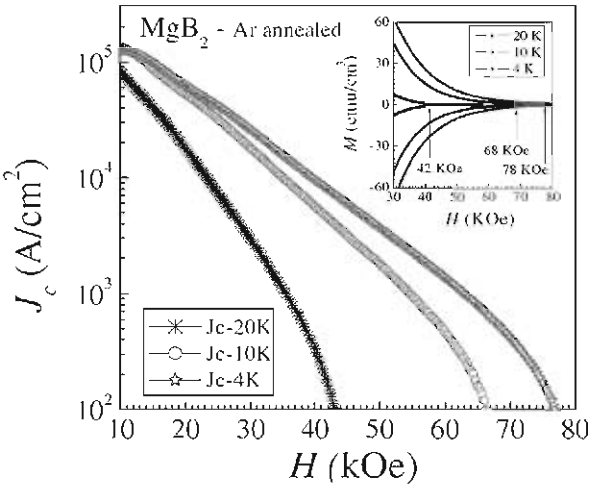


Fig. 7.5 : J_c versus H of Argon annealed MgB_2 sample. The inset shows M-H Loops.

reports. Critical current density (J_c) of up to 10^5 A/cm^2 in 1-2 T (Tesla) fields at temperatures (T) of up to 10 K is seen from magnetization measurements (Fig.7.5). The irreversibility field, defined as the field related to merging of M(H) loops is found to be 78, 68 and 42 kOe at 4, 10 and 20 K respectively (see inset Fig.7.5). The physical property parameters measured for polycrystalline MgB_2 are compared with earlier reports and a consolidated insight of various physical properties is presented.

Superconductivity of nano-TiO_2 added MgB_2

We report on the synthesis, phase formation, microstructure, and magnetization, of nano(*n*)-TiO_2 added MgB_2 polycrystalline compounds. The *n*-TiO_2 amounts are varied from 1% to 15% in weight (wt). All the studied samples are near single phase with small amounts of un-reacted Mg/MgO until 10 wt%. The 15wt% *n*-TiO_2 added sample seems multi phase compound with unusual broadening of main MgB_2 reflection and more unidentified lines in its X-ray diffraction (XRD) pattern. The superconducting transition temperature (T_c) being measured by magnetization experiments (Fig.7.6) decreases marginally with *n*-TiO_2 addition, for example the T_c is at 37.5 K and 35.5 K respectively for pristine and 10wt% *n*-TiO_2 added samples. This indicates that Ti has not significantly substituted into the host MgB_2 lattice. Grains morphology of these compounds reveals porous regions and does not change much with TiO_2 addition. The high resolution transmission electron microscopy (HRTEM) studies of these samples revealed presence of *n*-TiO_2 in these samples (Fig.7.7). The critical current density (J_c) of the MgB_2-n-TiO_2 samples, as estimated by using the Bean's model, shows better performance under magnetic fields above 3 Tesla than pristine MgB_2 for up to 4 wt% of addition, and decreases fast for additions above 6 wt% (Fig.7.8). We conclude that *n*-TiO_2 helps in enhancing the flux pinning centers in MgB_2 superconductor and hence improves the J_c(H) performance up to 4 wt% of addition in higher fields of above 3 Tesla.

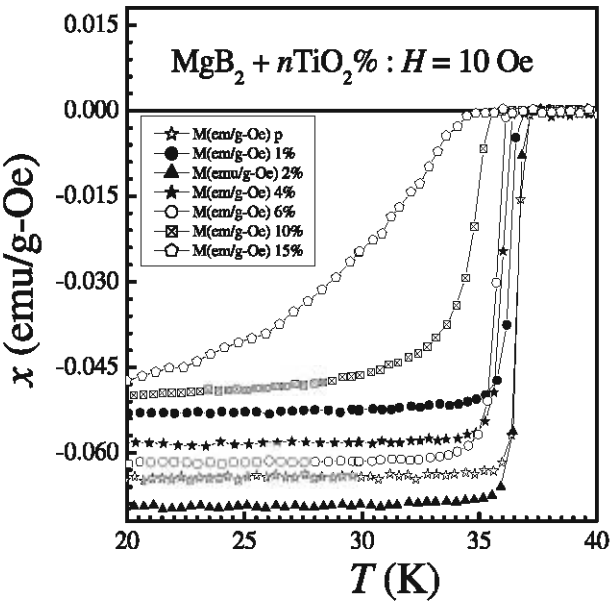


Fig. 7.6: χ versus T of n-TiO_2 added MgB_2 superconductor

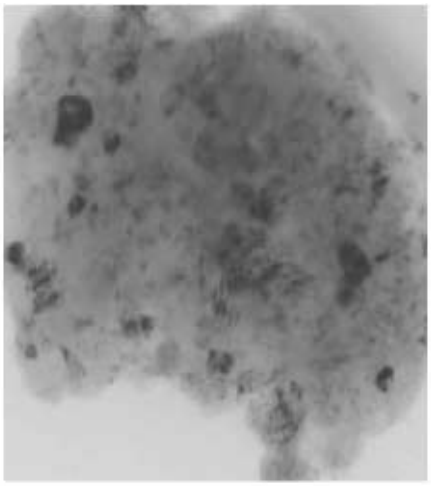


Fig. 7.7: Dark field image showing n-TiO_2 holes

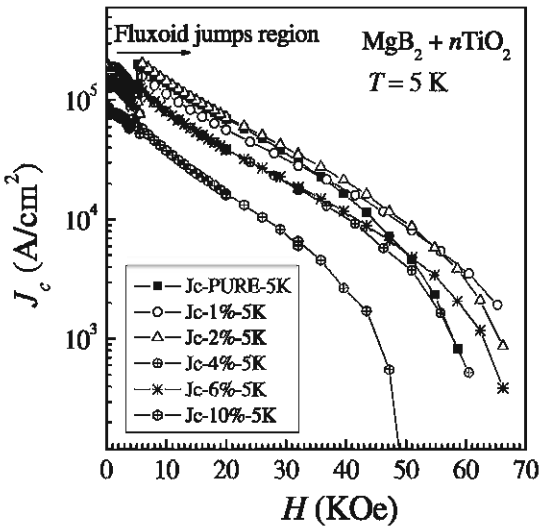


Fig. 7.8: J_c versus H of n-TiO_2 added MgB_2 superconductor

Avalanche of flux jumps in polycrystalline MgB_2 superconductor:

Dc magnetization studies were carried out on a polycrystalline MgB_2 superconductor, which was synthesized at 750 ^{0}C in Fe tube encapsulation under a vacuum of (10^{-5} Torr). Zero resistance at H = 0 and 8 T is obtained at 38 K and 22 K respectively. The material possesses a sharp diamagnetic transition in the zero-field-cooled branch, whereas, the field-cooled branch exhibits, the paramagnetic Meissner effect like phenomenon below T_c, indicating strong pinning in this compound. The critical current density at 20 K and 2 T, estimated by the Bean model is higher than 10^5 A/cm^2. Due to the strong pinning, we observed the presence of flux avalanches below H = 5 kOe at temperatures below 20 K (Fig.7.9). The magnetization M(H) grows (as usual) slowly with H and falls sharply to near zero moment value, and further grows again in a common way. The flux avalanches were seen quite symmetric in both increasing/decreasing the field in all four quadrants of the M(H) loops. The dynamics behavior of sinusoidal-like symmetric reproducible flux avalanches is discussed.

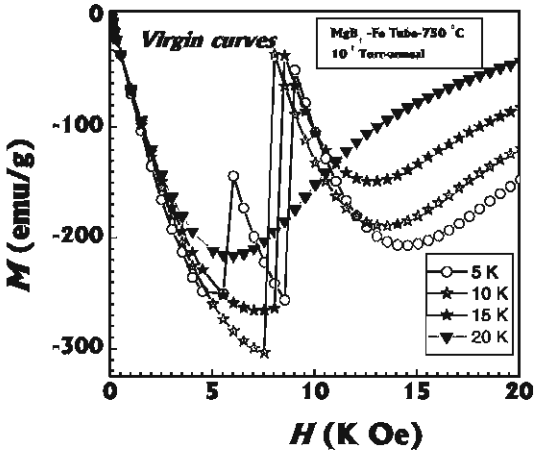


Fig. 7.9: Flux avalanches in Bulk MgB_2 superconductor

Rutheno-cuprate Ferromagnetic Superconductor (XPS studies)

XPS studies are carried out on Rutheno-cuprate ferromagnetic superconductor, and it is concluded that internal magnetic field of FM RuO_2 layers effect the superconductivity in this system, besides the carrier concentration.

Thermal conductivity and thermoelectric power in $(Y,Gd)Ba_2(Cu_{1-x}Mn_x)_3O_{7-\delta}$ superconductors

Investigations of the thermal conductivity and thermoelectric power carried out on

$(Y,Gd)Ba_2(Cu_{1-x}\ Mn_x)_3O_{7-\delta}$ ($x \leq 0.02$) superconductors exhibit a hump in $\kappa(T)$ in all the samples below the superconducting transition temperature Tc. Peak height of the hump decreases with the Mn content in both the Y- and Gd-based systems [except for $GdBa_2(Cu_{0.99}Mn_{0.01})_3O_{7-\delta}$] and this reduction is much faster in the Gd-based cuprates compared to the Y-based samples. Thermoelectric power (TEP) S(T) of the Y-based samples for $x \leq 0.0075$ is electron-like (upto ~140K) whereas it turns to hole-like even at x=0.005 for the Gd-based system. On the basis of the structure of the thermal conductivity hump, and of the electron or hole-like nature of the thermopower, it has been argued that in the Y-based system up to x=0.0075, Mn produces qualitatively the same effect as Gd in the Gd-based system. An analysis of the thermal conductivity data in terms of lattice theory, and the TEP data in terms of a narrowband picture has been made to invoke the role of Mn in these systems. Boundary scattering, point defects and sheet-like faults (from $\kappa(T)$ analysis) and chemical potential (from S(T) analysis) supports different roles of Mn for $x < 0.0075$ and $x > 0.0075$.

Linear thermal expansion in $YBa_2(Cu_{1-x}Mn_x)_3O_{7-\delta}$ superconductors

Measurement of linear thermal expansion (α) has been carried out for $YBa_2(Cu_{1-x}Mn_x)_3O_y$ ($0 \leq x \leq 2\%$) system using a high-resolution dilatometer in the temperature range 10-300 K. Across the superconducting transition, the jump in the coefficient of linear thermal expansion was found to decrease with increasing Mn content. For the pure sample, however, a negative jump is observed (Fig.7.10). While a three-fold decrease in $\Delta\alpha$ with x=0.5% was observed (Fig.7.11), only little changes in the oxygen content and transition temperature have

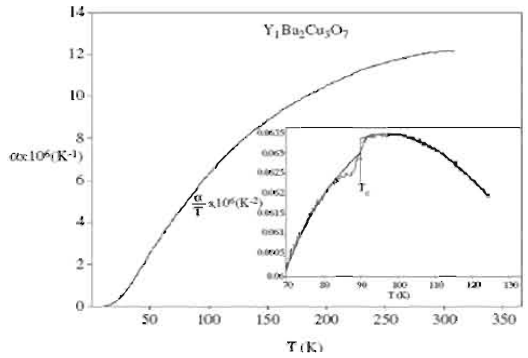


Fig. 7.10: Linear thermal expansion versus temperature plot of $Y_1Ba_2Cu_3O_7$

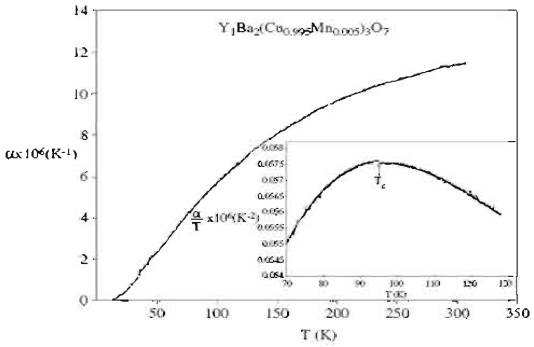


Fig. 7.11: Linear thermal expansion versus temperature plot of $Y_1Ba_2(Cu_{0.995}Mn_{0.005})_3O_7$

been noticed as a function of Mn concentration. The above observations clearly suggest that the substituent Mn is being incorporated into the superconductors as a whole and not in the form of a local cluster. Further, from the Ehrenfest relations, the pressure dependence of T_C (dT_C/dP) and the discontinuity in the compressibility, $\Delta\kappa$, are expected to decrease with Mn concentration.

Insulator-metal transitions in $La_{2/3}Ba_{1/3}Mn_{1-x}Sb_xO_3$ manganites

Structural, magneto-transport and morphological studies have been conducted on $La_{2/3}Ba_{1/3}Mn_{1-x}Sb_xO_3$ perovskite manganites. $La_{2/3}Ba_{1/3}MnO_3$ like $Pr_{2/3}Ba_{1/3}MnO_3$ system, also shows two insulator-metal (I-M) like transitions (at T_{P1} and T_{P2}) in its resistivity-temperature

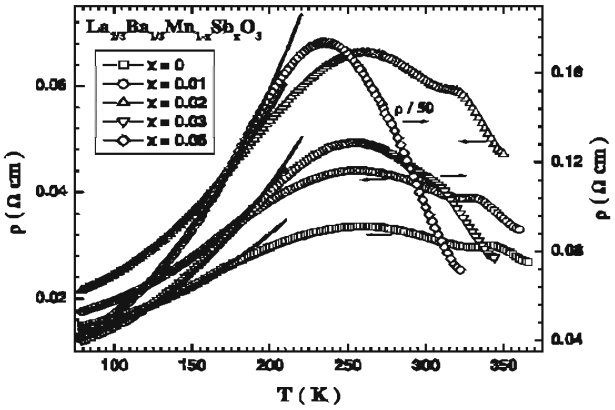


Fig. 7.12: ρ-T plot of $La_{2/3}Ba_{1/3}Mn_{1-x}Sb_xO_3$. Solid line represents the fitting of electron-magnon scattering at low temperatures.

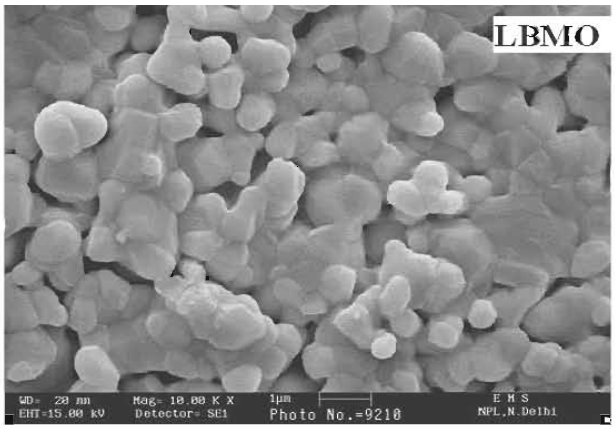


Fig. 7.13: Scanning electron micrograph of $La_{2/3}Ba_{1/3}MnO_3$.

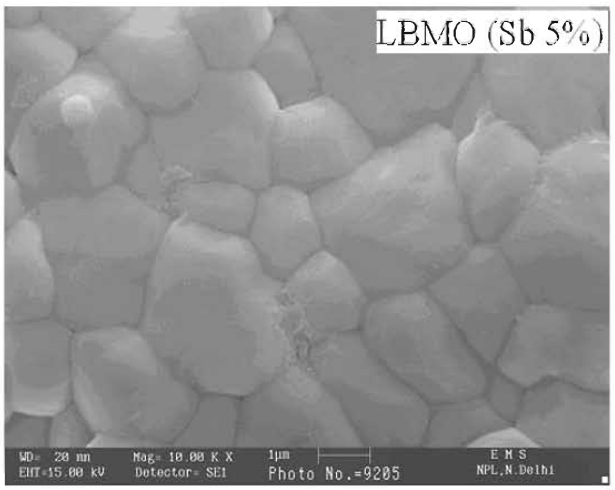


Fig. 7.14: Scanning electron micrograph of $La_{2/3}Ba_{1/3}Mn_{0.95}Sb_{0.05}O_3$.

behaviour (Fig.7.12). While T_{P1} ~ 340K is reminiscent of the usual metal-insulator transition, T_{P2} at ~ 250K refers to the grain boundary (GB) effects arising out of the ionic size mismatch between the ions present at the rare-earth site (La and Ba). With Sb-doping T_{P1} shifts to lower temperatures while T_{P2} remains nearly invariant upto 3% and shifts to lower temperature for 5%. Both the room temperature and peak resistivity values also increase successively with Sb content. Shift of T_{P1} with doping has been explained on the basis of a competition between double-exchange and super-exchange mechanisms. Scanning micrographs of the samples indicate a gradual increase in their grain sizes with Sb that indicates a gradual decrease in the grain boundary density (Figs.7.13 & 7.14). 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 magneto-resistance (MR) gets suppressed and extrinsic MR gets enhanced with Sb doping (Fig.7.15). At $T > T_{P1}$, resistivity is found to follow the adiabatic polaron hopping model whereas the electron-magnon scattering dominates the metallic regime ($T < T_{P1}$). Co doping of Cs at Ba-site in $Pr_{2/3}Ba_{1/3}MnO_3$ manganite system has also been investigated for its magnto-transport behaviour. The observed decrease in Curie temperature and the two transitions at T_{P1} and T_{P2} has been viewed in terms of the carrier concentration decrease due to a change in the Mn^{3+}/Mn^{4+} ratio. MR value at T_{P1} (intra-granular behaviour) remains nearly unchanged, the inter-granular behaviour is clearly reflected through a substantial higher MR value below T_{P2}. Insulating behaviour above T_{P1} has been correlated to the decrease in the

DOS at the Fermi level. Electron-magnon scattering process has been invoked to consider the ferrometallic state below T_{P2}.

