वार्षिक प्रतिवेदन

Annual Report

1992-93

NPL

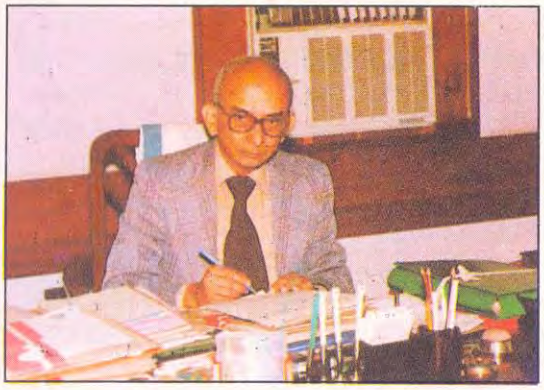
राष्ट्रीय भौतिक प्रयोगशाला

National Physical Laboratory

NEW DELHI

CONTENTS

Director's Report



The annual report for the year 1992-93 is in your hands which gives an account of the overall status of the work of the laboratory during this year. We feel pleasure in presenting through this report the achievements and progress made by the NPL in R&D and other activities inspite of the financial constraints all of us are experiencing.

In addition to the normal calibration work in the area of standards, improvements were made in the measurement systems as well as techniques. For example, the servo control system of 633 nm iodine stabilised He-Ne lasers was improved. Calibration of electronic weighing systems was fully streamlined. In the field of force measurements the I MN hydraulic multiplication machine was put to use. The melting point of gallium as a pre-requisite of ITS - 90 was established. Similarly, photometric and radio metric calibration activities were also upgraded. In the electrical measurements area a new HF and MW coaxial micro calorimeter system was set up. The standard time and frequency service broadcast was continued without any interruption. Research and development work in the field of materials development was continued which included the work on silicon devices, interface microstructure devices, luminescent materials, display devices, biomolecular electronic & conducting polymers, carbon products, thin film systems and metals and alloys. In collaboration with CEL, an improved process was developed for the fabrication of single silicon solar cells. A project on an electroluminescent back lighting panel for LCD was initiated. A new type of thermo-optic switch using polymer dispersed liquid crystals has been fabricated.

Studies on electrical transport properties of electro-active polymers have led to several exciting publications. Sol-gel processed oxide materials have been developed and their optical, dielectric and ferroelectric properties have been critically investigated. The work on characterisation of different kinds of materials was continued. This is an important activity since the characterization of materials plays a major role in evaluating, their usefulness in scientific and technological applications. Various techniques have been applied for this purpose in NPL for evaluating composition, purity, structure and perfection in organometallic compounds, carbon fibres and electronic materials. Techniques, including chemical methods, FTIR spectroscopy, EPR spectroscopy, X-ray diffraction techniques and electron microscopy etc., were used. Different kinds of crystals were grown and studied for their characteristics. Also, preparation of Indian Reference Materials was continued and work on samples of certified reference materials received from China for International comparision was completed. Radio Science is yet another major field in which the laboratory continued the work. The activities in this area include International Geosphere Biosphere Programme, Photo-chemical modelling, Indian Antarctic Research Programme and Radio communications. The Associate Regional Warning Centre (ARWC, New Delhi) was upgraded to the status of Regional warning Centre. An aeronomy experiment was also conducted in space, in the form of the RPA study payload of the ASLV-D3 satellite. This unique experiment was successfully performed in May 1992.

NPL continued R & D work in low temperature physics too. Both basic and applied research work was carried out in this field. Super conductivity has been an integral constituent of this area. The Scanning Tunnelling Microscopy technique was effectively used to study C_{60} fullerene samples. A project on superconducting High Gradient Magnet Separator was successfully completed. DST funded a project on special refrigerators for preservation of vaccines.

NPL maintained active collaboration with R&D organisations, scientific laboratories and educational institutions for exchange of scientific and technical knowledge. These include public sector, governmental and other national and international organisations. Several Projects were taken up during the year under sponsorship from DOD, DST, ONGC, DNES, IRDE, DOE, DRDO and ARD etc.

A number of Processes were released to industry for commercial exploitation, including STFS decoders, aviation grade brushes and liquid nitrogen containers etc.

In the academic field, six candidates were awarded Ph.D for their work done in NPL. Over a dozen training programmes were organised for trainees from various sectors. NPL scientists published over one hundred and forty papers and ten research reports in leading national and international journals.

Several distinguished personalities from scientific community delivered lectures at NPL. This year the prestigious Krishnan Memorial Lecture was delivered by Prof. D. Kind, President of PTB Germany, on 12th February, 1993 on the topic entitled "Current Trends towards National and International Metrology Systems.:

I find here an opportunity to congratulate a number of our Scientists for their outstanding work in science for which they have been honoured. Dr. A.V. Narlikar and Dr. K.K.Mahajan were elected Fellows of the Indian National Science Academy, New Delhi. Dr. V.N. Ojha and Dr. S.M.Shiva Prasad won the CSIR young Scientist Awards and Dr. S.K. Sharma was nominated as a member of the committee of Asia Pacific Society of Electron Microscopy. I myself was elected president of the Indian Society of mass spectrometry, delivered the Lord Memorial Lecture (IACS) and the B.N. Singh Memorial Lecture (Delhi University). I was also elected a fellow of the National Academy of Sciences of India.

The year as a whole was successful which has encouraged us. We have learnt from our weaknesses to over-come them successfully. The work of maximising the utilization of our existing resources was continued. The process of redeployment of scientists and technical staff was in progress so that they could be given an opportunity to serve the laboratory and hence the nation to their utmost ability. We have an encouraging past, a fruitful present and a hopeful future.

E S R Gopal

(E.S.R. Gopal)

PHYSICO MECHANICAL STANDARDS

LENGTH & DIMENSIONS

1. LENGTH

Improvements were made in the electronic servo-control system of 633nm iodine stabilised He Ne lasers, resulting in increasing the overall reliability. Using this, as a primary standard of length, a few lasers were calibrated. A portable unit of a Zeeman split stabilized laser, made at NPL, was used on a microintegrated circuit fabrication unit. An experimental facility was developed to determine with high precision, the reflectivity, transmission and scattering losses of laser mirrors.

The DOE sponsored project, on development of a mask aligner was completed. A software was developed and the x, y alignment accuracies of the order of $\pm$ 0.06 μm were attained.

The laser interferometric technique was used to calibrate a standard metre bar at Govt. of India Mint Bombay. Testing and calibration of optical components and instruments for length measuring m/Cs, was carried out.

2. DIMENSIONAL METROLOGY

With the establishment of the facility for three coordinate measurement, NPL can carry out inspection of such machines in the country. The surface roughness measurements were evaluated. The calibration of precision measuring equipment was done for the industry at Pune, Madras and Jamshedpur.

MASS

Calibration of electronic weighing systems was fully streamlined. The calibration work of reference standard weights, from various state organisations, was continued in addition to routine calibration work. One prototype of 1 kg. from Saudi Arabia was calibrated.

Regarding solid density stdd., the existing bath and suspension system was modified.

The preliminary work of fabricating the components of the system is in progress. Viscosity scale up to 1,000 was set up. The regular calibration work of hydrometers, viscometers, measures and oilmeters etc. was carried out.

FORCE

The 1 MN hydraulic multiplication machine was put to use. Various standard, machines were maintained and verified. The calibration of force measuring devices was done for the industry.

PRESSURE & VACUUM

1. PRESSURE

Mercury fixed point around 0°C, using volumetric method was established. The fabrication of the high pressure cell along with the pressure calibration of the strain gauge transducer was carried out. The estimation of the uncertainty of the measured equilibrium pressures inside the cell were also obtained. The average values for the melting pressure of mercury at 0.002° C was 756.93 $\pm$ 0.25 MPa, agreeing well with the reported value.

For the measurement of pressure upto I MPa and above, a variety of techniques were used to ascertain the uncertainty. The area ratio of dimensional measurement using two large diameter gauges, compared with the ratio obtained using manometer and agreed within I ppm. An investigation was performed on a modified piston gauge using the same piston/cylinder operated in

either the controlled clearance, simple or reentrant modes. This helped to determine the degree of degradation in the accuracy of measured pressure. Efforts were also made to design and fabricate a dead weight tester upto a full scale pressure of 600 kg/cm^2.

2. VACUUM

The study of the line pressure effects on the zero stability of a differential quartz bourdon gauge, for various gases, was done.

The magnitude of the zero shift was found to be directly proportional to the change in the line pressure for all the gases under different experimental conditions. The results concluded that the gauges behaved in different ways with different gases.

A vacuum system for the determination of low leak rates was set up under the INDO-US project. It was shown that the leak rate of helium permeation varied linearly over the range of 1×10^{-12} to 9×10^{-12} mol/s. For the purpose of automatic data acquisition, a computer programme was written.

3. SURFACE PHYSICS

Electron energy loss spectroscopy (EELS) and Auger electron spectorscopy (AES) were used to study the electron impact autoionization process in $Ta_2 O_5$ and $Ta Si_2$. The role of electrons in Ta during chemical bonding with oxygen and silicon was observed. It was demonstrated that such studies could be used to probe near-Fermi level features like the d-band occupancy of transition metals. The Si LVV Auger lineshapes of single crystal Si (1,000) surface, oxygen chemisorbed and clean $Ta Si_2$ surface were studied, observing the three Auger transitions having different final states in the valence band.