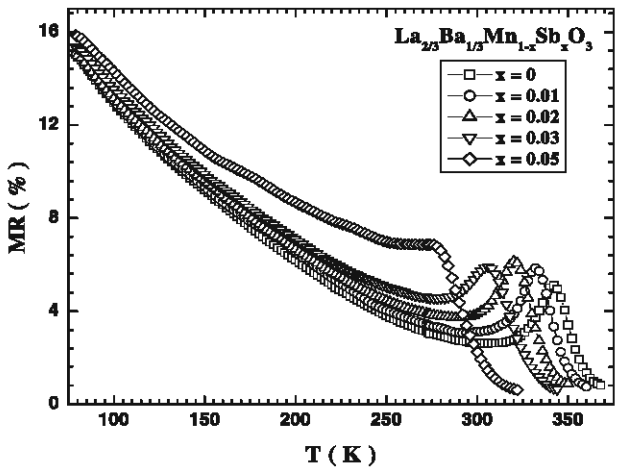


Fig. 7.15: MR versus temperature plot of $La_{2/3}Ba_{1/3}Mn_{1-x}Sb_xO_3$.

Effect of additives like PdO and Ag_2O on the magneto-transport, magnetic and morphological properties of the $Pr_{2/3}Ba_{1/3}MnO_3$ composite manganite system has also been initiated. Composite system is seen to exhibit single crystalline like behaviour with these additives. The observed enhanced intrinsic magneto-resistance in the composites has been ascribed to the factors like decrease in the electrical resistivity due to the formation of metallic component of the additives on dissociation, disorder reduction, magnetic inhomogeneity and growth of spin clusters. The decreased extrinsic magneto-resistance has been attributed to the disappearance of the barrier formed at the grain boundary due to canting of spins, defects etc.

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 conditions. 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.

PME has the additional responsibility of getting feed back on degree of customer satisfaction in a prescribed format from funding agencies who are funding the different contract research projects in NPL. The process is done at the end of each project. This function has been initiated by CSIR under the supervision of Customer Satisfaction Evaluation Unit (CSEU) at CSIR Headquarter, Rafi Marg, New Delhi 110 001. The feed-back received from the funding agencies are sent to CSEU, CSIR.

Industrial Liaison Group

This group undertakes two major areas viz marketing of developed technologies and consultancy and technical services. Besides this, the group is responsible for all matter connected with business development, open day function, wherein 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 licences are invited to deliberate with concerned PI of the technology for any suggestions. This group is also responsible for the dissemination of science through publication in CSIR news and in CSIR annual report, business and industrial magazines and their websites and through advertisements in news papers, conferences, symposiums, various other events and their souvenirs and also through participation in exhibitions Processes applications for the awards pertaining to technology or consultancy services rendered. Informs industries and licences for any new schemes. This group also takes care in the management of S & T outputs with other funding agencies viz. DST, CSIR, NRDC, AIMA,CDC, etc..

Human Resource Development Group

This Group organises Training Programmes for the benefit of NPL staff members as well as for the personnel belonging to Testing & Calibration Laboratories, S & T institutions and industries in various areas of core competence. 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. Besides this, the Group also organizes the placement of JRFs, SRFs, Research Associates

etc. in suitable sections/divisions of the laboratory, and 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 scientists 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 109 scholarly journals (90 foreign journals and 19 Indian journals) and added 167 S & T books, 54 Hindi books. 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 publishers. From this year, the Library has started providing access to intranet edition of Indian Standards.

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

This year, library has also installed 7 (Seven) dedicated computers in the library's reading hall to provide access to electronic journals for walk-in users (Who are mostly from the various educational & research institutes). Library Reading hall is also having the high-speed wireless internet area (hot spot) where one can have wireless connectivity for their wi-fi enable laptops.

The Library has a KSK Library site on the NPL intranet 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, and papers published by NPL scientists. The library continued to update this site during the year.

The Library also maintains NPL website (http://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.

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 'DECKEL 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.

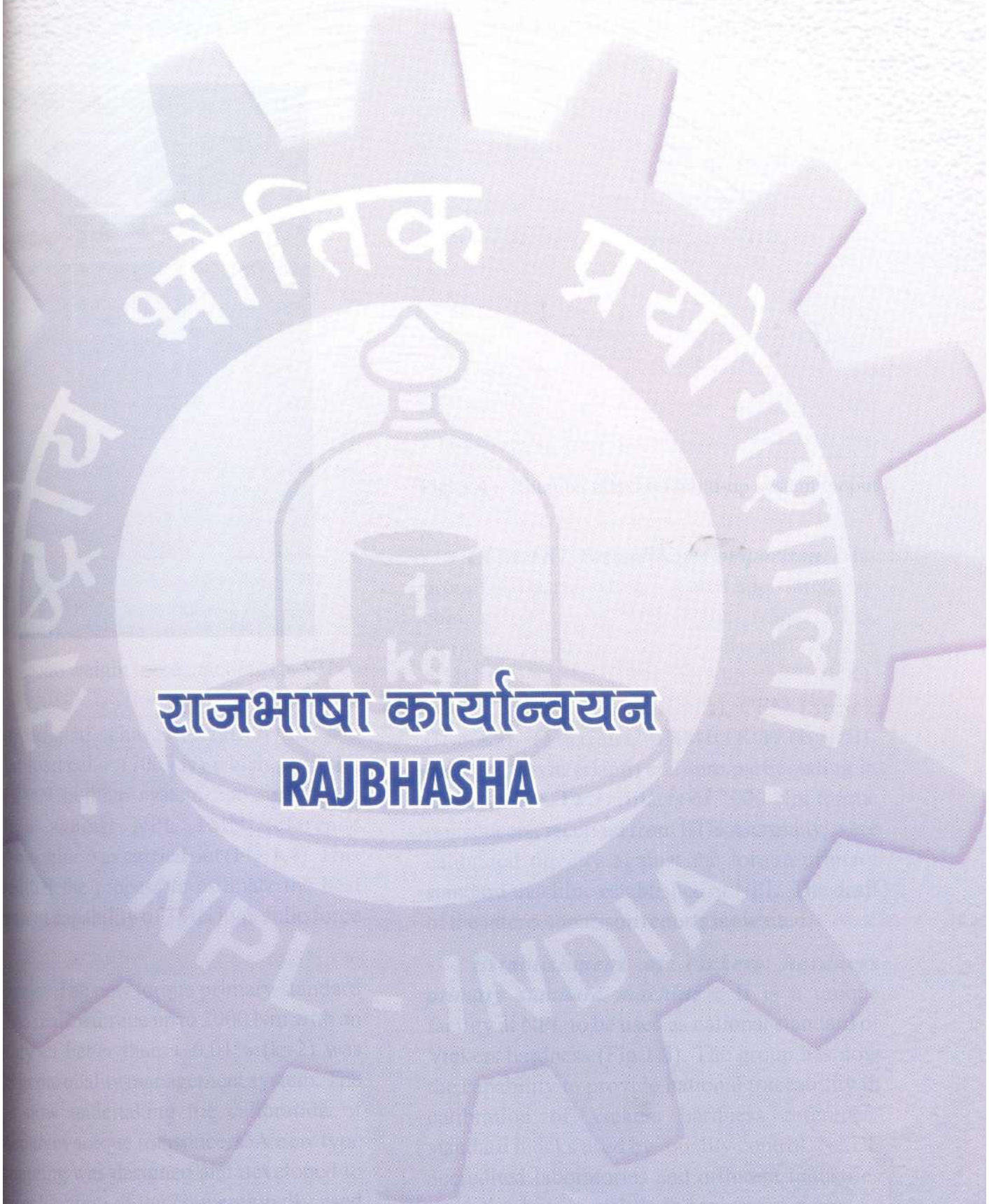
In addition to design, development and fabrication jobs, work-shop also undertakes a large number of maintenance jobs comprising different precision machines, pumps, compressors, gear boxes, machines of the Glass Technology Unit etc.

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.

Cryogenic Plants & Facilities:

NPL has excellent liquid Nitrogen & liquid Helium producing units. It is also having a 6000 litres capacity liquid Nitrogen storage vessel, making the availability of liquid Nitrogen round the clock for NPL's scientific work. We are also maintaining and producing liquid Helium at NPL. Till 31st Dec, 2007, we have produced approximately 31200 litres of LN^2 & supplied approximately 2400 litres of liquid Helium and Helium gas. Efforts are being made to improve the productivity further.



राजभाषा कार्यान्वयन
RAJBHASHA

राजभाषा यूनिट

प्रशासनिक कार्यशाला

प्रयोगशाला में प्रशासन विभाग से सम्बन्धित विभिन्न पहलुओं पर प्रत्येक तिमाही में कार्यशालाओं का आयोजन किया जाता है। दिनांक 20 सितम्बर, 2006 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

श्री आर. पी. शर्मा, प्रशासन नियंत्रक, एन पी एल, प्रतिभागियों का स्वागत करते हुए।

अधिकारियों/कर्मचारियों को 1963 की धारा 3(3) के नियम अधिनियमों से अवगत कराना, सी.एस.आई.आर. की नियमित्तता, आचार संहिता, चल–अचल धन सम्पत्ति निर्देश, अलॉटमेंट नियम, सतर्कता, अनुशासनात्मक कार्रवाई, क्रय प्रक्रिया, भण्डारण व्यवस्था, रिकार्डों के प्रबन्धन एवं सी सी एस नियम के विषय में विस्तृत जानकारी उपलब्ध कराना था ।

कार्यशाला का शुभारंभ प्रशासन नियंत्रक ने प्रतिभागियों का स्वागत करके किया। डा. ए. के. अग्रवाल ने कार्यशाला के विषय में संक्षिप्त जानकारी दी। डा. एच. एन. दत्ता ने धन्यवाद प्रस्ताव प्रस्तुत किया।

कार्यशाला को चार सत्रों में विभक्त किया गया था जिसमें क्रमशः प्रथम सत्र में श्री राकेश शर्मा (सी एस आई आर काम्प्लेक्स) ने नियमित्तता तथा आचार संहिता से सम्बन्धित विषय पर चर्चा की उसके पश्चात् दूसरे सत्र में श्री एस सी त्यागी ने चल–अचल धन सम्पत्ति निर्देश तथा आवंटन नियमों के विषय में विस्तार से बताया। तृतीय सत्र में श्री आर.पी. शर्मा ने सतर्कता एवं अनुशासनात्मक कार्रवाई के बारे में बताया। अंतिम सत्र में श्री आर के राव एवं श्री बृजेश शर्मा ने क्रय प्रक्रिया पर विस्तृत जानकारी दी। इस कार्यशाला में कुल 82 प्रतिभागियों ने भाग लिया।

कार्यशाला में भाग लेने वाले प्रतिभागियों को बहुत सी ऐसी जानकारियां प्राप्त हुई जिनसे वे अनभिज्ञ थे। कार्यशाला अत्यंत सफल रही।

विशिष्ट व्याख्यान

राजभाषा हिन्दी के प्रभावी कार्यान्वयन तथा इसके व्यापक प्रचार–प्रसार हेतु वैज्ञानिक, तकनीकी, प्रशासनिक क्षेत्रों में अधिक से अधिक बढ़ावा देने के उद्देश्य से राष्ट्रीय भौतिक प्रयोगशाला में पिछले कुछ वर्ष पूर्व व्याख्यान श्रृंखला आरम्भ की गयी थी जिसके अन्तर्गत समय–समय पर विशिष्ट व्यक्तियों द्वारा महत्त्वपूर्ण एवं प्रेरणात्मक विषयों पर व्याख्यान आयोजित किए जाते हैं। इसी श्रृंखला के अन्तर्गत दिनांक 17 अक्तूबर, 2006 को प्रो. पी. रामासामी, डीन रिसर्च, एस.एस. एन.कॉलेज ऑफ इंजीनियरिंग, मद्रास ने 'विश्व के सबसे लम्बे और वृहत् क्रिस्टल की ओर' (Towards world's longest & Largest Crystal) नामक विषय पर व्याख्यान दिया। इसमें प्रो. रामासामी ने उक्त व्याख्यान की पूर्ण रूप से जानकारी दी। प्रयोगशाला के सदस्यों ने इसमें

प्रो. पी. रामासामी, डीन रिसर्च, एस. एस. एन कॉलेज ऑफ इंजीनियरिंग, मद्रास, व्याख्यान देते हुए

अत्यधिक रूचि व जिज्ञासा प्रदर्शित की व अनेक प्रश्न पूछकर उनका समाधान प्राप्त किया।

इसी श्रृंखला के अन्तर्गत दिनांक 1 दिसम्बर, 2006 को श्री वेद प्रकाश रावत (पत्रकार) 'विज्ञान और प्रौद्योगिकी मंत्रालय तथा महासागर विकास विभाग की संयुक्त हिन्दी सलाहकार समिति के सदस्य ने 'हिन्दी को सर्वमान्य बनाने के लिए सभी भाषाओं का सहयोग' विषय पर व्याख्यान दिया। इसमें श्री रावत ने उक्त विषय पर पूर्ण रूप से जानकारी देते

श्री वेद प्रकाश रावत (पत्रकार) विज्ञान और प्रौद्योगिकी मंत्रालय तथा महासागर विकास–विकास विभाग की समिति के सदस्य, व्याख्यान देते हुए

हुए कहा कि हम यह नहीं चाहते कि अंग्रेजी का एकदम बहिष्कार कर दें क्योंकि शिक्षा, विज्ञान व प्रौद्योगिकी की अधिकांश पुस्तके अंग्रेजी में ही उपलब्ध हैं, जिन्हें पढ़ना हमारे लिए अनिवार्य है, मगर अपनी मातृभाषा पर हमारी पकड़ होना भी उतना ही आवश्यक है। अन्य भाषाओं के शब्द ग्रहण करके हमें अपनी भाषा को और अधिक सशक्त बनाना है।

हिन्दी पखवाड़ा

राजभाषा विभाग, गृह मंत्रालय की हिन्दी पखवाड़ा सम्बन्धी व्यवस्थाओं को ध्यान में रखते हुए प्रयोगशाला में अगस्त–सितम्बर माह में हिन्दी पखवाड़ा मनाया गया। पखवाड़े के दौरान विभिन्न प्रतियोगिताओं का आयोजन किया गया जिसमें प्रयोगशाला के सभी वैज्ञानिकों/अधिकारियों/कर्मचारियों ने उत्साह पूर्वक भाग लिया। इसके अन्तर्गत इनमें

हिन्दी पखवाड़ा समापन समारोह में डॉ. ए. के. अग्रवाल, वैज्ञानिक पुरस्कार लेते हुए

निबन्ध प्रतियोगिता, हिन्दी टिप्पण एवं आलेखन प्रतियोगिता, कविता पाठ प्रतियोगिता, टाइपिंग प्रतियोगिता व विज्ञान पहेली प्रतियोगिता का आयोजन किया गया। काव्य पाठ प्रतियोगिता में बाहर से तीन कवियों को आमंत्रित किया गया था जिन्होंने प्रतिभागियों की कविताओं को सुनने के बाद निर्णायक मण्डल की भूमिका निभाने के साथ–साथ अपनी रचनाएं भी उपस्थित श्रोताओं को सुनाई। समापन समारोह के अवसर पर प्रयोगशाला के निदेशक डा. विक्रम कुमार ने कार्यक्रम की अध्यक्षता की व उपस्थित स्टाफ सदस्यों को इस अवसर पर संदेश दिया। उन्होंने प्रयोगशाला में हिन्दी सम्बन्धी गतिविधियों के बारे में जानकारी दी व प्रतियोगिताओं में भाग लेने वाले प्रतिभागियों का उत्साह बढ़ाते हुए हिन्दी में और अधिक कार्य करने की प्रेरणा दी।

समापन समारोह के अवसर पर सुप्रसिद्ध कवित्री डा. प्रभा किरण जैन को आमंत्रित किया गया था। उन्होंने प्रयोगशाला में हिन्दी के क्षेत्र में हो रहे कार्यों की सराहना की व अपनी रचनाएं उपस्थित स्टाफ सदस्यों को सुनायी। इसके पश्चात् प्रतियोगिताओं में भाग लेने वाले विजेताओं को पुरस्कार प्रदान किए गए।

अंत में डा. अनिल कुमार गुप्ता ने धन्यवाद के साथ समारोह का समापन किया।

संलग्न
APPENDICES

APPENDIX - 1

Publications in SCI Journals

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APPENDIX – 2

PATENTS

Patents Granted in India

Sr. No.	Title	Patent No.	Grant Date	Inventors
1	A method for the preparation of Novel Lactate Biosensing Strip	197458	11.08.2006	M.K. Pandey, Asha Chaubey, K.K. Pande, Rajesh, Rajendra K. Sharma, K.K. Saini and B.D. Malhotra
2	An improved process for the preparation of high coercivity yittrium-iron garnet thin films useful for magnetic and magneto-optic recording	199570	08.09.2006	B.K. Das, A.C. Rastogi, B.R. Awasthi, H.P. Gupta, V.N. Moorthy and Sandeep Dhara
3	An Apparatus useful for generation of a gas under controlled pressure	199908	23.02.2007	P.K. Ghosh and Harish Chander

Patents Filed in India

Sr. No.	Title	Application No.	Filing Date	Inventors
1	Method for detection of earthquake precursors	02990DELNP2006	08.05.2006	B.S. Gera, H.N. Dutta, Gurbir Singh and V.K. Ojha
2	A process for the preparation of a low contact resistance contact on high transition temperature superconductors	02987DELNP 2006	24.05.2006	S.N. Ekbote, G.K. Padam, N.K. Arora, Mukul Sharma, Ramesh Kumar Sethi and M.K. Banerjee
3	A novel method for joining oxide superconducting tubes with a superconducting joint	198DEL2006	25.07.2006	S.N. Ekbote, G.K. Padam, N.K. Arora, Mukul Sharma and Ramesh Sethi.
4	A process for the selective growth of single-walled and multi-walled carbon nanotubes	2581DEL2006	04.12.2006	R.B. Mathur, Chhotey Lal, T.L. Dhami, Bhanu Pratap Singh, A.K. Gupta and Jagdish Ghawana
5	An automated dead weight force machine useful for calibrating strain gauge load cell	2625DEL2006	07.12.2006	K.K. Jain, H.N.P Poddar and R.P. Singhal
6	A process for making porous conducting carbon composite electrode suitable for fuel cell application	0395DEL2007	14.02.2007	R.B. Mathur, T.L. Dhami, Priyanka H. Maheshwari, A.K. Gupta, J. Rangarajan, R.K. Sharma and C.P. Sharma
7	An improved sol-gel process for the preparation of nanocrystalline $CeTi_2O_6$ Powder	279DEL2007	14.02.2007	Amita Verma and S.A. Agnihotri

Patents Granted Abroad

Sr. No.	Title	Patent No.	Country	Grant Date	Inventors
1	Conducting polymer membrane and a process for the preparation of the same membrane,	19914200	Germany	18.05.2006	Ramadhar Singh, Subhash Chandra, Hawa Singh, A.K. Narula and Shobha Broor
2	Formulation for iron chelation, a process for preparing the formulation and a method of treating thalassemia	2191664	Canada	07.11.2006	A.K. Sarkar, K. Sudarshan, P. Harsh, K.S. Rattan and D. Ghansham
3	Polymer coated long duration optical memory device and a method for the development thereof	0649054	Korea	16.11.2006	A.M. Biradar, S.S. Bawa, E.P. Haridas and Subhas Chandra
4	Copolymer of benzene and substituted benzene	7186793	United State of America	06.03.2007	S.K. Dhawan, M.N. Kamalasanan and S.S. Bawa

Patents Filed Abroad

Sr. No.	Title	NF No.	Country	Filing Date	Inventors
1	Improved process for the development of high temperature superconducting bulk current leads	0160NF2005	World Intellectual Property Organisation	03.08.2006	S.N. Ekbote, G.K. Padam, Mukul Sharma, Ramesh Sethi and M.K. Banerjee
2	Improved process for the development of high temperature superconducting bulk current leads	0160NF2005	United State of America	17.08.2006	S.N. Ekbote, G.K. Padam, Mukul Sharma, Ramesh Sethi and M.K. Banerjee
3	A process for the preparation of a low contact resistance contact on high transition temperature super-conductors	0163NF2004	United State of America	25.09.2006	S.N. Ekbote, G.K. Padam, N.K. Arora, Mukul Sharma, Ramesh Sethi and M.K. Banerjee
4	A process for the preparation of a low contact resistance contact on high transition temperature super-conductors	0163NF2004	Japan	28.09.2006	S.N. Ekbote, G.K. Padam, N.K. Arora, Mukul Sharma, Ramesh Sethi and M.K. Banerjee

Sr. No.	Title	NF No.	Country	Filing Date	Inventors
5	A new method for detection of a precursor for major earthquake	0059NF2004	Mexico	28.09.2006	B.S. Gera, H.N. Duta, Gurubir Singh and V.K. Ojha
6	A process for the preparation of a low contact resistance contact on high transition temperature super-conductors	0163NF2004	Europe	29.09.2006	S.N. Ekbote, G.K. Padam, N.K.Arora, Mukul Sharma, Ramesh Sethi and M.K. Banerjee
7	A new method for detection of a precursor for major earthquake	0059NF2004	Turkey	29.09.2006	B.S. Gera, H.N. Duta, Gurbir Singh and V.K. Ojha
8	A new method for detection of a precursor for major earthquake	0059NF2004	Indonecia	29.09.2006	B.S. Gera, H.N. Duta, Gurbir Singh and V.K. Ojha
9	A new method for detection of a precursor for major earthquake	0059NF2004	Phillipine	06.10.2006	B.S. Gera, H.N. Duta, Gurbir Singh and V.K. Ojha

APPENDIX - 3

TECHNOLOGIES MARKETED

Sr. No.	Technology Developed	Licensee	Date of Transfer
1	Porous Conducting Carbon Paper for Fuel Cell Application (Through NRDC)	M/s HEG Ltd, A-2, Sector-I, Bhilwara Tower, NOIDA-201 301	01.03.2007
2	An indigenously developed dead weight piston gauge pressure standard to generate/measure hydraulic pressures up to 80 MPa ± 0.01% (k=2)	M/s Sushma Industries, Plot No 18E, Block-B, 2nd Phase Peenya Industrial Area, Peenya, Bangalore – 560 058	13.03.2007

APPENDIX - 4

R & D COLLABORATIONS

Collaborating Institute	Area
National Institute of Standards and Technology (NIST), 100 Bureau Drive, Gaithersburg, MD 20899-8364 USA	Pressure & Vacuum Standards
• S.N. Bose Institute, Kolkata • High Pressure Laboratory, Department of Physics, University of Jaipur, Jaipur • Department of Physics, Barakatullah Vishwavidyalaya, Bhopal	Raman Spectroscopy
Indo-Belarus, Heat and Mass Transfer Institute, Minsk, Belarus	Synthesis of carbon nanotubes and their applications in composites and hydrogen storage
Luminescent Materials and Devices Group, Indian Institute of Technology, New Delhi	Nanophosphors
Plasma Processing of Materials Group, Indian Institute of Technology, New Delhi	Thick silica films
Silicon and Silicon Devices Group, Indian Institute of Technology, New Delhi	Silicon Photodiodes for high energy γ ray detection.
Surface Studies and Nanostructures Group, Indian Institute of Technology, New Delhi	Core shell nanoparticles
CARE, Indian Institute of Technology, New Delhi	Surface compositional analysis of PLZT thin films
• Department of Physics, Indian Institute of Technology, Delhi • Department of Physics, University of Delhi, Delhi	CMR Manganites
Indian Institute of Technology, Kanpur	Microcrystalline silicon
Central Electronic Engineering Research Laboratory, Pilani	Microchannels in silicon, growth of porous silicon and glucose detection
Central Laboratory of Solar Energy and New Energy Sources (CLSENES), Bulgaria	Low cost technology for high efficiency Si solar cells
University of Colorado, USA	Metal Multilayer structures
Far Eastern Branch of Russian Academy of Sciences, Vladivostok, Russia	Metal Semiconductor interface
Inter University Accelerator Centre (formerly Nuclear Science Centre), New Delhi	• Beam damage in Florence • Swift heavy ion induced interface mixing • Swift heavy ion irradiation
University of Delhi, Delhi	Core shell nanoparticles, Sb/Si interface
Central Glass & Ceramic Research Institute, Kolkata	BN coated carbon fibers
Central Glass & Ceramic Research Institute, Kolkata, under CSIR Network Project CMM 0022	PZT thin film for FERAM application
• Phys. Dept., Allahabad Univ., Allahabad • Phys. Dept., M.D. University, Rohtak	Characterization of Materials
Asia Pacific Metrology Programme	Traceability in Chemical Analysis and Key Comparisons
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.

Collaborating Institute	Area
• Central Building Research Institute, Roorkee • Central Drug Research Institute, Lucknow • Central Fuel Research Institute, Dhanbad • Central Food Technology Research Institute, Mysore • Central Glass & Ceramic Research Institute, Kolkata • Central Salt & Marine Chemical Research Institute, Bhavnagar • Indian Institute of Chemical Technology, Hyderabad • Indian Institute of Petroleum, Dehradun • Industrial Toxicology Research Centre, Lucknow • National Aerospace Laboratory, 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), Hyderabad • Defense Materials Research laboratory, Hyderabad • National Test House, Ghaziabad • Wadia Institute of Himalayan 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
Instrumentation Center, Jadavpur University, Kolkata	Surface and interface characterization of thin films
University Sophisticated Instrumentation Centre (USIC), Kolkata	Multilayer structure characterization using SIMS
Centre for Advanced Technology, Indore	Multilayer characterization using SIMS
Dept. of Physics, Anna University, Chennai	Crystal Growth and Characterization
Centre for Crystal Growth, SSN College of Engineering, Kalavakkam, Chennai	Growth and Characterization of Crystalline Materials
• Tejpur University, Napaam, Tejpur, Assam • Thapar Institute of Engg. & Tech. Patiala • Jamia Millia Islamia, New Delhi • MISU, Stockholm University, Sweden • Jawahar lal Nehru University, New Delhi	Environment/Metrology in Chemistry
• J.N.U. School of Environment Studies, New Delhi • Dept. of Applied Science, Indira Gandhi Institute of Technology, Indraprastha University, New Delhi	Atmospheric Trace gases & Aerosols
Osmania University, NERTU, Dept. of ECE, University College of Engineering, Hyderabad	Radio Communications

Collaborating Institute	Area
C-DOT, New Manglapuri Road, Chattrapur, New Delhi	Mobile communications
Rajdhani College, University of Delhi, New Delhi	Stratosphere-Troposphere Exchange
Frontier Research Center for Global Change, Japan	Eurasian Perspective of surface ozone
Max Planck Institute for Chemistry, Germany	Modeling in trace gases using MATCH-MPIC
• Department of Physics, National Dong-Hwa University, Taiwan • Department of Applied Physics, Manipal Institute of Technology, Manipal	High Tc Cuprates and CMR Manganites
Department of Applied Physics, Delhi College of Engineering, Faculty of Technology, University of Delhi	Ferro-electric Ceramics
Department of Material Science & Metallurgy, University of Cambridge, UK.	MgB_2 Superconductor
• NIMS - Tsukuba, Japan • TITECH - Yokohama, Japan • IUC - Indore, India • TIFR - Mumbai, India • BHU - Varanasi, India	Superconductivity
Racah Inst. - Jerusalem, Israel	Superconductivity and magnetism

APPENDIX - 5

SPONSORED/SUPPORTED R&D PROJECTS

(Rs. in lakhs)

Sr. No.	Title	Agency/Client	Amount Received (2006-07)
New Projects			
1.	A novel development of lab-on-chip biosensor for determination of myco-toxins in food (mainly cereals) – under SERC FAST Track Scheme	DST	6.00
2.	Development of carbon-graphite material for aeronautical application	DRDO (DMSRDE)	6.50
3.	Development of Carbon-Ceramic composites and the influence of oxidation at elevated temperatures on their properties	DST	6.58
4.	Development of mesophase pitch for high performance carbon fibres	DRDO (DMSRDE)	6.68
5.	Evaluation of emission factors and budgets of gases and particulate matter of relevance to climate change emitted by fuels particularly biomass used in India by the rural sector & scale industries	DST	13.00
6.	High stability atomic fountain clocks	DST-DAAD	1.30
7.	Modeling of organic Opto-electronic devices - LEDs and solar cells	DST	2.00
8.	Molecular and biochemical sensor for identification of cells and diagnosis of diseases	DST	1.25
9.	Proficiency Testing (PT) among National Accreditation Board for testing and calibration laboratories (NABL) accredited laboratories in chemical discipline	DST (NABL)	7.75
10.	SAARC-PTB Cooperation Programme	PTB-Germany	0.00
11.	Sol-gel derived optical biosensor for water pollution monitoring	DST	16.00
12.	Studies and formulations for upscaling the process for making porous conducting carbon paper and establish pilot plant scale facilities at NMRL	NMRL	5.00
13.	Study of the mechanisms involved in enhancement of electroluminescence dydrogene of inorganic nanophosphors	DST (Under SERC FAST TRACK PROPOSALS)	2.50
14.	Study on the effects of atmospheric dynamical activity in the tropical tropopause region: Implications on the stratosphere-troposphere exchange of the minor constituents	DOS	5.41
15.	Synthesis and characterization of nano size grains of ruthenocuparates MgB_2 superconductors	DST (Indo-Israel Fund)	2.25
16.	Synthesis of organic and inorganic nano-composites for sensor applications	DST	5.00
17.	Optical and spectral properties of organic compounds used as building blocks for nanostructures	CSIR, New Delhi	14.00

Sr. No.	Title	Agency/Client	Amount Received (2006-07)
Continuing Projects			
1.	A study of the formation of delta-doped silicon structures by surface phase control and solid phase epitaxy	DST	1.50
2.	Assessment of effects of high particulate on pulmonary health status in selected mega cities of South Asia	APN – Japan	0.00
3.	Cloud and precipitation phenomena estimation by using different systems for propagation characteristics in microwave and millimetre wave and frequency bands	DST	1.00
4.	Coherent radio beacon experiment (CRABEX) for tomographic studies of the ionosphere on-board GSAT-II satellite	VSSC, Thiruvananthapuram	0.00
5.	Design & fabrication of Filter Transmission Meter	DST	0.00
6.	Design and development of Urea-Biosensor	DST	0.00
7.	Development of Bandpass Interference Filters for Course Wavelength Division Multiplexing (CWDM)	DST	0.00
8.	Development of calibration-validation (CAL-VAL) sites at Kavartti Island	Department of Space, SAC, Ahmedabad	0.00
9.	Development of injection solar cells utilizing dye sensitized nano-crystalline TiO_2 films	MNES	0.00
10.	Development of Nanostructured electrochromic films with improved performance characteristics by wet chemical techniques for smart windows	DST	1.00
11.	Development of nanophosphors for industrial application	DST	0.00
12.	Development of plasma polymerization process and deposition system for thin film optical coatings on plastic substrates, conducting polymeric barrier membrane coatings	DST	5.00
13.	Development of speciality carbon materials for novel nuclear rectors	BARC, Mumbai	18.42
14.	Development of ultrasonic method to evaluate moisture in composite materials	ARDB, Bangalore	0.00
15.	Dynamics studies at the phase transition region of Sm-C*- Sm-A phase in electroline liquid crystal materials	DST	0.00
16.	Establishment of primary standards for Vickers & Brinell Hardness Scales	DST	0.00
17.	Fabrication and characterization of organic light emitting diodes	DST (Women Scientist Scheme-A)	4.00
18.	Generic Development of nanometrology for nanotechnology	DIT	0.00
19.	High rate deposition of the microcrystalline silicon films using high density microwave plasma and its application efficient large area thin film solar cells	DST	0.00
20.	Integrated campaign for aerosols, gases & radiation budget	VSSC, Thiruvanthapuram	0.00
21.	Interaction with Universities/Labs in the area of superconductivity	UGC	3.98

Sr. No.	Title	Agency/Client	Amount Received (2006-07)
22.	Investigation study on microwave sintering of Beta Alumina tubes	DST	0.00
23.	Ionospheres of Venus and Mars: Chemistry, dynamic thermal structure and solar wind interaction	Physical Research Laboratory, Ahmedabad	2.16
24.	Low cost technology for High efficiency Silicon Solar Cell	DST, Under Indo-Bulgarian Inter Govt. Program	0.45
25.	Metal induced crystallization behaviour on thin film of amorphous silicon	INDO-US	1.25
26.	Operation of the South Asian Regional Research Centre (SAS-RRC) for Study of Global Change Under SASCOM	International START Secretariat, Washington, USA.	0.00
27.	Optical Phase Singularity and its Applications	DST (Women Scientist Scheme-A)	3.30
28.	Physico-Chemical characterization of wet deposition at NPL, New Delhi and Pantnagar in Uttaranchal	SEI, SWEDEN	0.00
29.	Planning preparation and dissemination of certified reference materials for quality assurance in analytical measurements	DST (NABL)	0.00
30.	Semiconductor silicon for applications in solar energy microelectronics and power electronics	Indo-Russia (ILTP)	0.00
31.	Setting up of facilities for dissemination of Indian Standard Time in North-Eastern States	DST	0.00
32.	SROSS-C2 satellite RPA aeronomy payload data management	ISRO	0.00
33.	Studies on Bio-Mass Burning and Related Trace Gas Emissions Using IRS-P3 Satellite Data	NRSA	3.00
34.	Studies on fog occurrence on Delhi	CPCB	0.00
35.	Studies on the effect of dynamic multiple scattering on frequency shift of spectral lines and applications	DST	0.00
36.	Study of Atmospheric Aerosols Radiation and Trace Gases Under ISRO-GBP Road Campaign during February 2003: Delhi-Hyderabad-Delhi Corridor	Physical Research Laboratory, Ahmedabad	0.00
37.	Surface order and structure studies of polymer solid interfaces	Indo-US	0.00
38.	Synthesis and characterization of carbon nono tubes/polymer network composites	DST	0.00
39.	To conduct inter-laboratory proficiency testing amongst the NABL accredited calibration laboratories in India	DST (NABL)	32.00
40.	Integrated campaign for aerosols, gases & radiation	Dept. of Space (ICARB)	1.60

Sr No	Title	Agency/Client	Amount Received (2006-07)
Completed Projects			
1.	Development of organic light emitting diodes	DIT	0.00
2.	Development of spray forming technology of magnesium alloys	VSSC, Thiruvanthapuram	2.75
3.	A study of metal oxide coatings on glass substrate by sol-gel technique	DST	2.00
4.	Development of DNA biosensor	DST	0.00
5.	NIR spectroscopy techniques for cellulosic materials	Birla Management Corporation Limited	0.00
6.	Pressure Induced Phase Transitions for Metrological Applications	DST	2.50
7.	Synthesis of carbon nanotubes and their applications in composites and hydrogen storage	Indo-Belarussian	0.00
8.	To develop 10 pF capacitor using Quartz for use by accredited calibration laboratory	DST	0.00
9.	Plasma Assisted Deposition of Hydrogenated Amorphous Silicon Films at High Rates at VHF Frequencies (CW and Pulsed)	DST	4.00
10.	Studies on Bio-Mass Burning and Related Trace Gas Emissions Using IRS-P3 Satellite Data	NRSA	3.00
11.	Planning Preparation and Dissemination of Certified Reference Materials for Quality Assurance in Analytical Measurements	DST(NABL)	0.00
Note : (Project Completed in 04-05 but amount received in 2006-07)			
1.	Development of Hard Coating of Cubic Boron Nitride for Industrial Applications (received on 30/11/06)	DST	0.28
		Total Receipts	**193.41**

CSIR NETWORK PROJECTS

Sr. No.	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	Development of key technologies for photonics and opto-electronics	CMM0010	01.04.2003	31.03.2007	Dr. S. S. Bawa	CGCRI
4	Developing capabilities & facilities for micro-electromechanical systems (MEMS) and Sensors	CMM0011	01.04.2002	31.03.2007	Dr. S. T. Lakshmikumar	CEERI
5	Custom tailored special materials	CMM0022	01.04.2002	31.03.2007	Dr. Anil Kr. Gupta	CGCRI
6	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 & dissemination of certified reference materials	CMM0024	01.04.2004	31.03.2007	Dr. R. P. Singhal	NPL
7	Developing and sustaining high science & technology for national aerospace programmes	COR0001	01.04.2005	31.03.2007	Dr. R. S. Dabas	NAL
8	Development of speciality polymers	COR0004	01.04.2002	31.03.2007	Dr. S. K. Dhawan	NCL
9	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. Agrawal	NGRI
10	Electronics for societal purposes	COR0007	01.04.2003	31.03.2007	Sh. S. K. Singhal	CSIO
11	Pollution monitoring mitigation systems and devices	SMM0005	01.04.2004	31.03.2007	Dr. M. K. Tiwari	NEERI