TEMPERATURE

The melting point of gallium, as pre-requisite for ITS-90 was established. Triple point of water cell, using antarctic water, as reference fixed point on ITS, was made and established. One Standard platinum resistance thermometer was repaired and calibrated for M/s BHEL, Madras. Resistance temperature detectors were calibrated for the industry.

OPTICAL RADIATION

The photometric and radiometric calibration activities were upgraded by installing an-automatic goniophotometer and a spectroradiometer.

The goniophotometer was used for calibration of lamps and for testing of luminaires and the spectroradiometer for calibration of sources and detectors in the visible region. Calibration and testing was done for the industry.

The sponsored project on-retro-reflecting sheetings and tapes, was successfully completed. A report was also sent to the ministry of surface Transport. As an outcome of this work, facilities were set up for measurement of retro-reflective and for optical characterization of glass/plastic beads used for road marking and road signs.

INFRARED RADIATION

The detector and preamplifier parts of infrared line scanner were recalibrated and their infrared transmittance measured and computed. The transmittance and reflectance of germanium, silicon and other samples were measured with varying degree of polarisation of incident radiation in 2.5 to 25 μm spectral region.

ACOUSTICS

Under the S&T programme between India and USSR, NPL standard condenser microphones were calibrated at VNII FTRI, Moscow. The results confirmed the accuracy of 0.2 dB claimed by NPL, Noise and vibration measurements were carried out at two production platforms for ONGC

in Bombay High and the remedial measures, to bring down the noise and vibration levels on boards, were suggested.

Analog circuits in the Sodar system were changed to digital circuits and a suitable software was developed to make the system computer compatible. Steps were taken to add the Doppler facility to the sodar system for taking wind vector data. Sodar systems were set up at Jamshedpur and Mathura refinery for collection of data on air quality materological parameters, sponsored projects through NEERI. The data collected from Nimbahera and Nagothane sites was processed and analysed and reports submitted.

The exact details of the acoustical design of the auditorium at NIO, Goa were worked out in the form of a Technical Report. The accuracy of primary standards of sound pressure and vibration amplitude were maintained through periodic calibration in joint exercises with stdd. Labs. ab road. The evaluation of electro-acoustic equipment and products were undertaken for the industry consultancy services.

ULTRASONICS

Complete acoustic pinger device of 18 kHz was developed. Excitation voltage of 250 V peak to peak was achieved. Hydrophones received from industry were calibrated for the frequency and directional response. The work on the source transducer for seismic physical modelling was carried out. A technique for measurement of sound velocity in liquids at low frequencies was studied. Reference projector and hydrophones for use in pressure tube assembly were fabricated employing neoprene rubber encapsulation. The measurement of dielectric and electro mechanical properties of piezoelectric transducer material was extended to 17000 psi. Investigations on piezoelectric ceramic transducer materials using ultrasonic method were carried out. A new design of ultrasonic motor operating at a frequency of about 14.5 kHz for generating continuous and stepwise angular rotation was developed. An experimental arrangement using a water jet flow has been set up for the generation of hydro dynamic turbulence in the water test tank.

For the displacement measurement of pellicle in water a pellicle was made and its transmission coefficient was measured. For the evaluation of accuracy of ultrasonic velocity measurement by pulse echo method, the velocity has been measured in fused silica sample using ceramic transducer bonded with salol. The mechanical sector scanner transducer of CSIO was characterised for acoustic wave form and other parameters. A number of ultrasonic airborne transducers vibrating in various modes were designed to study the vibration amplitude pattern. A number of therapeutic transducers with varying thicknesses of plates and gaps were tested.

PIEZOELECTRIC CERAMICS

The piezo rubber composite based on 1-3 connectivity pattern was developed. The fabrication of piezoelectric ceramic tubes for seismic modelling transducer was undertaken. A hydrophone using the 03 rubber composite for use in the frequency range 10-100 kHz was developed. The effect of grain size on the conductance characteristics was studied. Preliminary investigations were done on the porous PZT and a hydrophone was made for operation in the frequency range 10-100 kHz.

FLOW MEASUREMENT

The civil work for an underground SUMP tank was completed. A hall of size 30 x 4.5m, above the SUMP tank is near completion. The construction of constant level overhead tank is in progress. Some preliminary work, on setting up the ultrasonic flow-metry facility, has been done.

CALIBRATION SERVICE PROGRAMME

A total number of 82 laboratories covering all sectors were accredited by the year 1992. The year was devoted towards aligning NCTCF Programme to international norms of laboratory accredition. Under the name "National Accreditation Board for Testing and Calibration Laboratories (NABL)".

The Accreditation Programme covered all types of Calibration Laboratories engaged in testing and calibration of measuring instruments used in Standardisation, quality assurance, consumer protection, public safety & utility and R/D activities.

ELECTRICAL STANDARDS

TIME AND FREQUENCY

The Standard time and frequency service (STFS) broadcast was used uninterrupted. Projects were initiated with watch manufacturers to make use of STFS broadcast for direct calibration of their various frequency standards. The decoder know-how was released to one more firm. An active hydrogen maser was designed and developed for use as an ultra stable frequency stdd. in a VLBI experiment. Time synchronisation to the order of submicro second between cesium clocks of NPL and Sikandrabad Earth Station could be achieved through common view mode of TV technique via INSAT-TV network. The study of telling the effect of selective availability on GPS timing was initiated. In the RB stdd. project, success was achieved in terms of filling of RB 85 filter cell, which was working satisfactorily. The work was under progress for improving upon the cleanliness of the vacuum system and filling up Rb 87 bulbs and absorption cells.

DC STANDARD

The stdds. of D.C. voltage and resistance were maintained in the form of a bank of stdd. cells and resistances. Measurements of DC voltage was extended upto 10 KV using a precision high voltage divider. The calibration of equipment including precision calibrators, stdd. cells, potentiometer, multimeter upto 7½ digits was continued.

JOSEPHSON VOLTAGE

The existing Josephson Voltage Standard at 1 mV level was being upgraded to IV level. The new standard is based on series array of 2000 thin film Nb/Al2 O3/Nb tunnel junctions fabricated at the PTB, Braunschweig, Germany under collaborative porgramme. Quantized Josephson voltage upto ± 2 volts was obtained when the array was irradiated with microwave radiations of about 73 GHz.

AC, LF & HF IMPEDANCE

Evaluation of William's bridge from 100 to 250 MHz, for precision measurement of HF, was completed. The accuracies ranged from 0.2°C to 2°C. Suitable computer software was developed for using the bridge to measure impedance of different types of terminals. Reference stdds. of inductance from IH to 100μH were reassigned values against the transfer stdd. of capacitance with accuracies of 10 ppm to 100ppm. Facilities were established to determine the effect of magnetic field on the performance of power and energymeters. A facility for 2KV, ac voltage and insulation resistance tests for energymeters was established. A technique for conducting temperature rise test on voltage transformers was established.

HF & MW/VOLTAGE, POWER FREQUENCY AND NOISE

A new HF and MW coaxial microcalorimeter system was set up to calibrate coaxial power sensors in the frequency range of 10 MHz to 18 GHz with an accuracy of ± 0.2%. With this, the facility for directly calibrating the coaxial power sensors was established.

The system, has the provision for both N-type and APC^{-7} type of connectors. The entire calibration is through PC AI and IEEE Bus compatible instruments. The required software was also developed. Measurements taken on a thermistor mount calibrated and supplied by PTB have confirmed an agreement of effective efficiency values assigned by us upto a frequency range of 1000 MHz.

A no. of precision instruments of various research organisations were calibrated.

MW ATTENUATION & IMPEDANCE

Improvements in the laboratory model of 30 MHz WBCO attenuator was carried out. Three stdd. mismatches for K-band microwave frequencies were evaluated by slotted line technique. Calibration of TP-I testers and coaxial attenuators was carried out for Govt. Deptts.

INSTRUMENTATION SYSTEMS

Design and fabrication of a semiconductor micro sensor have been made for particular performance characteristics like sensitivity, linearity, thermal stability etc. A p-type silicon wafer, mounted in four-arm Wheatstone bridge configuration has been developed. The system developed is able to measure pressure in the range of 0 to 500 mm Hg. A digital TCXO (temperature controlled crystal oscillator) was developed for use in time-base of DFC (digital frequency counter) and for frequency measurements echelon III (1×10^{-8}) level. TC X O is also useful in precision portable clocks. A 5½ digit digital Voltmeter (DVM) was designed to be used as a voltage standard at Echelon III level.

Upgradation of electronic circuitry was made for an electronic Ig light intensity meter being now commercially manufactured by M/S Hitech Products, Udyog Vihar, Gurgaon. In order to get higher intensity at a particular zone, focusing systems, were developed to focus the ultrasound beam. Main applications of such transducers are in lithotripsy and tumour surgery etc.

Dielectric and electrical parameters were measured for gall bladder stones collected from various hospitals. This would assist in the design of a disintegrator. Comparative study of normal and fractured bones was made for investigating the acoustic properties at RF frequencies. After standardising of the data, the fracture size and its location can be investigated. An ultrasonic technique, developed, was used to measure adulteration in food materials and even in petrol and diesel.

MATERIALS DEVELOPMENT

SILICON DEVICES

NPL in collaboration with CEL developed improved process of fabrication of single crystal silicon Solar cells to be used in photovoltic modules, a novel back contact which covered the back side of the contact only partially was designed. It does not degrade the I-V characteristics of the Solar cell and its performance. The new design has reduced the consumption of costly Silver - Aluminium paste by about 40% and was used by CEL in production of solar cells.