APPENDIX - 6

CONSULTANCY PROJECTS

(Rs. in lakhs)

Sr. No.	Client	Title	Contract Value	Amount Received (2006-07)
	NEW			
1.	Delhi Metro Rail Corp Ltd. (DMRCL), New Delhi	Consultancy services for studying noise impact of Delhi Metro operation	5.325	**5.027**
2.	Jadavpur University, Kolkata	Setting up-laboratory for calibration parameter-dimension and force in a limited range as per IS 17025	3.143	**3.143**
3.	M.N. Dastur & Co. Ltd, Kolkata	Mixing height determination at Paradeep, Orissa	2.760	**1.857**
	NEW and COMPLETED			
4.	Intel Testing, New Delhi	Characterization of low range pressure gauge covering the range of ± 5.35WC	2.929	**2.929**
5.	Regional Reference Stds Laboratory, (RRSL), Faridabad	Supply of transfer standard – 100 kg, 200 kg and 500 kg	1.951	**1.951**
6.	Jindal Steel Power Ltd, Raigarh, MP	Calibration of test rails	3.836	**3.836**
	COMPLETED			
7.	General Motors Pvt Ltd, Bangalore	Advanced magnesium extrusion alloys	36.253	**12.753**
8.	Delhi Metro Rail Corporation Ltd. (DMRCL), New Delhi	Noise and vibration study in and around metro station	4.992	**0.00**
9.	Power Grid Corporation, Gurgaon	Study of acoustics of multipurpose mall at Power Grid Township, Gurgaon	0.716	**0.000**
10.	Nitiraj Engineer Pvt. Ltd., Parwanoo	Characterization of load cells of 500kg used in weighing platforms	3.306	**0.000**
11.	Delhi Development Authority (DDA), Delhi	Study for reducing noise levels at commonwealth games village site adjacent to NOIDA	4.997	**0.000**
12.	Regional Reference Stds. Laboratory (RRSL), Bangalore	Design and fabrication of transfer standards confirming to class A	1.951	**0.000**
13.	National Thermal Power Corporation Ltd. (NTPC), Gautam Budh Nagar, Noida	Purchase of low noise converter	2.240	**0.000**
14.	Bajaj Allianz, New Delhi	Expert opinion for the damaged copper tube of heat exchanger of imperial malt	0.355	**0.000**
	CONTINUING			
15.	Regional Reference Stds Laboratory, (RRSL), Bhubaneswar	Supply and installation of load cell testing instruments of range 50-500 kg at RRSL, Bhubaneswar	14.293	**2.600**

(Rs. In lakhs)

Sr. No.	Client	Title	Contract Value	Amount Received (2006-07)
16.	Regional Reference Stds Laboratory (RRSL), Faridabad	Supply and installation of load cell testing instruments of range 50-500 kg at RRSL, Faridabad	14.293	**2.600**
17.	Regional Reference Stds Laboratory (RRSL), Faridabad	Fabrication and installation of load cell testing machine at RRSL, Faridabad	16.437	**0.000**
18.	Coal Chem, Bhilai	QI free coal tar pitch from coal tar	0.804	**0.000**
19.	Central Pollution Control Board (CPCB), Lucknow Zone	Inversion/mixing height studies at CPCB, Agra	9.990	**0.000**
			Total	**36.696**

APPENDIX - 7

EARNING FROM CALIBRATION & TESTING

Physico - Mechanical Standards				
Sr. No.	**Activity**	**DP No.**	**Calibration Charges**	**No. of Reports**
1	Mass	1.01	48.07	758
2	Length & Dimension	1.02	34.53	382
3	Temp. & Humidity	1.03A	10.76	71
4	Temp. & Humidity	1.03B	16.65	183
5	Temp. & Humidity	1.03C	3.74	48
6	Optical Radiation	1.04	76.30	489
7	Force & Hardness	1.05	52.41	501
8	Pressure & Vacuum	1.06	21.05	91
9	Acoustics	1.07	62.29	260
10	Fluid Flow	1.08	3.02	21
11	Ultrasonic	1.09	0.99	12
12	Shock & Vibration	1.11	2.63	62
13	Optical Testing	1.12	0.22	1
		Sub Total (A)	**332.66**	**2879**
Electrical & Electronics Standards				
Sr. No.	**Activity**	**DP No .**	**Calibration Charges**	**No. of Reports**
1	Time & Frequency	2.01	2.28	23
3	Josephson Voltage Std. DC I, V & R	2.03	5.70	38
4	DC High Voltage	2.04	0.36	4
5	AC Power & Energy	2.05	19.49	114
6	AC High Current& High Voltage (CT/PT)	2.06	15.00	38
7	LF & HF Impedance	2.07	8.35	63
8	LF & HF Voltage, Current & RF Power	2.08	11.17	29
9	RF Attenuation & Impedance	2.09	3.74	17
10	Magnetic	2.10	1.91	30
		Sub Total (B)	**67.99**	**356**

Engineering Materials

Sr. No.	Activity	DP No .	Calibration Charges	No. of Reports
1	Metal & Alloys	3.01	0.30	6
2	Advanced Carbon Product	3.02	0.44	4
		Sub Total (C)	**0.73**	**10**

Electronic Materials

Sr. No.	Activity	DP No .	Calibration Charges	No. of Reports
1	Polymeric Films & Devices	4.04	0.02	1
2	Advance Ceramics Devices & Optical Thin Films	4.05	0.09	2
3	Surface Physics & Nanostructured Devices	4.06	0.51	3
		Sub Total (D)	**0.62**	**6**

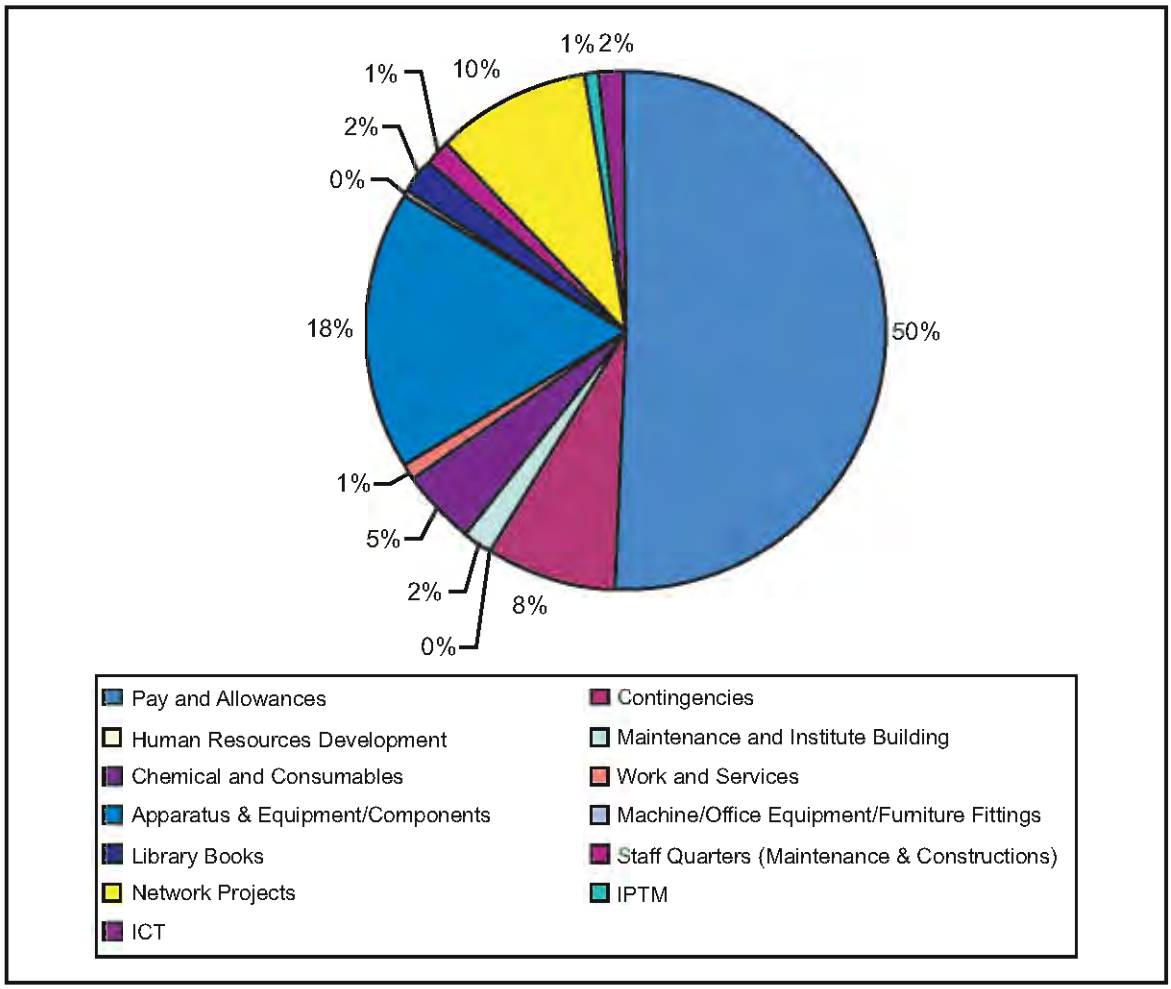
Materials Characterization

Sr. No.	Activity	DP No.	Calibration Charges	No. of Reports
1	Chemical Analysis	5.01	5.59	50
2	EPR & IR	5.02	0.84	6
3	X-Ray	5.03	0.48	4
4	Electron Microscope	5.04	3.23	26
5	Indian Reference Material	5.05	5.17	24
6	Crystal Growth	5.06	0.05	1
7	SIMS	5.07	0.19	0
		Sub Total (E)	**15.56**	**111**
	GRAND TOTAL (A+B+C+D+E)		**417.56**	**3362**

ACTUAL EXPENDITURE 2006 - 07

(Rs in lakhs)

Sr. No.	Budget Heads	Expenditure
1	Pay and Allowances	2356.888
2	Contingencies	371.452
3	Human Resources Development	3.554
4	Maintenance and Institute Building	93.267
5	Chemicals and Consumables	216.344
6	Work and Services	32.147
7	Apparatus & Equipment/Components	832.325
8	Machine/Office Equipment/Furniture Fittings	11.664
9	Library Books	99.519
10	Staff Quarters (Maintenance & Constructions)	69.534
11	Network Projects	456.125
12	IPTM	37.173
13	ICT	77.387
	Total	**4657.379**



APPENDIX - 9

RECOGNITIONS

Vikram Kumar
Chairman, DEC, APMP
Member, APMP Executive Committee

R P Singhal,
Chairman, TCL, APMP

A.K. Bandyopadhyay
Chairman, TCM, APMP
Chairman, TCM meeting at APMP General Assembly, Indian Habitat Centre, New Delhi., 13-14 December, 2006
Elected member of the Mass and Pressure Working group of CCM

P. Banerjee
Acting Chairman, Commission A, URSI, since January, 2007

H.C. Kandpal
Chairman of the Electrotechnical committee 23, Bureau of Indian Standards, since 2005
Chairman, Photography and Cinematograph committee, ME-32 since October 2006

Ashok Kumar
Chief Editor, J. Acoustical Society of India,

R. K. Garg
Editor, Invertis Journal of Science & Technology, published quarterly by Invertis Group of Institute General Secretary, Metrology Society of India (2006-07)

A. Sengupta
Member of Technical Programme Committee of CPEM-2006, held at Torino, Italy, July 9-16, 2006

R S Dabas
Member of "International Space Environment Services (ISES)" since 2002
Members of the "National Steering Committee on Climate and Weather of Sun Earth system (CAWSES-India) of ISRO, since 2004

Anil K. Gupta
Editorial Advisory Board Member of Indian Institute of Metals Book Series (IIM-Universities Press) in Metallurgy and Materials Science
Reviewer, Materials Science & Engineering 'A' Member "Project Advisory Committee" on Status of Nanotechnology in Indian Industries & Academia, sponsored by Dept. of Science & Technology, Govt. of India 2007
Management Council (MC) Member of Regional Research Laboratory (RRL), Bhopal, 2003-2007
Management Council (MC) Member of CEERI, Pilani, 2005 -2007
Management Council (MC) Member of NISCAIR, New Delhi, 2006-2007

S.K. Singhal
General Secretary, "Ultrasonic Society of India, Editor, Sensors & Transducers" Journal of USA.

P. Banerjee
Awarded IETE Hari Ramji Toshniwal Gold Medal 2006

R. B. Mathur
B.D. Bangur Award, presented by Indian Carbon Society
Endeavour India Executive award from DEST, Australia

V. P. S. Awana
Rajib Goyal Young Scientist Medal for Physical Sciences, Rs. 50,000 cash, a medal and citation

Kamlesh K. Jain, H N P Poddar, S S K Titus, Rajesh Kumar, R R Meena and Vikram
Outstanding team performance award by NPL for the development of the 500 kg load cell calibrator for RRSL (Ministry of consumer affair, food and public distribution, Govt. of India).

Harish Chander
Scientist of the Year Award of NPL, Sept. 2006

S.C. Gera, K. Veludhan, Ramdhan Sharma & T.K. Saxena
Best Technical Team Award (Support Services) by NPL for the successful installation of old liquid helium plant of INMAS at NPL

H.C. Kandpal
Best poster paper for the paper entitled "Optical Properties of anthracene nanotubes fabricated on a ground glass surface", presented in the Nanoscience and Technology conference was adjudged as one of the best out of four posters chosen by the Hon'ble President of India.

Govind & S. M. Shivaprasad
Received best poster Award for the poster entitled "Controllable Tungsten oxide thin film nanostructures as cathodes for electrochromic smart window" by M. Deepa, Govind, S.M. Shivaprasad, Shahzada Ahmad and A.K. Srivastava in the 18th AGM MRSI, at National Physical Laboratory, New Delhi during 12-14 Feb 2007

Mrs. P H Maheshwari
Best poster award to Ph.D. student , 28th Feb.,07

T.K. Saxena
Best Paper Award for the paper entitled "Fully Computer controlled Large Size triaxial testing machine" October 15, 2006

R. R. Pandey
Best Poster Award During 18th. MRSI Meet held from 12 to 14 February 2007, at NPL New Delhi.

A. K. Srivastava

ZEISS Best Micrograph Award in Transmission Electron Microscopy under Materials Science, National conference on Electron Microscopy and XXVIII Annual Meeting of Electron Microscope Society of India, Thiruvananthapuram, India, April 19-21, 2006.

Best Paper Award, Eighteenth Annual General Meeting of Materials Research Society of India, New Delhi, February12-14,2007.

N Karar

Best paper award won by N. Karar, R K Kotnala and Devinder Gupta, at MRSI Lucknow Chapter/ Lucknow University, National Workshop on Nanomaterials, 24-25 March, 2007)

APPENDIX – 10

VISITS ABROAD

Sr. No.	Name & Designation	Country Visited	Duration	Purpose
1.	Dr. Divi Harnath Sci.C	USA	28-03-2006 27-03-2007	To avail BOYSCAST fellowship for the year 2005-2006
2.	Sh. Prabhat K. Gupta Sci.F	Paris, France	04-04-2006 07-04-2006	To attend CCQM-Working Group meeting on Gas Analysis (GAWG), at NOVOTEL hotel in Paris & CCQM Plenary meeting at BIPM, Paris,
3.	Dr. S.K. Singhal Sci.F	South Korea	17-04-2006 14-07-2006	To visit Department of Materials Science & Engineering, Pohand University of Science & Technology (POSTECH) South Korea to work with Prof. Gyu-Chui Yi, under INSA-KOSEF Programme
4.	Dr. P.N. Dixit Sci.F	USA	24-04-2006 27-04-2006	To present a paper at 49th Annual Society of Vacuum Coaters Technical Conference
5.	Dr. Ashish Agarwal Sci.B	Germany	18-04-2006 20-04-2006	To visit M/s Toptica Photonics, Germany to get familiar with the critical care needed for the operation of the Laser system SYS TA850
6.	Dr. Vikram Kumar Director	China	27-04-2006 29-04-2006	To attend the "12th Micro machine Summit"
7.	Dr. Rina Sharma Sci.E-I	Thailand,	29-05-2006 31-05-2006	To attend APLAC Evaluator Course
8.	Dr. K.K. Maurya Sci.C	Taiwan	1-06-2006 31-05-2007	To work as a Post Doctoral Fellow for one year with Prof. C. W. Lan, Department of Chemical Engineering , National University of Taiwan on Sabbatical Leave
9.	Dr. A. Sen Gupta Sci. G	Germany	02-05-2006 17-06-2006	To design and develop Cs synthesis techniques and construction and evaluation of a laser cooled Cs clock under NPL-PTB MoU on cooperation in the field of Metrology.
10.	Dr. B.D. Malhotra Sci.F	France	21-05-2006 24-05-2006	To attend the Indo–French Workshop i.e. the Molecular / Organic Devices as an invited speaker
11.	Dr. R.P. Singhal Sci.G	Hongkong	10-05-2006 12-05-2006	To visit Hongkong Accreditation services (HKAS) as a technical assessors for assessment for the Govt. of Hong Kong special administration region Standards Calibration Lab (SCL)
12.	Mr. H.K. Singh Sci.C	Germany	26-05-2006 25-01-2007	To develop & fabricate a Cryogenic Current Comparator

				(CCC) for up gradation of the existing Quantum Hall Resistance Standards & super conducting devices with the collaboration of PTB & to get training at PTB Germany
13.	Dr. A.K. Srivastava Sci.C	Germany	15-06-2006 14-12-2006	On sabbatical leave to work as a visiting research scientist on material processing including oxide semiconductor & piezoelectrics and their characterization using electron microscopy spectroscopy techniques with Prof. H..J. Kleabe & Prof. H. Fuess of Technical Univ. of Darmstadt, Germany.
14.	Dr. R.P. Singhal Sci.G	SASO Saudi Arabia	03-06-2006 04-06-2006	To attend the Workshop on Metrology, Present status & future perspectives
15.	Dr. A.K. Hanjura Sci. F	SASO Saudi Arabia	03-06-2006 11-06-2006	To attend the Workshop on Metrology, present status future perspectives and help them in Time & Frequency Metrology.
16.	Dr. Vikram Kumar Director	Hong Kong	20-06-2006 21-06-2006	To attend the CODATA (Committee for DATA)Low Dimensional Nano Structure Task Group Meeting
17.	Dr. S.T. Lakshmikumar Sci. F	South Africa	26-06-2006 30-06-2006	To attend the Fab Lab workshop organized by NIT & DST, South Africa in terms of CSIR-DST-MIT MoU .
18.	Dr. Vikram Kumar Director	Philipines	10-07-2006 12-07-2006	To attend the Asia – Pacific Metrology Programme (APMP) July 2006 Meetings & Planning Workshops
19.	Dr. B.C. Arya Sci.F	Australia	12-07-2006 14-07-2006	To attend 2nd SCAR Open Science Conference at Hobart, Tasmania, Australia
20.	Dr. R.S. Dabas Sci. F	China	14-07-2006 23-07-2006	To attend Int. Environmental Space Services (IES) & 36th COSPAR assembly
21.	Dr. V.P.S. Awana Sci.C	Israel	20-07-2006 10-08-2006	To work at Racah Institute of Physics, Jerusalam, Israel under DST funded collaborative Joint Research Indo-Israel Programme entitled "Synthesis & Characterization of Nano-size grains of Rthenocuprates & MgB_2"
22.	Dr. Ram Kishore Sci.F	USA	05-08-2006 08-08-2006	To visit (i) Dept. of Mechanical Engg. UARK, Fayetteville, (ii) To work on Metal Induced

				Crystallization behaviour on thin films of Amorphous Silicon under DST-NSF collaborative project at Electrical Engineering Department, University of Arkansas , UARK
23.	Dr.Y.P. Singh Sci.F	Pakistan	28-08-2006 29-08-2006	To Attend the first SAARC Workshop on regional Intercomparison at Islamabad
24.	Sh. M.B. Das T.A	Pakistan	28-08-2006 29-08-2006	To attend the first SAARC Workshop on regional Intercomparison at Islamabad
25.	Sh. Mukesh Kumar T.A.	Pakistan	28-08-2006 29-08-2006	To attend the first SAARC Workshop on regional Intercomparison at Islamabad
26.	Sh. R.B. Sibbal T.A.	Pakistan	28-08-2006 29-08-2006	To attend the first SAARC Workshop on regional Intercomparison at Islamabad
27.	Sh. V.T. Chitnis Sci.G	Pakistan	28-08-2006 29-08-2006	To lead the NPL delegation and attend the first SAARC Workshop on regional Inter-comparison at Islamabad
28.	Dr.(Ms.) M. Deepa Sci.C	Turkey	03-09-2006 05-09-2006	To attend the 7th International meeting on electrochromics (IME-7)
29.	Dr. B.D. Malhotra Sci. F	Japan	04-09-2006 18-10-2006	To visit Japan Society for Promotion of Sciences (JSPS) under the "FY2006 JSPS invitation fellowship programme for Research in Japan (short term)
30.	Dr. P. Banerjee Sci.G	France	11-09-2006 15-09-2006	To attend (i) Joint Working Group CCL/CCTF meeting (ii) Seventh Meeting of Representatives of Laboratories to TAI & (iii) 17th meeting of Consultative Committee for Time & Frequency (CCTF)
31.	Ms. Anuradha Sengar Sci. E-I	Australia	Two years EOL & leave due admissible starting from 28.8.2006	For doing Ph.D as a full time International student at Macquaire University, Sydney, Australia.
32.	Dr. P.K. Singh Sci. F	Bulgaria	17-09-2006 16-10-2006	To attend 14th ISCMP & to visit Central Laboratory of Solar Energy & New Energy Sources , CL-SENES, Sofia, Bulgaria under Indo - Bulgarian Joint S&T Project (DST) on "Low Cost Technology for High Efficiency Silicon Solar Cell"
33.	Dr. Tuhin Kumar Mandal Sci. C	South Africa	17-09-2006 23-09-2006	To attend the Joint CACGP/IGAC/WMO Symposium - Atmospheric Chemistry at the interfaces-2006
34.	Dr. Mahavir Singh Sci.E-I	Thailand	18-09-2006 22-09-2006	For attending Joint Trainin gon Measurement Stds. at the interfaces-2006

35.	Sh.Gautam Mandal Sci. B	Thailand	18-09-2006 22-09-2006	For attending Joint Training on Measurement Standards at the interfaces-2006
36.	Dr. V. Mohanan Sci.G	BIPM, France	25-09-2006 26-09-2006	To attend the Consultative Committee for Acoustics, Ultrasound & Vibration (CCAUV)
37.	Dr. Vikram Kumar Director	France & UK	09-10-2006 10-10-2006 11-10-2006 13-10-2006	(1)To attend the meeting of Directors of National Metrology Institutes of Member States of the Metre Convention schedule to be held at BIPM , France, (2) To visit Dr. Steve Mcquillan of NPL, Teddington , UK
38.	Dr. V.N. Ojha Sci. F	Germany , UK & Switzerland	09-10-2006 17-10-2006	(1)To visit PTB, Germany, to discuss the future perspective of a possible cooperation of NPL, India-PTB, Germany in the field of Nano Metrology (2),To visit NPL, Teddington UK to discuss possible collaboration on various items (3) METAS Lab, Switzerland for discussions & future cooperation establishing the calibration facility of Nano-scale for calibration of step height, Line width, surface structure standards, also to learn the measurement on AFN, SPM & surface profiler used by Nano-technology centers in India.
39.	Dr. R.P. Singhal Sci. G	Germany , UK & Switzerland	09-10-2006 17-10-2006	For study visit to (i) PTB, Germany to discuss the future perspective of a possible cooperation of NPL India-PTB Germany in the field of Nano Metrology, (ii) NPL Teddington, UK to discuss possible collaboration on various items (iii) METAS Lab, Switzerland for disussions & future cooperation establishing the calibration facility of Nano-scale for calibration of step height, Line width, surface structure standards and also to learn the measurement on AFN, SPM & surface profiler used by Nano-technology centers in India
40.	Dr.V.T. Chitnis Sci. G	Japan	11-10-2006 14-10-2006	(i) To attend the Symposium on 21st Century Materials development for Environment, Energy & Information as an invited speaker and (ii) To visit the laboratory of Prof. Uchida at Aichi Institute of Technology, Toyota
41.	Dr. T.D. Senguttvan Sci. C	Singapore	11-12-2006 15-12-2006	To attend 5 th Int. conf. on Materials Processing for properties & performance

42.	Shri Alok Mukherjee STA	Taiwan	14-11-2006 25-11-2006	To attend "Advanced Training Workshop on Southeast Asia Regional Carbon and Water Issues"
43.	Dr. Sudhir Kumar Sharma T.A.	Israel	14-11-2006 16-11-2006	To attend the 3rd International Conference on Metrology: Trends on Applications in Calibration and Testing Laboratories
44.	Dr. Harish Bahadur Sci. F	Japan	05-01-2007 for two months	To avail the fellowship under the "FY2006 JSPS invitation fellowship programme for Research in Japan (Short –Term)
45.	Dr. Pardeep Mohan Sci. F	USA	07-01-2007 05-07-2007	To visit NIST Gaithersburg, MD, USA to work on a project involving pumping effect of hot cathode Ionization gauges and measurement errors.
46..	Dr. V.P.S..Awana Sci. C	Japan	08-01-2007 31-03-2007	To avail the fellowship under the "ICYS" visiting Research fellowship of the special coordination fund of MEXT, Japan
47.	Dr. S. Seelakumar Titus Sci. C	Italy	29-01-2007 06-02-2007	To understand the operation and proper maintenance of the Primary Standard Vickers hardness standardizing machine and to visit INRIM at Torino, Italy.
48.	Dr. Anil Kumar Gupta Sci. G	USA	21-02-2007 03-03-2007	To visit (a) Prof. John J. Lavendosky, Case-Western University, Cleveland, USA to explore the possibility of joint collaboration (b) to attend the Annual Technical Meeting of TMS at Orland , USA including the seminar to make presentation on the progress of the project sponsored by General Motors at NPL and (c) to visit general Motors Research and Development Centre at Warren, Michigan, USA
49.	Dr. Hari Kishan Sci.F	Israel	13-03-2007 30-03-2007	To work at Racah Institute of Physics , Hebrew University, Jerusalam, Israel under Indo-Israel joint project entitled " Synthesis and characterization of nano size grains of Rutheno-cuprates and MgB_2 superconductors"
50.	Dr. A.K. Bandyopadhyay Sci. F	France & Germany	23-03-2007 30-05-2007	To attend 10th meeting of CCM of BIPM and to visit PTB, Germany for the promotion of regional cooperation in South-East Asia for the establishment of MSTQ-structures

51.	Dr.(Mrs) M. Deepa Sci. C	Belgium	26-03-2007 30-03-2007	To visit FUNDP. Department of Chimie, University of Notre-Dame, de la paix, in Namur, Belgium to attend a seminar on Electrochromic subject
52.	Sh. Anil Kishore Saxena Sci.F	France	03-03-2007 16-03-2007	To attend the 9th Meeting of CCEM working Group on Low Frequency Quantities and Consultative Committee for Electricity.

APPENDIX - 11

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

Sr. No.	Title	Awardee	University/Institute	Guide(s)
1	Memory effect in deformed helix ferroelectric and electroclinic liquid crystal materials.	Sarabjot Kaur	Delhi University, Delhi.	Dr. A. M. Biradar (NPL) Prof. S. Annapurni (DU)
2	Study of pure and doped tetrahedral amorphous carbon films deposited by a 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. Hussain (Jamia Millia)
3	Studies on polymeric composite electrolyte	Shahzada Ahmad	Jamia Millia Islamia	Dr. S A Agnihotry (NPL) Prof. Sharif Ahmed (Jamia Millia)
4	Modelling & Statistical analysis of ionosphere using satellite and ground based observations	Mrs. Neerja Sharma	Barkatullah University (Bhopal)	Dr R.S. Dabas (NPL) Prof. A.K. Gwal (Barkatullah)

APPENDIX - 12

HUMAN RESOURCE DEVELOPMENT ACTIVITIES

1. Organization of Training Courses

An important activity of the HRD Group is to organize Training Courses on different scientific & technical topics, mostly related to Standards of Measurements of various physical parameters. These courses are conducted as per the Training Calendar specially prepared by the HRD Group in consultation with the Divisional Heads, and are primarily meant for personnel belonging to industries / laboratories / scientific institutions involved in the manufacturing / testing and calibration of scientific instruments / apparatus, or measurement of various physical parameters. The internal staff members, duly nominated by their Divisional Heads are also entertained. The Training Courses consist of theory lectures and the practical demonstration of various scientific and technical aspects related to the topics of training courses.

Twelve Training Courses on the following topics organized by NPL, were attended by personnels belonging to various organizations as well as by the NPL staff members.

Training Courses Organized

- Training Course on Right to Information Act 2005, May 03-04, 2006
- Training Course on ISO / IEC 17025, Expression & Evaluation of Uncertainty, July 25-28, 2006
- Workshop on Calibration Practices, September 15-16, 2006
- Training Course on DC Measurements, September 18-22, 2006
- Training Course on Photometry & Colorimetry, October 09-13, 2006
- Training Course on Dimensional Metrology, October 16-19, 2006
- Training Course on Mass Measurements, November 06-10, 2006
- Training Course on Calibration of SPRTs, November 20-24, 2006
- Indo-Italian Training Programme on Force & Torque Metrology, December 05-08, 2006
- Training Course on Radio Meteorology & Radio Propagation, January 08-10, 2007
- Training Course on Quality Management System based on ISO 17025, January 31-February 03, 2007
- Training Course on Dimensional Metrology, February 26-March 02, 2007

2. Deputation of NPL Staff Members to Attend Conferences / Special Training Programmes

NPL encourages and supports its staff members, including the floating members like JRFs, SRFs, PAs, RIs, RAs, SRAs etc., to attend and present papers at national / international conferences / symposia / seminars / workshops, organized by different agencies in areas relevant to research activities being carried out at NPL. This is primarily meant to enable the staff members to put forward their views and research results before the leading national / international experts and interact with them on the current developments in their research areas.

A large number of NPL scientists and other staff members (350 cases) were deputed to participate at various conferences or similar events held within India.

Besides the conferences / symposia, NPL also deputes its staff members to attend special training programmes organized by the DST or HRDC (CSIR), Ghaziabad. These programmes are aimed at improving the competence of the staff so as to be more productive and useful. Seven personnel of different cadre were deputed to participate in these training programmes.

3. Organization of Students Training

NPL provides both Short Term (Six weeks Plus) and Long Term (Three months Plus) training to students pursuing M.Sc. / B.Tech. / M.Tech. / MCA at different educational institutions spread all over the country, mainly during Summer and Winter Breaks, in areas of research activities being carried out at NPL. The basic objective is to provide them a feel and importance of that

activity and motivate them towards scientific research. A large number (160) of students were provided training oriented towards the fulfillment of their academic degree programme in different areas of research under the guidance of senior scientists.

4. Placement, Ph.D. Registration and other support to Research Fellows

One of the most prominent activities of the HRD Group is to provide help and support to the Research Fellows (JRFs / SRFs), starting from the time they join NPL till the time they leave NPL. This includes their placement in a particular Division / Group and helping them in getting Hostel Accommodation. This also includes their Ph.D. registration, their assessment for continuance / upgradation, their deputation to attend conferences etc. Sometimes, help to the Research Fellows starts even before they join NPL. This refers to the cases where they are invited to join NPL for their Ph.D. Programme.

Seven fresh JRFs / SRFs joined NPL during the year 2006-2007 making a total strength of Research Fellows (JRFs + SRFs) in NPL to be 55 as on 31-03-2007. Efforts are continuing to increase this number to at least 75 in a year's time.

5. Organization of Institutional Visits to NPL

Organization of institutional visits involving students / teachers / faculty members / officials belonging to schools / colleges / technical institutes / scientific institutions is an important activity of the HRD Group. During the year 2006-2007, 17 organizations covering 507 persons visited NPL. This included prestigious institutions like IIT-Delhi, IILM-Ranchi, IIPA-New Delhi, Amity University Noida and BIS-New Delhi.

6. CSIR Programme on Youth for Leadership in Science (CPYLS)

The CPYLS programme for the year 2006 was organized at NPL on Nov. 28-29, 2006. Around 20 bright young school children, all belonging to Delhi schools, participated in this programme, wherein the keynote lecture was delivered by the well-known bio-scientist, Prof. Dinkar Salunke of the National Institute of Immunology, New Delhi. This was followed by a series of lectures by reputed senior scientists of NPL in the areas of exciting / emerging scientific research. Besides this, the programme involved visits of the students to several Research Groups as well as Film shows on NPL activities and achievements. The basic objective was to attract and motivate the young school children towards scientific research as the career.

7. CSIR Foundation Day Celebrations (NPL Open Day)

Efforts were made towards designing, updating and publication of new/compact 3-fold NPL Brochures in connection with the CSIR Foundation Day Celebration 2006 on September 26, 2006. Efforts were also made for the publication of NPL Open Day advertisement in the newspapers.

8. NPL Diamond Jubilee (NPL-DJ) Celebrations & preparation of DJ document

(i) Compilation of List of NPL Awardees

(ii) Compilation of List of Krishnan Memorial Lectures

(iii) Formulation of NPL-DJ Long Term Programme

Several meetings of the Committee, specially constituted by the DNPL for the purpose, were convened all of which involved brain-storming by the members. Eventually, the Committee came out with certain recommendations, which were submitted to the D,NPL for his kind consideration and further necessary action.

9. National Science Day Celebration 2007

The National Science Day2007 was celebrated by NPL on 28th February, 2007 in a novel manner by organizing a Poster Presentation Symposium, which consisted of poster presentation of the work carried out by the Research Fellows (JRFs/SRFs) at NPL. It was kept open to all the NPL scientists so that there could be very useful and productive interaction between the two categories of NPL staff members. To make the symposium lively and attractive, it was decided to give 2-3 Best Poster Presentation Awards to top-ranking Research Fellows selected by a specially-constituted jury of scientists.

10. Maintenance of NPL Human Resource Record

HRD Group also maintains a record of its Human Resource in terms of Group I, Group II, Group III, Group IV and Administrative staff members; their minimum, maximum, and average age; their relative seniority etc. Besides this, the record of floating staff members, such as JRFs, SRFs, RAs, PAs, RIs, Emeritus Scientists etc. is also maintained. Such type of database is extremely useful for the institutional planning which may ultimately lead to an improvement in the productivity / performance of the institution.

11. Placement of Newly-Recruited Scientists 'B'/'C'

Co-ordination was done towards the placement of newly-recruited Scientists 'B'/'C' in a particular Division/Section. These scientists were made to undergo a 2-Week Orientation Programme, of meeting senior scientists, including all DU / DP Leaders, and interacting with them on their research activities. The basic aim of the Orientation Programme was to provide the freshly-inducted scientists an opportunity to have a glimpse of all the research activities being carried out at NPL, right in the very beginning of joining the NPL. This awareness could be very helpful in their proper placement by the authorities as well as in their pursuit of research activities in future.

CONFERENCES, SYMPOSIA, WORKSHOPS AND EVENTS ORGANISED BY NPL

October 12-14, 2006
National Conference on Advances in Technologically Important Crystals organized at Physics and Astrophysics Dept., University of Delhi.

November 15, 2006
Workshop on 'Noise Control Measures for D.G. Sets' was organized at NPL, New Delhi as a curtain raiser to NSA.