Thin film diffusion of Bismuth on strontium Calcium Copper Oxide (212) substrate was studied as a function of time & temperature of annealing on Tc. Argon and Nitrogen ion implantation on Bismuth Strontium calcium Copper Oxide (2212) Samples was also studied in collaboration with CEERI (Pilani).

INTERFACE MICROSTRUCTURE DEVICES

Extrinsic dielectric - Si based metal - insulator - semiconductors (MIS) structures have been investigated for the development of high density memory and sensor devices. Y_2O_3 thin film and bilayer Y_2O_3/SiO_2 dielectric structure on silicon were fabricated by a low pressure chemical vapour deposition (LPCVD) and electron beam deposition technique. Non compositional behaviour of SiO_2 in bilayer dielectric and its effect on electronic properties of MIS diodes have been brought out in LPCVD prepared heterostructures. Due to their unique composite dielectric behaviour, these appear very promising for device application.

In an effort to develop commercial level technologies for fabrication of solar grade copper indium selenide (CIS) thin films, electrochemical and Se-vapour phase selenization processes were developed. As the initial step electrochemical selenization technology to foom CuSe, CdSe, and InSe thin film for solar cell application were developed. Extensive studies of the selenization parameters on microstructure, crystalline phases and optical properties have been carried out. Gas phase selenization of vacuum deposited Cu and In thin films employing elemental Se vapour source is demonstrated as an essential first step in the search for optimized process parameters for the formation of single phase CIS material suitable for solar cell applications. Selenization of evaporated Cu and In thin films has shown that hexagonal CuSe and In_2Se_3 are the equilibrium phases to evolve, for reaction temperatures in the range of 340-400°C. New reaction route involving these binary phases have been suggested.

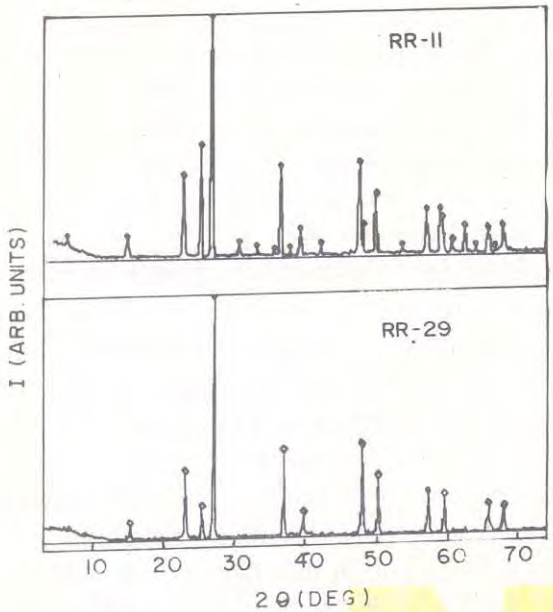
LPCVD technology has been applied to fabricate Co-doped gamma iron oxide and yttrium iron garnet films. Detailed studies of magnetic parameters as a function of fabrication variables have been done.

A unique model based on lateral dispersion of Co into gamma iron oxide film matrix has been proposed and verified by biaxial magnetic measurements to explain high magnetic coercivity values. Direct growth of gamma iron oxide with good magnetic properties without resorting to the conventional reduction-oxidation technology steps have been demonstrated.

LUMINESCENT MATERIALS

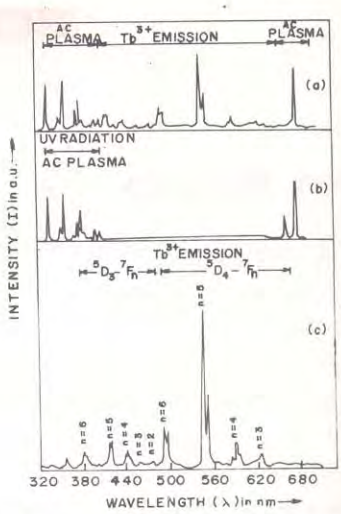
Preparative parameters such as flux ($S+Na_2CO_3$) proportion, temperature and time of firing of the

(Y_2O_3 + Eu_2O_3 + flux) mixture, were optimised and sample of red-emitting Y_2O_2S: Eu phosphor obtained which showed a pure oxysulfide phase under X-ray diffraction. Figure 1 shows powder

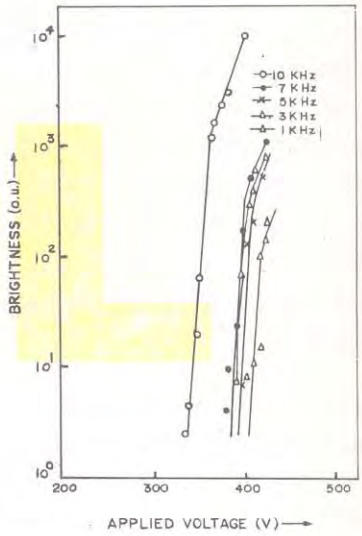


X-ray differactograms of two such samples, RR-11 and RR-29, prepared wtih different flux proportions showing multiple product and pure oxysulfide phase respectively. Particle size measurements were done to optimise the preparative parameters with respect to the desired distribution. Cathodoluminescence spectra and light output were measured on a demountable cathodoluminescence unit. At a fixed coating density, light output of various pure and mixed phase samples varied between 0.27 to 0.52 (arbitrary units) compared to 0.60 of the standard imported sample.

A strong green electroluminescence (EL) in powder layers of Tb doped gadolinium oxysulfide (Gd_2O_2S : Tb) with methyl methocrylate as binder has been achieved with an intensity of the order of 30 Cd/m^2. The EL emission spectra (Fig. 2) shows line emissions corresponding to $^5D_3$ and $^5D_4$ fluorescing levels of Tb^{3+} ions. A very sharply rising B-V curve normally related to insulator-



phosphor interface properties of a thin film EL device has been observed in these cells. (Fig. 3).



This indicates the possibilities of barrier formation due to the localized space charge region in the absence of any prominent interfaces leading to impact excitation of Tb^{3+} ions. This has further been confirmed by the excitation spectrum of Gd_2O_2S : Tb phosphor which reveals Tb^{3+} impurity absorption bands related to $4f^8$ shell transitions.

An extensive analysis of particle size characteristics of ground ammonium per chlorate, one of

the solid rocket propellant chemicals, at the site of processing in SPROB, SHAR center was conducted at ISRO's request.

A project entitled "Electroluminescent backlighting panel for LCDs" sponsored by "Centre for Liquid Crystal Research" has been initiated in the month of Feb. 93.

DISPLAY DEVICES

A method for symmetric switching of ferroelectric liquid crystal devices :

Surface effects are of great importance in the field of liquid crystals for device applications. The properties of ferro-electric liquid crystals (FLCs) are strongly influenced by surface boundary conditions. Different alignment techniques have been used for aligning the FLC molecules other than the well known technique of polymer rubbed surfaces. Our knowledge on the surface alignment phenomenon is, however, meager mainly due to lack of any reliable method to characterize the substrate - liquid crystal interface. The surface alignment technique is still more adequately used for the device. But the problem with surface is that controlling the suface anchoring energy at both surfaces of the cell is an art rather than a controlled technology. The switching characteristics would be asymmetric if the anchoring energy at both the surfaces is unidentical. Recently we have developed a method to obtain symmetric switching characteristics by applying an appropriate bias field to the FLC samples even though the difference between the anchoring energy on two surfaces is quite large. The temperature dependence of anchoring strength is also studied in the smectic C* phase of FLCS.

Thermo-optic switch based on polymer dispersed liquid crystal composite :

A new type of thermo-optic switch based on polymer dispersed liquid crystal (PDLC) composite has been fabricated. The PDLC composite has been made by dispersing a dual frequency addressable liquid crystal mixture in an isotropic polymer matrix in the form of very fine droplets of micron and submicron sizes. The PDLC cell in the presence of an electric field can be made to switch from transparent to scattering or vice-versa by varying its temperature.

Conduction Mechanism in electroactive Polymers :

The detailed investigation of dc conduction of lightly doped polypyrrole (PPY) films confirms the applicability of variable range hopping (VRH) model where in the multiphonon processes are replaced by the process in which the only contribution to the jump frequency of the polaron is due to the single optical phonon absorption and emission. The conductivity data has been used to extract the coupling constant, the effective polaron mass, the effective dielectric constant, the Debye temperature, the polaron radius, the hopping distance R, the density of states at the Fermi level N (E) and the hopping energy W, whose magnitude confirm the formation of small polaron in polypyrrole. For the first time the existance of low temperature relaxation in lightly doped PPY films has been reported and is attributed to the long range movement of polarons in PPY films.

Thin Films by Sol-gel techniques :

Extensive measurements have been carried out on the structure, optical, dielectric and ferroelectric properties of $SrTiO_3$ and $BaTiO_3$ thin films made by sol-gel process.

Development in Xeroradiography :

Detailed investigations have been carried out towards the development of high X-ray sensitive photoreceptors for dose reduction in Xeroradiography. Significant fundamental investigations have been done to identify precisely the cause of poor X-ray sensitivity in amorphous

selenium. It includes the identification of various parameters governing the X-ray conduction mechanism for example, both the intrinsic and photostructural defect levels for electrons as well as holes, mechanism responsible for the buildup of residual potential in a-Se the effect of suitable dopants on the above parameters, etc. Making use of the above fundamental knowledge we have developed Xeroradiography photoreceptors having enhanced X-ray sensitivity. These new Photoreceptors are undergoing testing for actual radiological applications, dose requirements, etc.

Besides above, some important investigations based on a new concept, were also carried out in XR photoreceptors. The concept being to develop X-ray intensifying-screen based XR photoreceptors much in an analogous configuration to the film-screen combinations being employed currently in the conventional radiology.

BIOMOLECULAR ELECTRONIC & CONDUCTING POLYMERS

DEVELOPMENT OF BIOSENSORS :

Under a DST project undertaken in collaboration with the Centre for Biochemical Technology, Delhi and the Indian Association for the Cultivation of Science, Calcutta, a mediated glucose biosensor based on second generation technology has been developed at NPL. The screen printing technique has been used to fabricate strip type glucose electrodes. The calibration of such enzyme electrodes that are disposable type has been carried out as a function of glucose concentration. The response time, sensitivity range and the shelflife of the strip type glucose electrode has been experimentally determined as 40 seconds, 40 mg/dL to 600 mg/dL and six months, respectively. A large number of samples of serum and blood procured from various hospitals and pathological laboratories have been tested with these strip type glucose electrodes. The necessary electronics for the glucose biosensor has been developed and fabricated.

A third generation glucose biosensor based on physically immobilized glucose oxidase (GOD) in p-toluene sulphonate (PTS) doped polypyrrole films prepared electrochemically, has been fabricated.

Estimation of urea in the given clinical sample is an important parameter in clinical chemistry. A urea biosensor that is at an advanced stage of development consists of the urease membrane, a pH electrode and an electronic circuit. Potentiometric method of detection has been employed. A urease membrane obtained by immobilizing urease in polyvinyl alcohol has been fabricated. Such a membrance can be re-used. The response time, sensitivity range and shelf-life of the urea biosensor have been measured as 10 minutes, 0.1 to 25mM and 3 months, respectively.

CONDUCTING POLYMERS :

An EEC project entitled 'Synthesis, Characterization and Applications of Some Conducting Polymers' has been in operation at NPL since Feb., 1989. Under this programme undertaken in collaboration with the Clarendon Laboratory, University of Oxford, U.K., a number of conducting polymers such as poly (o-toluidine), poly (ethylaniline), Poly-N (phenyl aniline), poly-1-(amino-Benzoic acid) and poly-N) (phenylenevinylene) have been synthesized using chemical technique. The characterization of some of these conducting polymers has been carried out using electrical conductivity, elemental analysis, gel permeation cromatography, uv-visible, FTIR and differential scanning calorimetric (DSC) techniques, respectively. It has been found that poly- (aniline orthoanisidine), a processable conducting copolymer, is thermally stable upto 400°C. A conducting polymeric composite comprising of component

polyaniline embedded in nylon matrix has also been fabricated.

Photoconductivity studies on polyaniline have been initiated. Preliminary results that have been obtained demonstrate the dominance of the bipolaron mechanism in charge transport during the visible light photo-excitation. The bipolaron mobility has been estimated to be 3.5×10^{-5} cm2/V.s using photoconductivity measurements. Photoelectro-chemical experiments carried out on emeralidine salt electrodes point out to the operation of polaron transport mechanism in this interesting conducting polymer.

The deposition and characterization of ordered Langmuir-Blodgett (LB) layers of conducting polymers with a view to utilize these devices, is being investigated. The electrochemical Characteristics of LB films of polyaniline have been systematically studied to probe the variation in morphology in LB films. Various devices such as metal insulator-semiconductor (MIS) structures, liquid State electrochromatic displays using polyaniline etc. have been fabricated.

Metal-insulator-semiconductors (MIS) structures have been fabricted by thermal evaporation of various metals. (In/Sn/Al) onto cadmium stearate Langmuir-Blodgett films deposited on electrochemically deposited semiconducting polypyrrole films.

CARBON PRODUCTS

(A) Carbon Fibres

(i) Development of superior grades of carbon fibres : A project sponsored by Aeronautical Research & Development Board (ARDB) on the development of high strength and high strain to failure carbon fibres was initiated from April, 1992, Extensive studies on the precursor PAN were undertaken to decode its various, physical & thermal characteristics. By applying improved techniques of low temperature thermal stabilization and carbonization, carbon fibres with tensile strength 3.6 GPa, young's Modulus 210 GPa and strain to failure of 1.7% were produced as compaired to the previous test of 2.5 GPa, 200 GPa & 1.3%, respectively.

A three month duration contract project from TIFAC, DST was successfully undertaken to improve the quality of carbon fibres, produced by IPCL Baroda at their imported plant.

Further studies on the modification of precursor PAN to produce low diameter carbon fibres on bench scale were continued and it has been established that the carbon fibre produced from modified PAN precursor show 30% improvement in their tensile strength.

ii) Carbon fibres possessing different morphologies & microstructure were intercalated with bromine in liquid phase & their intercalation & desorption kinetics were followed by varius measurements. An experimental facility for carrying at vapour phase bromine intercalation of carbon fibres has been created. (Indo-French Centre for promotion of Advanced Research).

(B) Carbon-carbon composites

(i) The work on development of laser-resistant carbon fibre composites was continued. Carbon fibre-reinforced FGP Glass composites as well as carbon fibre reinforced Borosil glass composites were evaluated for their damage against CO_2 lasers.

(ii) A new approach was adopted in the development of carboncarbon composites, using PANOX Fibres (Oxidised PAN Fibres) instead of carbon fibres. Carbon-carbon composites developed were having a density of

1.5-1.55 g/c.c, just after one impregnation. The mechanical properties of UD (Uni Directional) carbon- carbon composites developed were Flexural Strength 200-250 MN/M^2 and Flexural Modulus = 100-120 GN/M^2. These properties are comparable with the mechanical properties of UD carbon-carbon composites, developed with carbon fibres.

(iii) Characterisation of Carbon-carbon Brake Pad Materials: Carbon-carbon Brake Pads used in Mirrage-2000 and Dunlop Brake Pads used in Airbus 300 and 320, were characterised for their physical, mechanical and thermal properties as well as microstructure and macrostructure. Dunlop Brake Padhas been developed using mat as the precursor and Mirrage-2000 brake pad has been developed using carbon fibre and the lay up is of rosette type. The degree of graphitization of both the brake pad materials has been assessed.

(iv) High temperature oxidation resistant materials. Sol-Gel technique has been employed to prepare silicon carbide (SIC) using silicon alkoxides and alkylor only substituted alkoxides and different carbon source. The bulk material, prepared was characterised by X-ray, I.R. and SEM studies and was found to be β-silicon carbide.

The possibility of utilising the synthesis of SIC by sol-gel process in preparing the SiC-incorporated C-C, composites, was investigated and it was found that about 20% SiC can be incorporated into the composites by this method.

Silicon oxy carbide was also prepared by sol-gel technique. The silicon oxycarbides prepared from methyl substituted alkoxides were found to be thermally stable and their chemical composition was arrived by physico-Chemical techniques. Efforts are being made to introduce silicon oxycarbide into the c/c composites.

Special Coal tar pitches and speciality carbons: Work was done to develope a process for the production of Quinolene Insolubles (QI)-free impregnating coal tar pitch (import-Substitution product) for a project sponsored by Graphite India Ltd., Bangalore/Calcutta, novel process has been found, which comprises heating a coal tar pitch having QI upto 15% in the presence of suitable aromatic and aliphatic solvents at a suitable temperature to cause the coagulation and consequent precipitation of the QI particles in the pitch-solvents mixture. The precipetated particles are removed by a simple separating device. The QI-free pitch solution is then distilled to recover the solvents and obtain the QI-free impregnating grade coal tar pitches. A patent for this process have been applied for. The know-how will be transferred to the industry shortly.

(C) Graphite-reinforced resin carbon bipolar (separator) plate for the phosphoric acid fuel cell.

Efforts were continued under the DNES - sponsored project to develop the graphite-reinforced phenol-formaldehyde resin carbon based bipolar seperator plate of size 60 mm x 20 mm x 5mm, carbonised to 1000°C.

It has been found that the synthetic graphite gives better characteristics of the carbon plates, compared to the natural graphite.

Work is being carried out to scale up the process to the desired size of 200mm x 100mm x 5mm.

high density high strength isotropic graphite (HD-HS-IG)

(C) R&D work was carried out to develop the HD-HS-IG, an import substitution product, from mesophase spherules with a size of 5-15 μm formed in suitable coal tar pitches by heat-treatment. A detailed study was conducted to see the effects of calcination of these spherules on the characteristics of the final product made therefrom.

The special graphite heat-treated to 2700°C made from such spherules calcined at 300°C, possesses a bulk density of 1.85 g cm^{-3}, bending strength of 700 Kg cms^{-2}, besides a fine and isotropic microstructure.

THIN FILM SYSTEMS

DLC and a-Si:H Coatings & Systems

An improved process of coating large area Ge substrates for enhancing transmission in the 8-12 μm range (AR coating) for application in a strategic area by DRDO was optimised to meet specifications laid down by IRDE (MIL specs).

To apply such coatings, NPL designed RF plasma CVD facility (and largely fabricated by M/s HHV, Bangalore) was put to extensive trials and various problems related to EMI, pressure and flow control, gas delivery etc. were solved. On request from the sponsers a semiconductor laser based optical thickness monitoring facility was developed and integrated to the plant to detect end point. A facility to monitor self bias voltage and control the same has also been provided.