November 16-17, 2006
The National Symposium on Acoustics (NSA 2006) was organized at NPL, New Delhi with the special theme 'Environmental Noise Pollution Standards & Control' as a part of NPL Diamond Jubilee (1947-2007) Celebrations.

November 22-24, 2006
Twenty first National Symposium on Cryogenics was organized jointly by NPL and Indian Cryogenic Council (North Zone) at NPL, New Delhi.

December 5-8, 2006
Indo-Italian Training Program, New Delhi.

December 11-12, 2006
3rd APMP Pressure And Vacuum Workshop, Indian Habitat Center, New Delhi,

December 14, 2006
Seminar on Metrology in Chemistry organized at NPL jointly by National Physical Laboratory and Indian Society of Analytical Scientists – Delhi Chapter. Dr. Robert Kaarls, Secretary Comite International des Poids et Measures (CIPM) and Chairman consultative Committee on Amount of Substance (CCQM) and Dr. Ed Leer, Chairman, Gas Metrology Working Group of CCQM had delivered the lecture on Metrology in Chemistry and metrology in Gas Analysis respectively. About 90 scientists of various organizations attended the seminar.

December 11-16, 2006
APMP General Assembly, New Delhi, December 13-14, 2006.

February 12-14, 2007
MRSI 18th AGM" and the Theme Symposium on "Materials for Energy Generation, Conservation and Storage" at National Physical Laboratory, New Delhi.

February 15, 2007
Materials Under High Pressure A Discussion Meeting on Materials Under High Pressure was organized by Delhi Chapter MRSI and National Physical Laboratory, New Delhi, along with 18th Annual General Meeting Material Research Society of India (MRSI).

February 21-24, 2007
Golden Jubilee Symposium on Radio Science (INCURSI 2007) at National Physical Laboratory, New Delhi.

LECTURES ORGANIZED UNDER NPL SEMINAR SERIES

Sr. No.	Date	*Speaker*	Affiliation	Title of the talk
1	24-04-06	Prof. Ravi F. Saraf	Department of Chemical Engineering, University of Nebraska – Lincoln, USA	Self-assembled Electronic Devices on Microorganism, Polymers & DNA Molecule
2	25-04-06	Dr. Tapas Kar	Department of Chemistry & Biochemistry Utah State University Logan, UT 84322-0300, USA	Chemical modifications of Fullerenes and Carbon Nanotubes
3	02-05-06	Dr. Shaibal. K. Sarkar	Materials Research Center, University of Missouri, Rolla	Surface Properties of Nanocrystalline Materials
4	02-06-06	Dr. S. Bhattacharyya	Advanced Coatings and Surface Engineering Laboratory, Colorado School of Mines Golden, Colorado, CO 80401	Multifunctional Nano-hybrids by self-patterning route
5	11-07-06	Prof. Ravi F. Saraf	Department of Chemical Engineering, University of Nebraska – Lincoln, USA	Dynamics at Metal/Electrolyte interface: An Avenue towards combinatorial electrochemistry
6	18-08-06	Dr. Dipankar Das	Dept of Physics, IISc, Bangalore	High precision optical frequency metrology
7	24-08-06	Dr. Somnath Bhattacharyya	Nano-Electronics Centre, Advanced Technology Institute, University of Surrey, UK	Resonant Tunneling and Fast Switching in Amorphous Carbon Quantum-well structures
8	14-09-06	Dr. Robert Wynands	Head, Unit of Time PTB, Germany	Atomic Clocks of Today and Tomorrow
9	06-10-06	Dr. G. Bhagavannarayana	Materials Characterization Division, NPL, New Delhi	An introduction to high-resolution X-ray diffraction methods established at NPL for characterization of device quality single crystals and epitaxial films
10	10-11-06	Dr. S.T. Lakshmikumar	Electronic Materials Division, NPL, New Delhi	Nobel Prizes (2006) in Science: An Appreciation
11	18-12-06	Dr. Rainer Michalzik	Institute of Opt-oelectronics of Ulm University, Germany	Ultra-compact optical traps based on vertical-cavity laser diodes
12	22-12-06	Dr. Devki N. Talwar	Dept of Physics, Indiana Universitat of Pennsylvania, Indiana, USA	Assessing the preferential chemical bonding of nitrogen in novel dilute III-As-N alloys
13	09-01-07	Dr. Adarsh Sandhu	Tokyo Institute of Technology, Japan	Nano-Hall Effect Sensors for Imaging Magnetic Domains and Biomedical Applications

APPENDIX – 15

INVITED TALKS, LECTURES BY NPL SCIENTISTS

Sr. No.	Speaker's Name	Topic	Event and Venue
1	Anil Kr. Gupta	i) Significance of Wrought Magnesium Alloys for Automobile Applications - New Opportunities & Challenges	Senior Management of Hero Group of Industries, 12th April, 2006
		ii) Metallic Component Development for Automobile Applications at NPL	NPL Industry Meet at NPL, New Delhi, 7th November 2006
		iii) Light Metallic Materials and Components - Opportunities & Challenges for Automobile & Aerospace Industries	INAE Lecture, 8th December 2006
		iv) Development of Lightweight Materials & Components at NPL	ALCOA-CSIR Workshop at CSIR Science Centre, 15th December 2006
		v) Developments of Magnesium Alloy Component for Automobile & Aerospace Industries	ARC International, Hyderabad, 18th December 2006
		vi) Significance of Advanced Metal Forming Techniques	CASE Western Reserve University, Cleveland, USA 20th February 2007
		vii) Advance Magnesium Extrusion Alloys, In-house General Motors R&D Symposium on Wrought Magnesium alloy	Orlando, Florida, USA, 25th February 2007
2	A. Basu	Thin Film Optical Coatings by Plasma Polymerization	Plasma Processing Industry Interaction Meet 2006, Institute of Plasma Research, Gandhinagar, 27-28 July 2006
3	A.K. Agrawal	i) Quality Assurance and Quality Control in Chemical Analysis	DST Sponsored National Training Course on Applications of ICP-MS in Earth System Sciences at National Geophysical Research Institute, Hyderabad, June 26-30, 2006
		ii) National Certified Reference Materials Programme	Training Course on ISO-IEC 17025: 2005 & Uncertainty in Measurement at National Physical

			Laboratory, New Delhi, July 25-28, 2006.
		iii) Evaluation of Uncertainty in Chemical Measurement.	-do-
		iv) Evaluation of Uncertainty in Chemical Measurement: A Case Study AAS.	-do-
		v) Evaluation of Uncertainty in Chemical Measurement: A Case Study pH Measurement	-do-
		vi) Indian Programme on Preparation and Dissemination of Certified Reference Materials	6th International Conference on Advances of Metrology (AdMet-2006), New Delhi, December 11-13, 2006
		vii) The COMAR Database and the NPLI Policy	-do-
		viii) ICP Emission Spectrometer: A Novel Technique for Characterization of Materials.	National Workshop on "Recent Trends in Analytical Techniques" New Delhi, Februar 14-15, 2007
		ix) Metrology in Chemistry and Traceability in Measurements	Management Development Programme on Operation, Maintenance and repair of Analytical Equipment, at CSIO, Delhi Centre, Delhi, Feb. 26, 2007
4	A.K. Bandyopadhyay	i) Effect of viscosity of the pressure transmitting fluids in the characterization of CCPG up to 1 Gpa	3rd APMP Pressure And Vacuum Workshop, Indian Habitat Center, New Delhi, 11-12th December, 2006.
		ii) TCM report in APMP region	TCM meeting along with APMP General Assembly at Indian Habitat Center, New Delhi., 13-14 December, 2006
		iii) High Pressure Phase Transition and Band Structures of different phases in CeO_2	Discussion Meeting on the Materials under High Pressures (MRSI-MHP), 15th February, 2007, National Physical Laboratory, New Delhi.
5	A.K. Srivastava	i) Oxide Nanostructures: Synthesis, Microstructure and Properties	National Workshop on Nanomaterials and Nanotechnology, University of Lucknow, Lucknow, India, March 25, 2007.
		ii) Advance Materials: Processing, Microstructure and Properties	University of Reims, Reims, France, August 31, 2006

		iii) TEM, SEM and EDS analysis of micro- and nano- scaled cadmium oxide grown by a solid –vapour deposition process	National Conference on Electron Microscopy and XXVIII Annual Meeting of Electron Microscope Society of India, Thiruvananthapuram, India, 19-21 April 2006
6	Anil Kumar	Evaluation of bmc of force calibrating machines	Indo-Italian Training Program, National Physical Laboratory, New Delhi, 5-8 Dec 2006
7	Arun Vijayakumar	Characterization of Low Range Differential Pressure Transducers covering the range of ± 1333 Pa.	3rd APMP Pressure And Vacuum Workshop, Indian Habitat Center, New Delhi, 11-12 December 2006
8	Ashish Agarwal	New development of Atomic Clocks at NPL	National Seminar on Perspectives in Engineering Optics and Spectroscopy held at Indraprastha Engineering College, Ghaziabad, 27th April 2005
9	B.D. Malhotra	i) Recent Trends In Conducting Polymer Based Biosensors	Indo –French Workshop on 'Molecular/ Organic devices, 22-24 May 2006
		ii) Conducting polymers LB films for Biosensors	BRNS Theme Meeting on "Self-assembly Routes for Nanotech Materials (SARNaM-06)", 26-28 April 2006
		iii) Prospects of Nano-materials in biosensors	Sri Venkateshwara College, 8th December 2006
		iv) Emerging trends in conducting polymer based biosensors	India-Japan Workshop on ZnO Oxide Devices, 18-20 December 2006, Delhi University, Delhi
		v) Nano-materials based bio- sensors	International Nano-biotechnology Conference, 3rd May 2006, Pune
		vi) Conducting Polymer based bio-sensors	Central Electro-chemical Research Institute Institute, Karaikudi, Tamil Nadu, India. 29th June 2006
10	B.R. Chakraborty	i) Secondary Ion-Mass Spectrometry analytical tool for characterizing surfaces & interfaces	International Seminar on Surface & Interface, Jaipur
		ii) Sputter depth profiling of nano-scale interfaces by optimizing depth resolution in SIMS	12th ISMAS workshop cum symposium, Goa
		iii) Chemical imaging of nano-phosphor materials by ion mass spectrometry.	National Symposium on Instrumentation (NSI-31), ITM, Gwalior 12-15 Oct., 2006

11	D.R. Sharma	i) Measurement Uncertainty of Ultrasonic Interferometer Manometer a Primary Pressure Standard established at NPL, India ii) Global and Regional Metrology Equivalence of low pressure measurement facility established at NPL, India in barometric range.	3rd APMP Pressure And Vacuum Workshop, Indian Habitat Center, New Delhi, 11-12 December, 2006 National Symposium on Instrumentation (NSI-31), ITM Gwalior, 12-15 Oct., 2006
12	G. Bhagavannarayana	i) Role of High-resolution X-ray diffraction methods on Crystal Growth ii) Structural and optical characteri-zation of laser crystals and quantum wells by high-resolution X-ray diffractometry, FTIR, UV-Vis. and birefringence techniques iii) Effect of growth conditions, annealing, reduction, implantation, dopants etc. on the crystalline perfection of NLO single crystals by high-resolution XRD iv) An interesting correlation between crystalline perfection and SHG efficiency due to Dopants or additives	Crystal Growth for Electro-Optic Applications held at CGRC, Dept. of Science and Humanities, Karunya Institute of Technology and Sciences, Karunya Deemed University, Coimbatore, Tamil Nadu during 16-17 June 2006 CEP Course on Laser Materials Development & Characterization" at LASTEC, Metcalf House, Delhi-110 054, held during 18-22 September 2006 11th National Seminar on crystal growth held at SSN College of Engineering, SSN Nagar, Tamilnadu during 7-9 December 2006 Second National Symposium on Nonlinear Optical Crystals and Modeling in Crystal Growth, held at Department of Physics, Anna University, Chennai, during 26-27 March 2007
13	H.C. Kandpal	i) Photometric Measurements and Problems ii) Metrology of LEDs iii) Course containing Ten Lectures on Photometry and Colorimetry	Central Institute for Road Transport, Pune, 12th June 2006 International Conference on Solid state Lighting, Anna University, Chennai 2nd July 2006 M. Tech Students Automotive Research Association of India, 11-12 September 2006

		iv) Classical and quantum coherence and its Applications v) Parametric Down conversion vi) Metrology of LEDs –the light for future	National Symposium on Recent Advances in Modern Physics, Physics Department, Kumaon University, Nainital 11-13 November 2006 APMP General Assembly, New Delhi, 13-14 December 2006 National conference on Contemporary Optics and Optoelectronics, M.S. University, Vadodara, 1-3 March 2007
14	Harish Chander	i) A review on Synthesis of nanophosphors-Future Luminescent Materials ii) Recent Trends in Materials-Nano-materials iii) Phosphors for Plasma Display Panels and related problems	9th Asian Symposium on Information Display, ASID'06, India Habitat Centre, New Delhi, 8-12 October 2006 National Seminar on Emerging Trends in Physics Education and Experimental Physics at Department of Physics, V S R & N V R College, Tenali-522 201, AP, 27-28 October 2006 National Conference on Luminescence and its Applications, NCLA-2007, Bharathiar University, Coimbatore, 18-20 January 2007
15	J.K. Gupta	i) Evaluation of Uncertainty in Temperature Measurements - A case study ii) SPRT calibration by fixed point method and evaluation of uncertainty	Training course organized on "ISO-IEC17025:2005 & Uncertainty of Measurements" NPL, New Delhi, 25-28 July 2006 Training program on Temperature Metrology using Fixed Points, NPL, New Delhi, 20-24 November 2006
16	K. Nagarajan etal	Birefringence and high resolution X-ray diffraction studies on KAP, NaAP, and RbAP nonlinear optical single crystal	11th National Seminar on crystal growth held at SSN College of Engineering, SSN Nagar, Tamilnadu during 7-9 December
17	K.P. Chaudhary	i) Maintenance of Lasers Used in Ophthalmology ii) Laser Applications in Bio-medical Science"	CSIO S&M Centre , New Delhi, 21st December 2006 Training program on repair, maintenance and calibration of Biomedical Instruments for Technocrats from Army at CSIO S&M Centre , New Delhi, 20th March 2007

18	K.K. Jain	Establishment of force scale at NPLI India up to 1MN and its dissemination	Indo-Italian Training Program, New Delhi, 5-8 Dec 2006
19	M. Deepa	Development of high performance electrochromic coatings and devices	Facultes Universitaires Notre-dame De La Paix, Laboratoire de Chimie et d'Electrochimie des Surfaces (CES), Namur, Rue-de Bruxelles, Belgium, 26-30 March 2007
20	M.V.S.N. Prasad	i) Performance of fixed and mobile communication links ii) (a) Fixed & Mobile Communication (b) Trans-horizon propagation	Golden Jubilee Symposium on Radio Science (INCURSI-2007), NPL, New Delhi during 21-24 February 2007 Third Course on radio meteorology and radiowave propagation over sea, Indian Navy
21	N. Vijayan	i) Studies on the structural, thermal and optical characteristic of some organic and semi-organic single crystals	Crystal Growth for Electro-Optic Applications held at CGRC, Dept of Sceince and Humanities, Karunya Institute of Technology and Sciences, Karunya Deemed University, Coimbatore, Tamil Nadu during 16-17 June 2006
22	N.P Rajesh	Effect of metal impurities on crystalline quality of KDP crystals	11th National Seminar on crystal growth held at SSN College of Engineering, SSN Nagar, Tamilnadu during 7-9 December 2006
23	N. Vijayan	i) Studies on the growth, thermal, optical and crystalline perfection of pure and additives added some nonlinear optical single crystals ii) Bulk growth of benzimidazole (BMZ) single crystal by Sankarnarayanan – Ramasamy (SR) method and the effect of dopants on the conventional grown BMZ crystals	Second National Symposium on Nonlinear Optical Crystals and Modeling in Crystal Growth, held at Department of Physics, Anna University, Chennai, during 26-27 March 2007 11th National Seminar on crystal growth held at SSN College of Engineering, SSN Nagar, Tamilnadu during 7-9 December 2006
24	Nita Dilawar	i) Bilateral comparison between NIST (USA) and NPL (India) in the pneumatic pressure region 0.4 Mpa to 4.0 Mpa	3rd APMP Pressure And Vacuum Workshop, Indian Habitat Center, New Delhi, 11-12 December 2006

		ii) Pressure induced amorphization in nano-crystalline	Discussion Meeting on the Materials under High Pressures (MRSI-MHP), National Physical Laboratory, New Delhi, 15th February 2007
		iii) Raman behaviour of nano-crystalline Gd_2O_3 under high pressures	-do-
25	P. Mohan	Generation of Pressure Scale From 1000 To 10^{-6} Pa At NPL, India	3rd APMP Pressure And Vacuum Workshop, Indian Habitat Center,
26	P. N. Dixit	"Growth of nanocrystalline silicon using plasma route"	New Delhi, 11-12 December 2006 2nd National Conference on Condensed Matter, Jaipur, 1-3 February 2007
27	P. Srinivasan	Growth and characterization of L-asparaginium picrate (LASP) – a noval nonlinear optical crystal	Crystal Growth for Electro-Optic Applications held at CGRC, Dept. of Sceince and Humanities, Karun Institute of Technology and Sciences, Karunya Deemed University, Coimbatore, Tamil Nadu during 16-17 June 2006
28	P.K. Banerjee	Microwave line of sight propagation over sea-an implementation	Third Course on radio meteorology and radiowave propagation over sea, Indian Navy
29	P.K. Singh	Soft Materials	14th International School on Condensed Matter Physics, Varna
30	R K Garg	i) Calibration and Measurement of UV Radiation	Training Course on "Photometry and Colorimetry" hald at NPL, 9-13 October 2006
		ii) UV Emission from General Purpose Lamps	-do-
31	R. B. Mathur	Carbon Nanotubes: Production, Purification and Challenges in Composite Applications	International Workshop on the Science and Applications of Nanostructured Materials, Prasanthinilayam, Puttaparthy, 29th November–1st December 2006
32	R. Mehrotra	IR Spectrophotometers, Management development programme on operation, maintenance and repair of analytical equipment	CSIO, New Delhi, 6th October 2006
		IR Spectrophotometers, Management development programme on operation maintenance and repair of analytical equipment	CSIO, New Delhi, 2nd March 2007

33	R.K. Kotnala	i) Magnetic Standards and Calibration Techniques	Workshop on Measurements & Characterization of Magnetic Materials held at Saha Institute of Nuclear Physics, Kolkata, 20-21 April 2006
		ii) Verstality and Application of Nanomagnetism	National Seminar on Theoretical and Experimental Techniques on nano science and Nano technology, Punjab University, Chandigarh, 29-30 March 2007
34	Ram Kishore	Studies on in-situ heating effects on interface between aluminum and an amorphous silicon	National Conference on Electron Microscopy and XXVIII Annual Meeting of Electron Microscope Society of India,Thiruvananthapuram, India, 19-21 April 2006
35	S K Singhal	Metrological Research: Trends Analysis for Future Needs	National Symposium on Ultrasonics, Allahabad University, 1-3 November 2006
36	S.K.Jain	International scenario for calibration of force proving and torque measuring devices'	Indo-Italian Training Program, New Delhi, 5-8 Dec 2006
37	S.M. Shivaprasad	i) Beauty is skin deep	COGNIZANCE'07, Physics Department, Indian Institute of Technology, Roorkee, 24th March 2007
		ii) Surface Physics and Nano-science	National Seminar by M.D University, Rohtak, 16th March 2007
		iii) Efficacy of photoemission spectroscopies	International Seminar on Surfaces and Interfaces held at University of Rajasthan, Jaipur, 10-13 November 2006
		iv) Nanoscience and Nanotechnology	Graphics Era Institute of Technology, Dehradun, 3rd November 2006
		v) Characterizing the nanophases by surface sensitive techniques	Indian Institute of Science, Bangalore, 12th October 2006
		vi) Heteroepitaxy of metal-metal and metal-semiconductor systems	Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, 11th October 2006
		vii) Fascinating Surface Physics	Khalsa College, New Delhi, 'National Conference on Emerging Trends in Physics, September 2006
		viii) X-ray Photoelectron Spectroscopy	Inter-University Accelerator Centre (NSC), New Delhi, Workshop on X-ray Techniques, 14th June 2006

38	S.N. Singh	Terrestrial solar Cells	18th Annual General Meeting of MRSI, National Physical Laboratory, New Delhi, 12-14 February 2007
39	S.S.K. Titus	Guidelines for disseminating torque primary standard through torque transfer standard according to DIN/BS documents	Indo-Italian Training Program, New Delhi, 5-8 December 2006
40	Sachchidanand Singh	i) Study of Aerosol, Radiation and Trace-gases in the IGP ii) Ground validation and utilization of I-STAG data	Brain Storming Workshop on Aerosols and its Impact on Climate with special reference to Indo-Gangetic Plains, IIT Kanpur, 10-11 November 2006 -do-
41	Sanjay Yadav	Summary of the proficiency testing programmes under NABL-NPLI in the pressure range up to 70 Mpa	3rd APMP Pressure And Vacuum Workshop, Indian Habitat Center, New Delhi, 11-12 December 2006
42	Subbiah Meenakshisundaram	Influence of complexing agents on the crystal growth, properties and crystalline perfection of some technologically important crystals	11th National Seminar on crystal growth held at SSN College of Engineering, SSN Nagar, Tamilnadu during 7-9 December 2006
43	Suresh Chand	Organic Electronics	Delhi College of Engineering 25th February 2007
44	T. Lal	i) Country Report on "Present Status of Mass Measurements at NPL India" ii) Evaluation of Uncertainty in Mass Measurements iii) Mass Metrology & Standards of Mass iv) Uncertainty Evaluation in Mass Measurements v) Guidelines for calibration of Hydrometers	APMP TCM meeting on 14th December 2006 Training Course on ISO/IEC 17025:2005 and Uncertainty in Measurement, NPL New Delhi, 25-28 July 2006 Training course in Mass Metrology, NPL, 6-10 November 2006 -do- -do-
45	V. N. Ojha	i) Uncertainty in measurement: Evaluation and expression as per ISO GUM	In training course on " ISO-IEC 17025: 2005 and Uncertainty in measurement", held at National Physical Laboratory, New Delhi, 25–28 July 2006

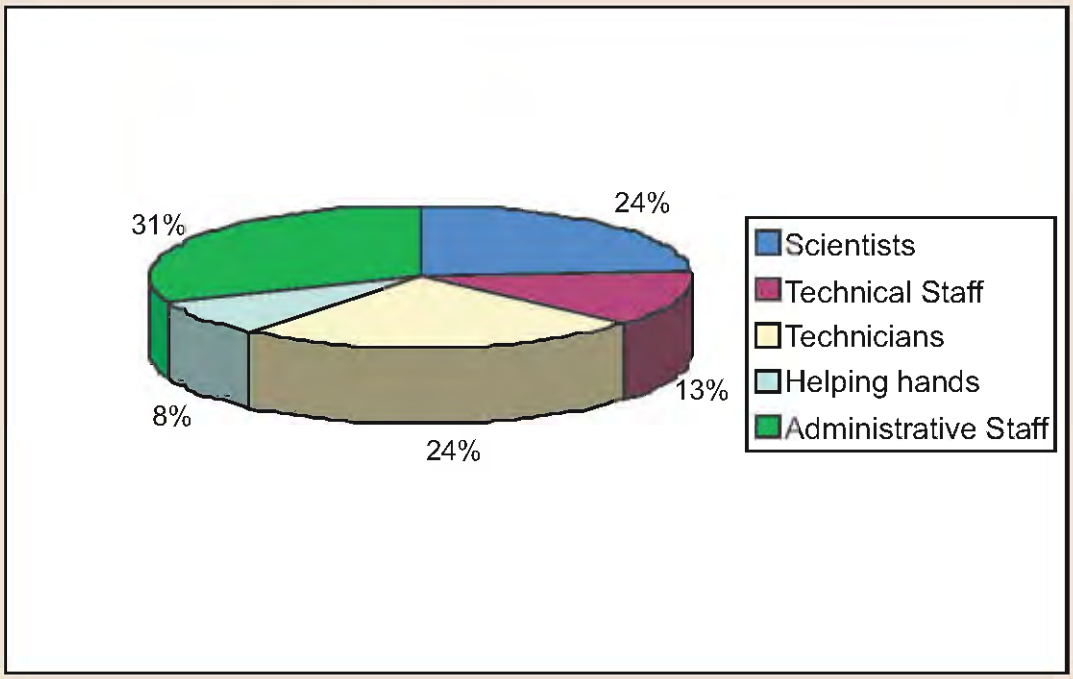
		ii) Evaluation of uncertainty in DC measurements- A case study	In training course on " ISO-IEC 17025: 2005 and Uncertainty in measurement", held at National Physical Laboratory, New Delhi, 25–28 July 2006
		iii) DC measurements	In training course on "Precision Measurement and Calibration", held at National Physical Laboratory, New Delhi, 18-22 September 2006
		iv) Uncertainty in measurement: Evaluation and Expression as per ISO GUM	-do-
		v) Role of Josephson effect in voltage metrology	21st National Symposium on Cryogenics, at National Physical Laboratory, New Delhi, 22-24 November 2006
		vi) Quantum Standards	In "CSIR Programme on Youth for Leadership in Science (CPYLS)", at National Physical Laboratory, 28-29 November 2006
46	V. Mohanan	i) Type Approval and Conformity of Production Tests on Diesel Generator Sets	Workshop on Noise Control Measures for DG Sets, NPL, New Delhi, 15th November 2006
		ii) Environmental Noise Pollution	Invertis Institute of Engineering & Technology, Bareilly (U.P) 14th October 2006
47	V.K. Rustagi	i) Present status of Electro-Technical Measurements at NPL India	"Workshop on Importance and Applications of Metrology", organized by CII, Eastern Region & by QCI, Kolkata, 28-29 June 2006
		ii) Introduction to Electrical and Electronic Standards at NPL and their status vis-à-vis International Standards and Principles & Standards of Alternating Voltage and Current Measurement	"Workshop on Calibration Practices" at Jadavpur University, Jadavpur Kolkata, 15-17 September 2006
		iii) Transfer Standards and Calibration Techniques for AC voltage and Current Measurement and Uncertainty in ac voltage &	- do -
		iv) Frequency counter & oscilloscope measurement and their applications	- do -

		v) "A case study on past CCEM Comparison CCEM-K6.a piloted by PTB."	9th APMP TCEM Meeting and Workshop" organized by NPL and APMP, India Habitat Center, New Delhi, 13-14 December 2006
48	Vikram Kumar	i) MEMS based Sensors- an overview of the developments in India	Eleventh Micro-Machine Summit, Beijing, China, 28-30 April 2006
		ii) Electroceramics- Some applications and Devices	National Conference on Electroceramics, ARDE, Pune, 5th May 2006
		iii) International System of Metrology and its Economic Impact	CII – Seminar on Metrology and Standards, Kolkata, 29th June 2006
		iv) Mutual Recognition Arrangement & Global Trade	NPL course on 17025 and Uncertainity, held at National Physical Laboratory, New Delhi, 26th July 2006
		v) Nanotechnology in India – An Overview	International Conference on Nanotechnology held at Cochin, 18th August 2006
		vi) Organic Electronic and Optoelectronic devices	Recent Advances in Electronic Materials, Amity University, NOIDA, 30th August 2006
		vii) Organic Electronics and Nanotechnology	International Symposium on Frontiers of Nanoscale Science, Technology and Education, Jamia Milia University, New Delhi, 19th September 2006
		viii) Organic Electronics and Nanotechnology	De Montfort University, Leicester, UK, 11th October 2006
		ix) NPL India - An Overview	National Physical Laboratory, U.K., 13th October 2006
		x) Photovoltaics – A Perspective	Indo-US workshop on Power & Energy at New Delhi, 14th March 2007
49	Y.P.Singh	i) Calibration of liquid-in-glass thermometers and thermocouples.	Workshop on Temperature Sensors and their Calibration, M/s Tempsens Instruments (I) Pvt. Ltd., Udaipur, 10-11 November 2006
		ii) Evaluation and expression of uncertainty in the calibration of glass thermometers & thermocouples	-do-
		iii) Uncertainty evaluation in thermocouple calibration	TCT meeting of APMP Assembly during 13-14 December 2006

HUMAN RESOURCE

As on March 31, 2007

GROUP IV		
Director		1
Scientist G		9
Scientist F		88
Scientist EII		43
Scientist EI		16
Scientist C		33
Scientist B		22
	Sub-Total	**212**
GROUP III		
TO (EII)		1
TO (EI)		16
Exe. Engg.		2
Assist. Exe. Engg.		1
TO (C)		40
TO (B)		18
TO (A)		5
STA		10
Junior Engg.		2
Tech. Asst. VIII		22
	Sub-Total	**117**
GROUP II		
	Sub-Total	**210**
GROUP I		
	Sub-Total	**72**
ADMN-A		9
ADMN-B		89
ADMN-C		44
ADMN-C (Cafeteria Staff)		11
ADMN-D		104
ADMN-D (Cafeteria Staff)		11
	Sub-Total	**268**
	GRAND TOTAL	**879**



SCIENTISTS AND OFFICERS AS ON 31.03.2007

Director

Dr Vikram Kumar

Scientists and Officers as on 31.03.2007

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 Ashok Kumar	Scientist F
Dr Ashis Kumar Bandhyopadhyay	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
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 (Ms) Rina Sharma	Scientist EI
Sh D Arun Vijayakumar	Scientist EI
Dr Sanjay Yadav	Scientist EI
Dr (Ms) Nita Dilawar	Scientist EI
Dr S Seela Kumar Titus	Scientist C
Sh Rajesh Kumar	Scientist C
Sh Gautam Mandal	Scientist B
Sh Naveen Garg	Scientist B
Ms Sumitra Singh	Scientist B
Sh Gopan C K	Scientist B
Dr Parag Sharma	Scientist B
Sh Harish Kumar	Scientist B
Sh Virendra Babu	Tech Ofcr (EII)
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 Gurbir Singh	Tech Ofcr (EI)
Mrs Reeta Gupta	Tech Ofcr (C)
Sh T K Parameshwaran	Tech Ofcr (C)
Sh Gurcharanjit Singh	Tech Ofcr (C)
Sh V K Ojha	Tech Ofcr (C)
Dr Yudhisther Kumar Yadav	Tech Ofcr (C)
Sh Ishwar Singh Taak	Tech Ofcr (C)
Sh Gurdeep Singh Lamba	Tech Ofcr (B)
Sh Bhikham Singh	Tech Ofcr (B)
Sh Mukesh Kumar	Tech Ofcr (B)

Sh K N Basavaraju	Tech Ofcr (B)
Sh Sudama	Tech Ofcr (B)
Sh Mahargha Baran Das	Tech Ofcr (A)
Sh Bharat Kumar Yadav	Tech Ofcr (A)
Sh Harish Kumar	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 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 T Raghvendra	Scientist F
Sh Anil Kishore Saxena	Scientist F
Dr R K Kotnala	Scientist F
Sh Ritander Aggarwal	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 Kavindra Pant	Scientist EII
Sh M P Singh	Scientist EII
Sh H R Singh	Scientist EII
Sh Ajeet Singh	Scientist EI

Sh Joges Chandra Biswas	Scientist EI
Sh Rajbeer Singh	Scientist EI
Dr Hari Krishna Singh	Scientist C
Sh Shiv Kumar Jaiswal	Scientist C
Ms Manju Singh	Scientist C
Dr Ashish Agarwal	Scientist C
Dr Aloysius R P	Scientist C
Sh Saood Ahmed	Scientist C
Sh Chockalingam Sreekumar	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 (C)
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 Ashok Manikrao Biradar	Scientist F
Dr Suresh Chand	Scientist F
Dr (Ms)Vasantha Raman	Scientist F
Dr Tarsem Lal Dhami	Scientist F
Dr Bansi Dhar Malhotra	Scientist F
Sh Ramesh Chandra Anandani	Scientist F

Dr Sunil Kumar Singhal	Scientist F
Dr Harish Bahadur	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
Dr R K Sharma	Scientist EII
Sh Sudhanshu Dwivedi	Scientist EII
Sh Sanjay Rangnate Dhakate	Scientist EI
Dr(Ms) Ritu Srivastava	Scientist C
Sh Vipin Jain	Scientist C
Dr Surendra Pal Singh	Scientist C
Dr (Ms) G Sumana Gajala	Scientist C
Sh Ashok Kumar	Scientist B
Dr R G Mathur	Scientist B
Sh. Bhanu Pratap Singh	Scientist B
Sh Pankaj Kumar	Scientist B
Sh Bathula Sivaiah	Scientist B
Sh M Sarvanan	Scientist B
Sh Rajiv Sikand	Tech Ofcr (EI)
Sh Gauri Datt Sharma	Tech Ofcr (C)
Sh Pinaki Ranjan Sengupta	Tech Ofcr (C)
Sh Rakesh Khanna	Tech Ofcr (C)
Sh Chander Kant	Tech Ofcr (C)
Sh Jokhan Ram	Tech Ofcr (B)
Sh J P Singh	Tech Ofcr (B)
Sh Rajesh Kumar Seth	Tech Ofcr (B)

Electronic Materials
Head: Dr Shiv Nath Singh

Dr Shiv Nath Singh	Scientist F
Dr Amitabha Basu	Scientist F
Dr Virendra Shanker	Scientist F
Dr S T Lakshmikumar	Scientist F
Dr Mohan Lal	Scientist F
Dr Harish Chander	Scientist F
Dr Prakash Narain Dixit	Scientist F
Dr Ramadhar Singh	Scientist F
Dr Bidhan Chandra Chakravarty	Scientist F
Dr Parakram Kumar Singh	Scientist F
Dr Omvir Singh Panwar	Scientist F
Dr S M Shivaprasad	Scientist F
Dr Sher Singh Rajput	Scientist F
Dr (Ms) Meenakshi Kar	Scientist EII
Dr (Ms) Kiran Jain	Scientist EII
Dr (Ms) Santa Chawla	Scientist EII
Sh C M S Rauthan	Scientist EII
Dr KMK Srivatsa	Scientist EII
Dr Abdul Mobin	Scientist EII
Dr Narinder Kumar Arora	Scientist EI
Mrs Santosh Singh	Scientist C
Dr T D Senguttuvan	Scientist C
Dr Shailesh Narayan Sharma	Scientist C
Dr Amish G Joshi	Scientist C
Dr(Ms) Gurusharan Kaur Padam	Scientist C
Dr Sushil Kumar	Scientist C
Dr Divi Haranath	Scientist C
Dr Govind	Scientist C
Dr(Ms)M Deepa	Scientist C

Sh Mahesh Kumar	Scientist B
Sh Sanjay Kumar Srivastava	Scientist B
Sh Ravi Kumar	Tech Ofcr (EI)
Sh M K Banerjee	Tech Ofcr (EI)
Sh Tarun Kumar Chakraborty	Tech Ofcr (EI)
Sh Mukul Sharma	Tech Ofcr (C)
Sh T K Bhattacharya	Tech Ofcr (C)
Dr V K Hans	Tech Ofcr (C)
Sh Murari Lal Sharma	Tech Ofcr (C)
Sh Vipin Kumar Singhal	Tech Ofcr (B)
Sh Om Prakash	Tech Ofcr (B)
Sh Jagdish Chand	Tech Ofcr (B)
Sh Amar Singh	Tech Ofcr (A)

Materials Characterization
Head: Dr S K Gupta

Dr S K Gupta	Scientist F
Dr Bibhash Ranjan Chakraborty	Scientist F
Dr Sujit Kumar Halder	Scientist F
Dr Godavarthi Bhagavannarayana	Scientist F
Dr Arun Kumar Agrawal	Scientist F
Dr Ram Kishore	Scientist F
Sh Prabhat Kumar Gupta	Scientist F
Dr (Ms) Rashmi	Scientist F
Dr Devinder Gupta	Scientist EII
Dr Rajendra Prasad Pant	Scientist EII
Sh Sukhvir Singh	Scientist EI
Dr Avanish K Srivastava	Scientist EI
Dr Kamlesh Kumar Maurya	Scientist C
Dr(Mrs) Prabha Johri	Scientist C