To enhance growth rates of amorphous silicon films by PECVD process a VHF plasma deposition facility (100 MHz) was created with assistance from Nuclear Science Centre, New Delhi.

Optical Coating Design and Device Development

Design and development of UV filters (200-340 nm) were completed. The design details of multicavity narrow band (HbW≤2%) interference filters covering a broad spectral region (400nm to 12000nm) were worked out.

HIGH PRESSURE TECHNOLOGY

Single crystals of cubic boron nitride are synthesized in the laboratory by subjecting its hexagonal form to high pressures and temperatures either directly or with the aid of some catalyst solvent materials. So far the direct hBN -cBN phase transformation required very high pressures (P>115 kb) and temperatures (T>2000°C). Recently it has been investigated that with the use of hexagonal boron nitride of lower three dimensional ordering it is possible to reduce the above mentioned pressures to about 68 kb and temperatures to 1800°C to grow cBN crystals. However, this type of starting material (hBN of lower three dimensional ordering) has not yet been used in the catalyst - solvent process. Therefore, at the NPL this work was initiated this year. Initially, a process was developed to prepare amorphous boron nitride in the laboratory. This material is now being used as the starting material and the relevant P-T conditions for transformation to cBN are being studied.

METALS AND ALLOYS

In NPL, a project was undertaken to study the extrusion behaviour and the upsetting characteristics during extrusion and forging of 2124 aluminium alloy reinforced with 15 v/o of SiCp (1.9 to 3 μm). The project was undertaken as a collaborative effort between DMRL, Hyderabad and NPL, New Delhi.

72 mm diameter billets of 2124 aluminium alloy material having 15 v/o SiCp (1.9 μm) were produced at DMRL, Hyderabad using conventional Powder Metallurgy route. These billets were successfully secondary processed using Hot Extrusion Technique to give cylindrical rods. Two extrusion ratios (ER) of 16:1 and 36:1 were used for hot extrusion. The different process parameters like extrusion temperature, strain rate, die design and lubrication for producing the MMC rods have been optimized. Mechanical and metallurgical characterization of the extruded rods was also carried out. The characterization was done in the as extruded condition as well as after a homogenization treatment.

In the second part of the project, the upsetting behaviour of metal metrix cuprates (having

15 v/o SiC and with 1.9 μm size particulate) during warm forging was studied. The forged component, was successfully forged in a single operation. Percentage deformation of 95% during the forward extrusion and 62% during upsetting was achieved.

Keeping in view the various aspects during the extrusion of MMC cylindrical rods, another project on the development of MMCs tubes has been undertaken. The Project is of 3 years duration and is funded by DST in which four other premier institutions of the country namely DMRI Hyderabad, HAL Bangalore, IISc Bangalore and RRL, Trivandrum are collaborating. ISRO, Bangalore has been chosen as a user industry for the MMC developed tubes. Few MMC tubes with 10 to 15% v/o SiC with varying wall thicknesses (2 to 3mm) have been made. Preliminary characterization of these tubes have shown encouraging results.

MATERIALS CHARACTERIZATION

Chemical Methods

More than fifty samples received from NPL and different outside organizations have been analysed. Organometallic compound of copper has been prepared and supplied to CEERI, Pilani for CVD work in their laboratory. R&D work has been done for the rapid and accurate simultaneous analysis of phosphorus and arsenic in steel and silicon, cobalt in steel, arsenic in silicon and boron in gallium arsenide crystals. A new water proof, fire proof chemical has been developed for cellulose based material.

New indirect spectrophotometric methods have been developed for the determination of nitrite and sulphate.

Indian Reference Materials of mercury and selenium have been evaluated by atomic absorption spectrophotometer for compositional analysis.

Indian Reference Materials

The preparation of Indian Reference Materials was continued. A round robin programme of evaluation of toxic elements in high purity water was undertaken and six certified reference materials were prepared which are now available to user organisation. Five samples of certified reference materials were received from people Republic of China for international comparision. 34 constituents were required to be determined in these samples. The work has been completed and final values have been assigned to them. A workshop on Indian Reference Materials was organised in combination with the Fourth International Conference on Health and Disease on Feb. 5-6, 1993 at NPL, New Delhi. Indian Reference Material of selenium concentration at Ippm is being measured periodically for assessment of its stability.

Anion chromatograph supplied by M/s Dionex Corporation, USA has been installed in the division, Anions like Chloride, Sulphate and Nitrate have been estimated quantitatively in samples received from people Republic of China. They were found to be in the range of 5-40 ppm.

SURFACE AREA & POROSITY

under (NPL - IIT Delhi Joint Research Programme)

About 17 samples of activated carbon fibres were prepared with varying pre-treatment conditions. These were characterised for their surface area, carbon yield and linear shrinkage. Results of these investigations have been presented in the National Workshop on Newer Carbon Products and their applications.

FTIR Spectroscopy

Samples of doped silicon and thin film coated on silicon received from CEERI, Pilani were characterised by FTIR using absorption method.

Silicon samples used for making solar cells by CEL, Sahibabad were analysed for quantitative measurement of oxygen and carbon contents. Emission spectroscopic characterisation facilities were maintained. A number of samples from different projects of the laboratory were characterised.

EPR Spectroscopy

EPR studies of as grown and air annealed p-type $Cu_{1.9}$ Se polycrystalline samples were made to understand different types of defects obtained during oxidation process. Samples were prepared by the chemical method and were subjected to heat treatments similar to those used to Cd5/Cu_{2-x} Se solar cell fabrications. Three types of EPR signals identified due to copper vacancies, selenium vacancies and Cu^{2+} ions were obtained at RT on heating the samples in air. The initial rise in electrical conductivity has been attributed to decrease in hole concentration due to diffusion of copper into $Cu_{1.9}$Se bulk from local regions such as grain boundaries. A number of samples from NPL and out side organisations were also characterized at room and low temperatures.

X-ray diffraction

X-ray diffraction studies were carried out for hundreds of samples of materials including high Tc superconductors, carbon-carbon composites and fibres, boron nitride, piezoelectric materials, selenide of copper and indium, phosphors, Ni-Mn alloy and coatings of aluminium and tungsten on silicon wafers.

Assistance was provided to various research institutes and private industries including CEERI, IARI, University of Delhi, NTPC, M/s. Aroni Chemicals, Nagda and M/s. Fort Gloster Industries Ltd., New Delhi regarding the X-ray analysis of their materials.

In study of the effect of irradiation by Nickel and Oxygen ions on Y-Ba-Cu-o (123) high Tc materials, we found an appreciable change in XRD peak intensities and the crystallite size in Ni-ion irradiated samples as compared to that of 0-ion irradiated samples. Similar studies have also been initiated on Bi high Tc superconductor materials. On the other hand, X-ray irradiation of $Bi_3PbSr_3Ca_3Cu_4O_y$ compound, at room temperature, results in degradation of super-conducting properties of the material and is supported by XRD studies. Effect of different calcination temperature and that of annealing has also been studied in relation to formation of single phase (2212) in antimony doped high Tc material. XRD studies were also carried out on the optimization of synthesis parameters for Tl (2201) phase prepared by flash sintering process.

Chalcopenide materials like Ga_2Te_3, $CuSbSe_2$, CuInSeTe and ZnTe were synthesized and it was found that some of these materials needed long period annealing before a single phase materials could be formed. In single crystal study of Ga_2Te_3, it has been found that most of crystals are twinned and the direction has been found to be (110).

Development & preparation of silicon powder X-ray diffraction standard reference material has been started. High purity silicon powder of desired range, 2 to 8μm, has been obtained using sedimentation technique and XRD characterization on this material is under progress.

ELECTRON MICROSCOPY

The results of the TEM investigation on Au/Sn thin film couples were analysed. It has been observed that the couples deposited at room temperature showed the presence of Au, Sn and one or more phases of gold and tin. Depending upon the overall composition of the couples, four major phases have been detected and these phases namely AuSn, $AuSn_2$, $AuSn_4$, and Au_5Sn have been identified by electron diffraction techniques.

The work on the study of structure of Ag/Sn thin film couples by TEM was initiated. Several samples

prepared and investigated had a range of composition varying from 15 to 90 at % of Ag. The investigation is in progress and the data are being analysed.

The analysis of data on the study of solar selective block nickel coatings prepared on to zincated and zinc electroplated Aluminium substrates by a conversion process led to the conditions which yield high solar absorptance while maintaining low thermal emittance values. It has been found that the morphology of the underneath zinc surface and the morphology and the composition of the final block coatings are important for getting the best values of absorbance and emittance.

The detailed study of Lead doped $Bi_2Sr_2Ca_2Cu_2$ oxide Superconductors revealed that T_c increases with sintering time up to a certain period of time after which it shows a decreasing trend. The furnace cooled and quenched samples after sintering invariably showed relatively lower values of $T_{c(on)}$ and $T_{c(R=o)}$. The higher values of T_c could only be achieved in the sample subjected to slow cooling rates. The samples rich in Ca and Cu showed higher values of T_c which is caused due to the increase in the volume fraction of high T_c phase and the results are supported by SEM and XRD investigations.

A number of samples of different projects/activities from NPL and outside organizations were investigated by TEM and SEM.

CRYSTAL GROWTH & CHARACTERIAZATION

A high resolution X-ray diffraction study was carried out on natural diamond crystals of type II variety to see the possibility of observing dynamical effects. These crystals were thin, such that μt is about 0.3 and in some cases goes down to almost 0.1. The degree of perfection of these crystals varied in a wide range. Their diffraction curve half widths were in the range : 100 arc sec to 300 arc sec. ($(\bar{2}20)$) diffracted planes, Mok, radiation)). Yet, well defined peaks in the diffraction curve for the forward diffracted beam could be observed and photographed. As the degree of imperfection increases the intensity of the forward diffracted beam decreases. It has been found experimentally that the forward diffracted beam can also be observed with imperfect crystals having diffraction curve widths of about 280 ar sec. This is practically the limit for the observation of the forward diffracted beam. A very exciting observation is the simultaneous decrease in absorption coefficient of the crystals for the X-ray beam at the Bragg angle.

Strict control is required for producing desired degree of shrinkage in micro-patterns in photoresists used for microelectronic device fabrication. A study has been carried out in collaboration with CEERI, Pilani. The irradiation was controlled in terms of its wavelength and the time period of iirradiation. For high quality dimensional control an optimum time period of X-ray irradiation has been found experimentally.

Biaxial stress has been studied in (100) silicon wafers with ~1000 A° thick cosputtered molybdenum-silicon films before film deposition, just after deposition and after rapid thermal annealing. The Mo:Si ratio in the as deposited films was 89:11. Biaxial stress, σ, was determined from the radii of curvature measured by employing a double crystal X-ray diffractometer designed and developed at NPL. Double crystal diffractometry and topography was employed to monitor crystalline perfection of substrate crystals. All the experiments were performed in the symmetrical Laue geometry. Blank wafers with a wide range of radii of curvature (33mm to 250mm) were chosen and their curvatures were taken into account while determining the value of biaxial stress in wafers with deposits. Values of σ for wafers with as-

deposited films were in the range : $3x10^9$ dyn/cm^2 - $14 x10^9$ dyn/cm^2. The stress was tensile in nature. Wafers with high initial bending showed higher values of stress. Deposition also led to degradation of perfection. Distribution of stress was directly observed in topographs. Rapid thermal annealing at 1000°C and 1100°C (3-4 min.) was employed to form $Mo:Si_2$ phase. It led to notable relaxation of stress. The values of σ were in the range : $1x10^8$ dyn/cm^2 to $6x10^9$ (tensile). The final value of stress is lowest for the blank wafer with smallest bending. Annealing also improved the degree of crystalline perfection. Diffraction curve half width decreased from 25 arc sec. (just after deposition) to 12 arc sec (after annealing). Contrast in topographs also supported this result.

An ambitious experiment is being set up for in-situ measurement of biaxial stress induced by thin films in semiconductor crystals. A double crystal X-ray diffractometer has been set up to generate parameters of high resolution X-ray diffraction curves in various settings of the diffractometer and diffraction geometries. The crystals were set up in Laue as well as Bragg geometries. Dispersive (+,+) and nondispersive (+,-) settings of the diffractometer were employed. The following diffracting planes of silicon single crystal had been investigated: (111); (333); (555) and (220). In the case of (+333, -333) setting, the diffraction curve half width of a nearly perfect silicon single crystal was less than 1 arc sec. Optimization between the resolution and intensity of diffracted beam can be achieved from the matrix of data generated in this investigation.

A high resolution diffuse x-ray scattering study has been carried out on structural defects produced by BF_2 + implantation in device quality silicon single crystal wafers. A high resolution multicrystal X-ray diffractometer has been used in (+,-,-,+) setting. In the first phase of the experiments we observed the defect clusters produced by BF_2 + implantations. The size, shape and number of defects in each cluster depends on both the ion beam energy and dose level of BF_2^+ ions. A detailed investigation on BF_2^+ implanted samples at different dose levels : $1x10^{14}$, $5x10^{14}$, $1x10^{15}$ and $5x10^{15}$ ions/cm^2 has been carried out keeping the energy fixed at 90 keV and dose rate defined by 55μA. From the diffraction curves it is clear that the implantation damage increases with dose level. The half width of the diffraction curves systematically increases and the peak intensity decreases with increase in the dose. Diffuse X-ray scattering measurements have also been carried out on these samples for structural characterization of the point defects and their clusters.

Nearly perfect lithium niobate single crystals have grown by the Czochralski technique on a pulling machine developed in the group. Poling of crystals during their growth was carried out. This enable preparation of single domain crystals of lithium niobate. Electric current density was varied to optimize conditions for preparation of single domain crystals. A few crystals with iron impurity were also grown. Different doping levels were achieved.

The commissioning work on crystal growth system acquired from Russia was initiated. A Russian team of three scientists from Institute of Inorganic Chemistry, Novosibirsk, assembled the various parts of the system. For this effort a number of small components were made and tested in the laboratory. Experiments on optimum thermal conditions for crystal growth are being persued.

Rb_2ZnCl_4 single crystals have been grown by the Bridgman technique. These crystals will be used to test our theoretical model for determination of atomic distortion by phase transitions or external stresses in the vicinity of incommensurate-commansurate phase transition of A_2BX_4 type ferroelectrics.

LOW TEMPERATURE PHYSICS SUPER CONDUCTIVITY

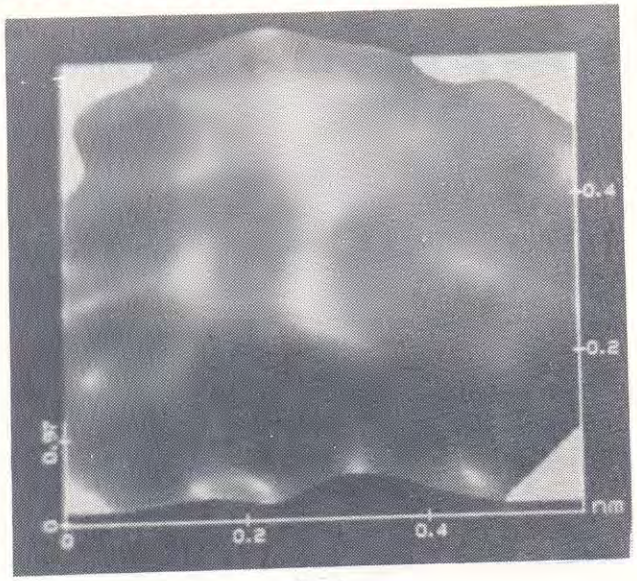


Fig.1

The first direct observation of the summolecular features of the carbon C-60, a spheroidal fullerene molecule formed with sixty carbon atoms. The carbon cage in the form of hexagons and pentagons is resolved by high resolution scanning tunnelling microscopy.

LOW TEMPERATURE PHYSICS SUPERCONDUCTIVITY

(i) STM studies of C_{60} fullerenes ;

Discovery of superconductivity at appreciable temperatures in C_{60} solids doped with alkali metals led to a worldwide excitement during last one year. At NPL, Scanning Tunnelling Microscopy (STM) technique was effectively used to study C_{60} fullerene samples synthesized at IIT, Kanpur. For the first time, it was possible to directly observe and image submolecular details of the carbon cage of individual C_{60} buckyball.(Fig.1) The characteristic arrangement of hexagons and pentagons predicted through indirect neutron and X-ray diffraction studies was confirmed by these studies. The fact that the submolecular details of the carbon cage are not smeared-out and were distinctly visible in STM images obtained at NPL suggested that the rotational diffusion of the buckyballs was considerably retarded or frozen. Various possible reasons of freezing of the spinning motion were suggested.

STM studies further indicated the presence of higher fullerene derivatives in the molecular higher fullerene derivatives in the molecular lattice observed. The characteristic FCC lattice of C_{60} as well as HCP lattice of C_{70} were resolved.

High resolution STM studies of C_{60} lattice have revealed the presence of defects in the form of dislocations and stacking disorders. The images of dislocations confirm that the equilibrium positions of two edge dislocations of opposite sign on parallel slip planes are in 45° orientations as per theoretical predictions. The images unambiguously corroborate the Burgers vector to be ½ [110], the characteristic of FCC lattice.

Diameter of the spheriodal carbon cage of C_{60} measured in both <100> and <110> direction in {111} plane is close to 0.7 nm. This is the value given by the positions of the carbon atoms and thus suggests that the system is better described in terms of pi-molecular orbitals rather than pi-valence orbitals.

STM studies have shown the individual cage structures to be distorted. High resolution studies are underway to detect anomalies and defect structures present in the carbon cage.

Specific heat measurements on Bi-2223 system :

In collaboration with Max-Planck Institute

for solid State Research, Stuttgart, a completely automated computer controlled calorimeter was designed and set up for measurement of specific heat. A series of Bi-2223 samples containing different concentrations of Pb was studies. Clear specific heat anomalies were observed. The specific heat data was used in conjunction with magnetic susceptibility measurements to give useful insight into the occurrence of superconductivity in this system.

(iii) Magnetic susceptibility studies of bulk sintered samples and single crystals of HTSCS.

As susceptometer was used to investigate superconducting properties of Fe, Ga, Ni Co substituted Bi 2122 and Pb substituted Bi 2223 and Pb substituted Bi 2223 phases. The field dependence studies of x' and x'' on pure 123 sample were done to estimate intergrain JC values. In collaboration with Crystal Growth Centre at Anna University, Madras, single crystals of bi-2122 were characterized. The field dependent studies on Bi 2122 single crystals were performed to investigate the anisotropy of magnetic properties. Similarly, a systematic study of a series of Bi-2122 single crystal samples containing different Y at the Ca-site was done to understand their susceptibility behaviour.