Dr Nirmalya Karar	Scientist C
Dr Nahar Singh	Scientist B
Sh.Parveen Saini	Scientist B
Sh N Vijayan	Scientist B
Dr Sushree Swarupa Tripathy	Scientist B
Dr (Ms) Daya Soni	Scientist B
Sh Niranjan Singh	Tech Ofcr (EI)
Sh Kedar Nath Sood	Tech Ofcr (C)
Dr (Ms) Manju Arora	Tech Ofcr (C)
Dr Dharam Pal Singh	Tech Ofcr (C)
Sh Rajiv Kumar Saxena	Tech Ofcr (C)
Mrs Abha Bhatnagar	Tech Ofcr (B)

Radio & Atmospheric Sciences
Head: Dr M K Tiwari

Dr M K Tiwari	Scientist F
Dr P K Banerjee	Scientist F
Dr Swapan Kumar Sarkar	Scientist F
Dr Pradeep Kumar Pasricha	Scientist F
Dr P N Vijayakumar	Scientist F
Dr Raj Singh Dabas	Scientist F
Dr Mahendra Kumar Goel	Scientist F
Dr S D Sharma	Scientist F
Dr Bhuwan Chandra Arya	Scientist F
Dr M S V N Prasad	Scientist F
Sh Pattamatta Subrahmanyam	Scientist F
Ms Madhu Bahl	Scientist F
Dr Mahendra Mohan	Scientist F
Dr Radhe Shyam Arora	Scientist F
Sh Narendra Kumar Sethi	Scientist F
Sh H K Maini	Scientist F
Sh Thomas John	Scientist F

Dr Vijay Kumar Pandey	Scientist F
Sh Deo Raj Nakra	Scientist F
Ms Parvati Chopra	Scientist EII
Dr (Ms) Meena Jain	Scientist EII
Sh Randhir Singh Tanwar	Scientist EI
Ms Anuradha Sengar	Scientist EI
Dr Tuhin Mandal	Scientist C
Dr Sachidanand Singh	Scientist C
Dr Y Nazeer Ahammed	Scientist C
Sh K G M Pillai	Tech Ofcr (EI)
Sh Iqbal Ahmed	Tech Ofcr (EI)
Sh Vishram Sing Yadav	Tech Ofcr (C)
Ms Shiv Kumari Bhatia	Tech Ofcr (C)
Sh Arun Kumar Ghoghar	Tech Ofcr (C)
Sh Dhan Singh Chaunal	Tech Ofcr (C)
Sh Shambhu Nath	Tech Ofcr (C)
Ms Beena Gupta	Tech Ofcr (C)
Sh Man Mohan Gupta	Tech Ofcr (C)
Sh Ramesh Kohli	Tech Ofcr (B)
Ms K Ratnamala	Tech Ofcr (B)

Superconductivity & Cryogenics
Head: Dr Hari Kishan

Dr Hari Kishan	Scientist F
Dr Ratan Lal	Scientist EII
Dr S K Agarwal	Scientist EII
Dr (Ms) P L Upadhyay	Scientist EII
Sh Man Mohan Krishna	Scientist C
Dr Anurag Gupta	Scientist C
Sh M A Ansari	Scientist C

Dr Veerpal Singh Awana	Scientist C
Sh S B Samanta	Tech Ofcr (EI)

Director's Office
Head: Dr Vikram Kumar

Dr Vikram Kumar	Director
Dr V T Chitnis	Scientist G
Sh Ganga Prasad	Scientist EII
Mrs Indra Tiwari	Scientist EII
Dr D P Bhatt	Scientist EII
Dr Mrs S Niranjana N Goswami	Scientist EII
Sh S K Rastogi	Tech Ofcr (C)
Sh Jagan Nath Prasad	Tech Ofcr (C)
Sh Lalit Jain	Tech Ofcr (C)
Mrs Shashi Lekha Bhatnagar	Tech Ofcr (B)

Library
Head: Sh Deepak Kumar Tewari

Sh Deepak Kumar Tewari	Scientist EII
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)

Scientific Support Services

Dr R K Aggarwal	Scientist F
Sh Rajan Babu Saxena	Scientist F
Sh Narinder Kumar Babbar	Scientist F
Mrs Shikha Mandal	Scientist EII

Sh P L Pashricha	Scientist EII
Dr (Ms) Jyoti Lata Pandey	Scientist EII
Sh Tushar Kanti Chakravarty	Scientist EII
Sh Sushil Kumar Sharma	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 (C)

Technical Support Services
Head: Dr Jagdish Chandra Sharma

Dr Jagdish Chandra Sharma	Scientist F
Sh Dharam jit Singh	Exe. Engnr.(Civil)
Sh I P Singh	Exe. Engg.
Sh Deepak Bansal	Tech Ofcr (C)
Sh Prabhu Shankar Tripathi	Tech Ofcr (C)
Sh J B Soni	Tech Ofcr (C)
Mr G Singh	Tech Ofcr (C)
Sh Mohan Chandra Singh	Tech Ofcr (C)
Sh Anuj Gaur	Astt. Exe. Engg.

Workshop & GTU
Head: Sh Surendra Singh Verma

Sh Surendra Singh Verma	Scientist F
Sh Srinivasan P	Scientist C

Central Computer Facility
Head: Dr Ravi Mehrotra

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

Administration & House Keeping

Sh R P Sharma	COA
Sh S K Mehta	F&A O
Sh Sudipto Chaterjee	F&AO
Sh Prem Singh	SPO
Sh Mukesh Khanna	SPO
Dr (Ms) Shakuntala Sharma	Sr Hindi Officer
Sh Dhirender Kumar	Admn. Ofcr
Sh Lakhpat Singh	Sr Security Ofcr
Sh Vijay Kumar	Sr Security Ofcr
Sh Kuldeep Kaushik	S O (str & pur)
Sh Surendra Kumar	S O (str & pur)
Sh Bhag Singh	S O (str & pur)
Sh Naveen Pavithran	S O (str & pur)
Sh Sukhbir Singh	Security Ofcr
Sh Mange Ram	PS
Mrs Paramjit Kaur	PS
Sh Indrajeet	PS
Sh S K Thakur	SO (F&A)
Sh Gyan Chand	SO (F&A)
Sh Upendra Kumar	SO (F&A)
Sh D K Salone	SO(G)
Ms Veena Anupa Kullu	SO(G)
Sh Umesh Gupta	SO(G)
Sh Balraj Singh	SO(G)

Retired Persons

Sh G K Kapoor, Tech Ofcr (B)	Sh S K Chakladar, Sci F
Sh Kishanji, Sr Mech Asstt	Sh Dan Singh, Safaiwala
Sh Duli Chand, Jr Sec Grd	Dr Kanwar Sushil Zalpuri, Sci F
Sh Rajinder Singh, Security Asstt Gr I	Sh Hukam Singh, SO(G)
Dr Surender Kumar Mahajan, Sci F	Dr Chhatra Pal Sharma, Sci F

Sh B K Roy, Tech Ofcr (EI)

Sh J D Batra, SO(Str&Pur)

Sh Mati Lal Das, Sci F

Dr Sohan Lal Jain, Sci F

Sh Umesh Chandra Upreti, Sci EII

Sh C S Prasannakumar, Sci G

Sh Rama Shankar Singh, Tch Ofcr (EI)

Sh R K Bhasin, PS

Dr Srikant N Ekbote, Sci F

Sh Sunder Lal, GrII(4)

Sh Ram Vinod Singh, Sr Mech Asstt

Sh Kasturi Lal, Sci EII

Sh Chaman Singh Tyagi, Sr Mech Asstt

Sh Ram Singh Yadav, Asst(G) Grade II

Sh Davinder Singh Basra, Gr II(4)

Sh S L Thind, Tech Ofcr (EI)

Sh A K Minocha, Gr II(4)

Sh Gusain Singh, Gr II(4)

Sh Krishan Lal, Gr II(4)

Sh Dhani Ram, Record Keeper

Sh R K Sodhi, Gr II(4)

Dr Risal Singh, Sci EII

Sh Sri Bhagwan, w/s Asst.VII

Sh Dal Chand, w/s Asstt. VII

Sh Pratim K Dutta, Sci EII

Sh Same Singh, Sr. Mech Asstt

Dr Hirday Nath Dutta, Sci F

Dr Bhanu Pratap Singh, Sci F

Sh P R Bhatia, Sr Mech Asstt

Sh V D Singh Gr II(4)

Obituaries

Sh Man Mohan Lal Arora, Sr Steno (ACP)

Sh Ram Lalit, Safaiwala

Sh Ram Subhawan, Bearer(ACP)

Sh Ramesh Kumar, Safaiwala

Scientist Fellow & Emeritus Scientists

Dr A P Mitra, Hony. Scientist

Dr A R Varma, INSA Hony Scientist

Dr K K Mahajan, INSA Sr Scientist

Dr Krishan Lal, INSA Sr Scientist

Dr A V Narlikar, Emeritus Scientist

Dr Ashok Kumar Gupta, Emeritus Scientist

Dr B S Mathur, Emeritus Scientist

Dr O P Bahl, Emeritus Scientist

Dr P K Ghosh, Emeritus Scientist

Dr U N Sinha, Emeritus Scientist

Dr Subhash Chandra, Emeritus Scientist

Sh S C Garg, Emeritus Scientist

Dr R Bhattachryya, Emeritus Scientist

Dr S L Jain, Emeritus Scientist

Dr Lakha Singh, Emeritus Scientist

Dr Vikram Soni, Research Scientist

Dr Marshal, Scientist Fellow

Dr Ashutosh Tiwari, Young Scientist

Dr Raju Khan, Young Scientist

Research Fellows / Associates / Interns

Sh Praveen Kumar Singh, JRF (CSIR)

Sh Gautam Singh, JRF(CSIR-UGC)

Sh Feroz Khan, JRF (CSIR-UGC)

Zimole Matharu, JRF (CSIR-UGC)

Sh Ravi Kant Prashad, JRF (CSIR-UGC)

Ms Arpita Vajpayee, JRF (CSIR-UGC)

Sh Vivek Kumar Varma, JRF (CSIR-UGC)

Sh Anil Ohlan, (CSIR-UGC)

Ms Hema Bhandari, JRF (CSIR-UGC)

Sh Praveen Kumar, JRF (CSSIR-UGC)

Sh Manoj Kesaria, JRF (CSIR)

Ms Priyanka, JRF, PhD

Dr Shilaja Pande, P.I.

Dr Kanchan Saxena, P.I.

Dr Suman Anand, P.I.

Ms Km P Jemima, RA

Sh Ravinder Singh Parmar, RA

Sh Prem vir Singh, RA

Sh Sunil Dutta Sharma, RA

Dr Mitali Shah, RA

Sh Anand Kumar Dwivedi, RA

Dr Sippy Calra Chauhan, RA

Dr Umendra Kumar, RA

Ms Punita Singh, RA

Dr Anil Kumar, RA

Ms Amita Verma, RA

Dr S P Singh, RA

Ms Vibha Srivastava, RA

Sh Raj Kishore Sharma, RA

Dr Ashok Kumar, RA

Sh Dinesh Kumar, JRF (CSIR-UGC)

Ms Chetna Dhand, JRF (CSIR-UGC)

Sh Umesh kumar, JRF (CSIR-UGC)

Sh Nitin Kumar, JRF (CSIR-UGC)

Sh Bikash Ghosal, JRF (GATE)

Sh Veerendra Kumar Sharma, JRF (CSIR)

Sh Rajesh Kumar, JRF (CSIR)

Sh Vibhav Pandey, JRF (CSIR)

Sh Amit Singh, JRF (CSIR)

Km. Rachna Gupta, JRF (CSIR)

Ms Jyoti Shah, Res. Intern

Ms Suman, Res. Intern

Sh Jitendra Kumar, Res. Intern

Ms Neha Goel, Res. Intern

Sh Ashok Kumar, Res. Intern

Ms K Jayanthi, Res. Intern

Ms Kavita Varshany, Res. Intern

Ms Pallavi Pukhar, Res. Intern

Ms Archna Mishra, Res. Intern

Ms. Taranuum Bano, Res. Intern

Ms Neha Gera, Res. Intern

Sh Prashant Gautam, Res. Intern

Sh Abhishek Bhattacharya, Res. Intern

Mohd. Imran Ansari, Res. Intern

Ms Manisha, Res. Intern

Ms Ritu Vishnoi, Res. Intern

Dr Sushri Pratima, Sr. Res. Assoc.

Sh Ravinder Pratap Singh , Sr. Sr. Assoc.

Dr Manoj Kumar Srivastava, Sr. Res. Assoc.

Sh Amit, SRF

Ms Gayatri Chauhan, Res. Intern	Ms Shampa Das, SRF
Ms Anita Rani, Res. Intern	Sh Ajay Kumar Gupta, SRF
Sh Jai Govind Varma, Res. Intern	Sh Sanjay Kumar, SRF
Ms Lakshmi Manral, Res. Intern	Sh Rajeev Kumar Singh, SRF
Ms Nidhi Gupta, Res. Intern	Ms Amita Varma, SRF
Sh Satya Kumar Kushwaha, Res. Intern	Sh Neeraj Panwar, SRF
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Sh Arif Faiz Khan, Res. Intern	Sh R Nagrajan, SRF
Sh Shailesh Kumar, Res. Intern	Sh P Tyagrajan, SRF
Ms Sarabjeet Kaur, SRF(CSIR)	Sh Sunil Kumar Arya, SRF(CSIR)
Ms Vandana Gupta, SRF(CSIR)	Sh Shivraj Sahay, SRF(CSIR)
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Ms Kavita Arora, SRF(CSIR)	Ms Shalini Singh, SRF(CSIR)
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Sh Jitendra Kumar, SRF (CSIR)	Sh Shahzada Ahmad, SRF (CSIR)
Sh Prafull Mathur, SRF(CSIR)	Ms Kavita Sharma, SRF (CSIR)
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(01.04.2006 - 31.03.2007)

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05	Dr M J Zarabi SAMTEL Colour Ltd., Village Chhapraula, Bulandshahar Road, GHAZIABAD 201 009 (UP) Residence Address C–28, Pamposh Enclave, NEW DELHI - 110 048	...	...	Member
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12.	Dr Vikram Kumar Director, National Physical Laboratory, Dr K S Krishnan Marg, NEW DELHI - 110 012	...	...	Member
13.	Sh R B Saxena Scientist 'F' & Head, PME, National Physical Laboratory, Dr K S Krishnan Marg, NEW DELHI - 110 012	...	...	Non-Member Secretary

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(01.04.2006 - 31.03.2007)

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03.	Dr Hari Kishan, Scientist Gr IV(5)	...	...	Member
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09.	Sr F&AO(SG)/Sr F&AO/F&AO	...	...	Member
10.	Sr Controller of Administration/ COA/AO	...	...	Member Secretary

Notes

Notes

Important nearby landmark

- **Sidharth Hotel**
- **Pusa Campus**

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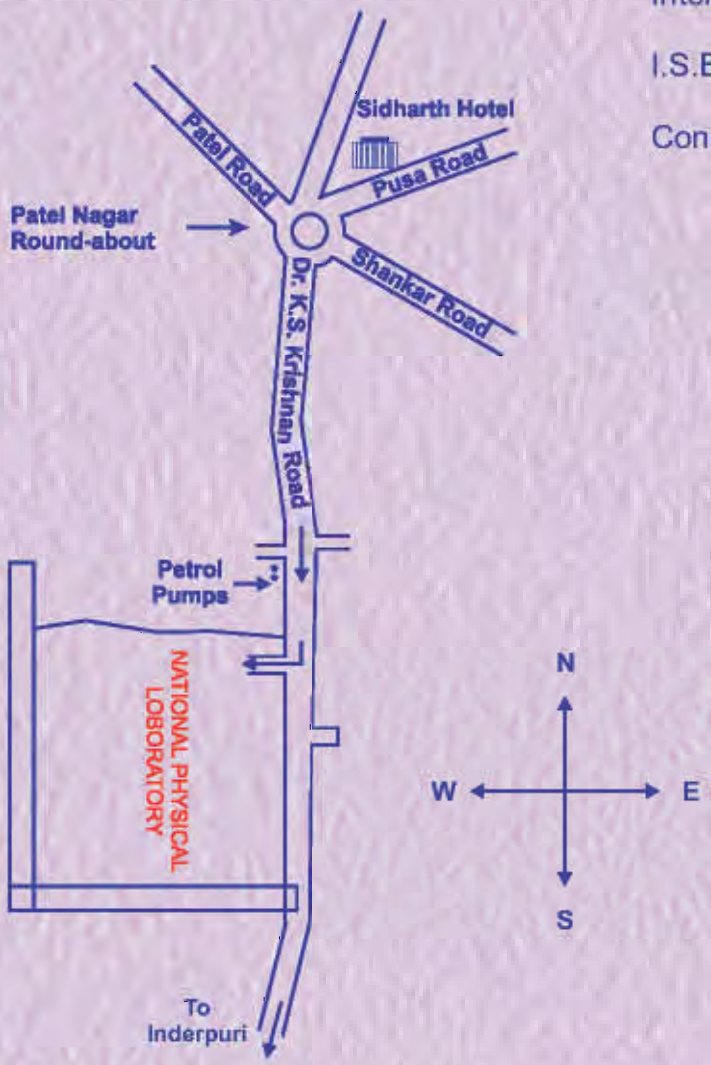
New Delhi Railway Station	:	06 km
Delhi Railway Station	:	09 km
Indira Gandhi International Airport	:	
Domestic (Terminal)	:	11 km
International (Terminal)	:	19 km
I.S.B.T.	:	08 km
Connaught Place	:	05 km



Director :

Dr. Vikram Kumar

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Monday to Friday

Working Hours :

9.00 a.m. to 5.30 p.m.

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