(iv) Phase transformation in Bi-system :

Phase transformation of nominal Bi deficient 2212 has been studied through X-ray diffraction, resistivity and susceptibility. The reversibility of converting the lower TC phases of Bi system alongwith $Ca_2 Cuo_3$ and Cuo.. into high Tc Bi-phase has been observed. The N_2 annealing of this istorted Bi-2223 phase leads of the formation of lower Tc phases in the system. Further higher temperature nitrogen annealing of the Bi-2223 phase has been seen to generate the amorphicity in the material. Results are also discussed in the light of recent band structure calculations.

(v) Substitutions in Y-124 system :

Zn and Ga substitution in place of Cu in Y-124 system has been investigated. The samples of $YBa_2 (Cu_{1-4} Zn_2)_4 O_2$ with x=0.00—0.20 and $YBa_2 (Cu_{1-x} Ga)_x O_8$ with x=0.01-0.10 were synthesized at ambient oxygen pressure using sodium oxalate. With increase in concentration of Zn in Y-124 and significant change is observed in the values of the lattice parameters a_c and c_o. With Ga substitution Y-124 d_c and b_o values trend to come closer and the c_o parameter decreases resulting a decrease orthorhombicity of the unit cell. It is observed that Zn substitution in Y-124 depresses the T (R=o) at a faster rate compared to Ga substitution in this system. The results are compared with the reported data for the $YBa_2 Cu_3 O_7$ system.

(vi) Eu doped Bi-2122

A well characterised Eu-doped $Bi\text{-}Sr_2 Ca_{1-x} Eu_x Cu_2 O_x$ (x=0 to 1) system has been studied using core level photoemission. The trivalent Eu is found to be incorporated into the lattice causing an increase in the valence states of Bi, Sr and Ca and a decrease in the Cu valence. The observed superconductor-insulator transition in this system is found to be caused by an enhanced insulating nature of the Bi-o planes and a decrease in the O 2p, hole concentration in the Cu-O planes. The results of Sr 3d Ca 2p Cu-2p and Bi 4f core level spectra are discussed in detail.

PROCESSING STUDIES

The critical current density in silver clad BPSCCO (2223) tapes has been raised to $1.5 \times 10^5 A/cm^2$ at

4.2K and 7000 A/cm^2 at 77K and OT. Silver clad tapes of BSCO (2212) prepared using partially melted powder showed Jc of 9000 A/cm^2 at 65K and OT.

A new method for making large area silver contacts to pure and silver doped YBCO has been developed. Thermal cycles and magnetic field dependence of the contact resistance suggest the presence of a "weak-link-like" interface. Theoretical modeling on the MH-loop of super-conducts has been developed.For simulation, an elegent Fortron programme was developed.

AC susceptibility measurement on YBCO and silver doped YBCO was carried out in the presence of small dc magnetic fields. An analysis of result is leading to the inter-gain and intra-grain critical currents. The function of temperature at different frequencies and different ac field excitations. The temperature history of the specimen which is not normally expected from the microscopic theories.

Superconducting Magnet Applications

The DST sponsored project : Superconducting High Gradient Magnet Separator' (S-HGMS) in collaboration with BHEL (R&D) Hyderabad has been successfully completed. The design of current leads of 1000 amps was provided to BHEL for their 5MV superconducting generator project under a consultancy arrangement, their superconducting wire has also been characterized for J_c-H behaviour upto 8T field. Persistent switches have been fabricated and tested successfully. Work is in progress in the construction of a high homogeneity magnet.

LIQUID HELIUM

Liquid helium plant supplied liquid helium to other organisations like siemens, Wipro, Bruker, All India Institute of Medical Sciences, Central Drug and Research Institute and GRD University Liquid helium was also supplied to BHEL under NPL-BHEL project.

SQUIDS

Rf-SQUIDS were fabricated using c-axis oriented polycrystalline thin films of high-Tc superconductors. The thin films of Y-Ba-Cu-O were deposited by dc/rf magnetron sputtering while that of Bi-Sr-Ca-Cu-O were deposited by e-beam evaporation. In both the cases the films were post annealed at a suitable temperature to increase the grain size to about 50μm. The large sized grain enabled to obtain almost single grain boundary weaklink in the microbridge region of the SQUID. The SQUIDS showed periodic voltage-flux characteristics at 77 K with a period of one flux quantum $\overline{O}$ ($\simeq 2.07 \times 10^{-7}$ Gauss-Cm)^2. The SQUIDS were successfully operated in the flux-locked - lock - loop mode at 77 K and were used to detect very small external magnetic fields due to chromite and igneous rock samples as well as low frequency (0.5 Hz) magnetic field generated by a quartz analogue wrist watch. The application potential of these SQUIDS in non-destructive detection of cracks and deformations in steel plates has also been demonstrated. The as-deposited thin films are superconducting with TC $\simeq$91K and Jc (as obtained from magnetization measurements)> 10^6 A/Cm^2 at 77 K and zero field. The films are c-axis oriented and have extremely smooth surface.

CRYOGENIC SYSTEMS

The conceptual design of the stirling Engine was made on the basis of optimised parameters for maximum power and efficiency using the second order isothermal analysis. Patterns for casting of the components viz. crankcase, piston housing, connecting rods, pistons and the sleeve are being fabricated.

Two special refrigerators, based on vapour compressor cycle for preservation of vaccines have

been evaluated. DST has now funded the project w.e.f. 1.4.1993.

Effective storage facility in terms of 1000 litres and vessel repairing facilities have been created. During this period spare parts were procured and the LN_2 was purchased from M/S SMS Udyog Ltd. and distributed to various groups in the laboratory to their satisfaction.

Hermetically sealed receptacles using soldering and 'O'ring techniques were developed for the long term preservation of the Constitution of India.

THEORETICAL STUDIES

The negative U Hubbard model with repulsive nearest neighbour interactions is used to explain the superconductivity of perovskites of the type $BaPb_{1-x}Bi_xO_3$. the theory predicts that in the presence of magnetic field the superconductivity disappears well below Hc_2 and a charge density wave develops in the material.

The S-wave and extended S-wave superconducting order parameters are investigated varying on-site off-site and the doping parameters in the context of high Tc materials. The non-Bcs behaviour of order parameter is observed when on-site interaction is repulsive and off-site is attractive.

An effective chiral Lagrangian is used to explain the unexpected EMC results that the net spin carried by the quarks and antiquarks in the proton is approximately zero. This model theory is being used to explain the equation of state of strongly interacting matter.

A new baryon number violating configuration is found in the standard electroweak theory in the presence of an applied magnetic field. The Gibbs free energy of the configuration becomes negative for $H_oR \sim 10^9$ gauss, where R is the extent of the applied field H_o.

RADIO SCIENCE INTERNATIONAL GEOSPHERE BIOSPHERE PROGRAMME

UV-B and aerosol measurements

An atlas of solar UV-B Radiation, Erythermal dose and ozone over Indian subcontinent was prepared and submitted to the Ministry of Environment and Forest. A computer programme was developed to draw contours for UV-B radiation, Erythermal dose and total ozone.

Inputs for preparing the terminal report on UV-B under IMAP network was provided. Calibration for all the stations set up under IMAP programme were also given.

Langley plots to calibrate the sunphotometer were redrawn. A computer programme was developed for the calculations related to all the observations taken at 'Maitri' during XI antarctic expedition. Detailed computer calculations on data taken on 'Spectroradiometer' & UVB-Sunphotometer' were made and Ozone was estimated. IR-Sunphotometer data was also analysed. The Aerosol extinction coefficient ($Tp\lambda$) studies at Delhi (1at. 28.6N; long.77.22E) were carried out using solar intensity measurements. The behaviour of ($Tp\lambda$) for the period August 1987 to March 1991 were analysed.

Solar infrared spectroradiometer measurements: Analysis has been made of spectroscopic measurements of atmospheric water vapour over Delhi using a solar infrared spectroradiometer. An inversion technique has been developed to retrieve atmospheric water vapour content. The water vapour content obtained from solar infrared spectroradiometer has been compared with the water vapour content obtained from radiosonde observations. Long term trend of total ozone over Indian region has been studied.

PHOTO CHEMICAL MODELING

Two dimensional photochemical model studies

are in progress. To understand the different elements of geosphere-biosphere interactions and in particular the many interaction aspects of atmospheric chemistry. The first global meridional model of the stratospheric positive and negative ion compositions have been generated.

INDIAN ANTARCTIC RESEARCH PROGRAMME

NPL participated in the 12th Indian Antarctic Expedition and the planetary boundary layer was explored over the Schirmacher oasis region of Queen Maud land of East Antarctic. Automatic weather station recorded automatically the met parameters including pressure over the Schirmacher region

A total of sixteen met sensors for the measurement of temperature, humidity, wind velocity and direction were mounted at 4 levels on the 28m tower.

Acoustic sounding system was operated with an advanced version of Turbo C software for VGA developed in the Radio Science Division for system operation upto 1 km. Radiation data for the direct and the reflected components was recorded on a continuous basis as an input to the PBL modelling work under progress at NPL. 3-axis sonic anomometer developed was put in operation for the measurement of turbulent flow over Maitri.

The air quality data was recorded enroute using a high volume sampler, and a ship-borne acoustic sounding system was operated over the ship Thuleland during the return journey from the Indian Bay in Antarctica to Gpa.

Samples of lake water, soil, mud, fungus and other biomaterials were collected from the various lakes and were handed over to ITRC, Lucknow for various toxicological studies and to study the water samples as part of the Environmental Impact Assessment studies of our activities in Antarctica.

During this period, two complimentary systems have been developed for the measurement of Ozone over Antarctica. The first one is the Laser heterodyne system and the other system, the mm-wave radiometer, is an all weather system.

RADIO COMMUNICATIONS

RWC (New Delhi)

Associate Regional Warning Centre (ARWC, New Delhi), being operated from NPL, has been upgraded to the status of a Regional Warning Centre during 1992. RWC (New Delhi) continued to provide near-real-time solar geophysical data and short-term-forecasts on solar and magnetic activities to a large number of users including radio communication as well as Research Organization in India. Special solar and magnetic activity predictions were provided to ISRO, Bangalore during SROSS satellite period and also a number of research institutes in India received these forecastes. RWC (New Delhi) is also bringing out a monthly bulletin containing summaries of solar-geophysical information received through Daily GEOALERTS and URSIGRAM messages for user agencies.

IEC Variation with EUV Flux

Ionospheric electron content (IEC) and slab thickness (T) data for the period 1977-1980 from a tropical station Lumping (23 N, 121.90 E) have been examined for their solar activity dependence.

Tropical Studies

Tropical Studies were made which deal with the problems in the prediction of interference levels over the Indian subcontinent using CCIR recommendations relating to tropospheric radio wave propagation. These studies advocate for new

integrated prediction procedure.

Anmalous Long Distance TV Signals

Diurnal variation of anomalous long distance TV signals received at Delhi on channels 2 and 3 in Band I (47-68 MHz) during rising period of solar activity showed high percentage in summer for the whole period, while in winter and equinoxes such situation occures in higher solar activity period only.

Mechanical Distrometer

As part of the project on the design and development of mechanical distrometer sponsored by the DOE, NPL has developed an indigeneous distrometer for the measurement of rain drop size distribution (RDSD).

Effects of Rain on Radiowave Propagation

The effects of rain on microwave and millimeter wave propagation over selected regions in Indian were investigated as a part of a DRDO project. Several studies including rain rate distributions over the Indian subcontinent, Rain attenuation on earth-space path over Delhi, Results, on rain heights over selected stations for slant path rain attenuation, Rain attenuation on earth space path over Shillong situated in hilly region, long term statistics of rain attenuation over terrestrial paths at Delhi etc. are made.

Airborne Microwave Refractometer

A PC based data acquisition system was designed and fabricated and the software developed. The integration of this system was successfully completed on board of the aircraft.

GHz Scintillations

Statistical investigations of the data collected during the years 1989-91 were carried out in the year 92-93. The studies included: power spectral densities for weak and strong scintillations at both C and L bands, their spectral slopes and associated distributions, variation of spectral slope as a function of S4 index, fifty percent decorrelation times and their variation with perturbation level, ground correlation scales and finally, the S4 variation with time.

Microwave/mm wave Radiometry

X and k-band modulator systems were redesigned and fabricated at the NPL workshop. K-band Guun oscillator was made operational by imbedding Guun diode in a specially made cavity holder designed and fabricated at NPL workshop. Trials for achieving perfection and tunning are continuing.

One additional complete microwave receiver comprising 60/70 MHz BPe-amplifier, IF amplifier with detector: low noise modulation amplifier and the phase sensitive detector was fabricated on PC boards.

During the year observations continued for attenuation measurements at 11 and 18 GHz along with the rain rate measurement using 10 seconds fast response opto-electronic rainguage.

RADIO AND ATMOSPHERIC PHYSICS

The origin of molecular ions in the magnetosphere of Mars:

On the basis of knowledge gained from the Radio Occultation measurements on the Pioneer Venus during solar minimum, it was shown that the O_2— profile observed by the viking landers at Mars have been grossly eroded by the solar wind. This erosion takes place down to an altitude of 160 km and thus contributes to the high outflow of the molecular species.

Solar EUV index for aeronomical studies from Pioneer Venus:

A solar EUV index for aeronomical studies at Earth, obtained from the Langmuir probe measurement of photoelectron, Current on the Pioneer Venus orbiter (PVO) has been obtained. To examine the potential of the solar EUV flux index derived from Langmuir Probe mesurements of photoelectron current on Pioneer Venus Orbiter, the behaviour of ionospheric parameters foE, FoF1, and foF2 at mid-latitude stations was obtained and compared with this index and with the 10.7 cm solar radio flux.

Superthermal ions at Venus

A comprehensive morphological analysis of the dayside superthermal ion presence in the dayside ionopause region of Venus was made using the Orbital Ion mass Spectrometer (OIMS) measurements. Superthermal O^+ ions with energies ranging from 15 to 90 eV relative to the spacecraft were observed on essentially every orbit of Pioneer Venus that penetrated into the dayside ionosphere.

MST Radar Studies

For analysing the observations taken during ST-mode operation of Indian MST Radar, a software was developed on VAX 11/780 computer. The software has been tested to give total signal power, Doppler shift, Doppler width and signal to noise ratio.

Studies on the Isobaric F2-Layer

Incoherent-scatter measurements indicate that hmF2 shows large local time variations. During the day when the neutral pressure is expected to be nearly constant between 09 to 15 hours, hmF2 shows significant fluctuations which were used to infer ion drift velocities. It is found that the calculated drift velocity does not exactly match with that measured by the incoherent scatter radar.

IRI improvement - E-F Valley Model

High resolution electron density measurements were used for intensive study of the E-region valley to provide E-F valley model for IRI. The three valley parameters, namely the depth, width and the location of the valley were derived for all the daytime electron density profiles observed during the above period. A model was developed by fitting the multidegree polynomials to the median values of these valley parameters as a function of solar zenith angle, and it has been accepted as an input to improve IRI model.

SATELLITE BEACON STUDIES

The VHF signals of geostationary satellite FLEETSAT at 250.35 MHz were recorded at Delhi, Bhopal and Hyderabad on P.C. based data loggers. Scintillation data campaigns were carried out under AICPITS and IEEY.

A comprehensive study including power spectral analysis is being carried out using data for the period Sept.-Oct. 1991.

Ionospheric electron content obtained at Lunping (23°N, 122°E) through the solar cycle 21 (1976-1985) were used to develop a model of IEC.

Faraday rotation data obtained from satellite ETS-II for the period Nov. 1988 to Oct. 1989 has been used to study the effect of geomagnetic storms on IEC.

NPL's AERONOMY EXPERIMENT IN SPACE

The Retarding Potential Analyser (RPA) aeronomy experiment was designed and developed and was sent in space onboard an Indian Satellite SROSS-C. A 106 kg satellite SROSS-C of Indian Space Research Organisation (ISRO) was launched from Sriharikota Range (SHAR). ASLV-D3 satellite launch vehicle and was placed successfully in the lower earth eliptic orbit (apogee 435 km, perigee 265 km) having 46° orbit inclination. The RPA payload was switched-on in orbit on May 21, 1992 through ground telecommands issued from

ISRO Satellite Tracking Centre (ISTRAC), Bangalore.

Initially the data from RPA payload was collected at ISTRAC, Bangalore for all visible orbits. Later in 1st week of June, Lucknow and Mauritius ISTRAC stations were also added to collect RPA data for all high elevation passes from respective stations. RPA's are operated in duct mode specially in nights, to measure irregularities in densities. A typical ion density profile obtained from the data of orbit no. 650 visible from Bangalore and Lucknow stations is shown.

Payload data is available on Computer Compatible Tapes (CCT) and is being processed for detailed analysis on VAX main frame computer as well as on PC's.

TECHNICAL INFRASTRUCTURE

LIBRARY

About 300 new titles in Physics and related areas were added to the library collection and 157 to its Hindi collection. It paid subscription for 164 journals. The library continued to provide library, documentation and reprographic services, it lent out 2460 publications including the titles on inter-library-loan. Nine bibliographies were supplied on demand and about 3000 references on 34 research projects were given to scientists under the SDI project.

The National information system in science and Technology. DSIR sanctioned a project for development of a national facility for information retrieval in Physics.

COMPUTER FACILITY

VAX-11/780 computer system with a few terminals in other divisions was in regular operation during the period. The system was used mostly by the scientists for their mathematical modelling work, the library and administration also. The system was also utilized for the jobs of Exam unit of CSIR and NISTADS. Research Scientists from universities also made use of the system. The staff helped the scientists in the analysis of their problems for developing, Computer programmes. E-mail service was utilized to a great extent by the staff.

The staff delivered lectures on computer science to students of NPL-BITS programme. A few students from technical institutions were also provided facilities for their Summer vacation practical Training.

GLASS WORKSHOP

Various R & D Projects of the laboratory were assisted in the fabrication of glass and silica apparatus like compact double distillation apparatus, stop cocks, distillation flasks, water jacket for adsorption column, gas samplers Dewar flasks, mixer settlers and manometers.

Various universities & R & D institutions were also served in the fabrication and supply of glasswares/apparatus. These included Defence food Research laboratory, Mysore, D.A.V. College Muzaffarnagar, M/s Indian oil corporation Ltd., Faridabad, IARI New Delhi, M/s Engineers India Ltd., Gurgaon, JNU New Delhi, IIP Dehradun, IIT, New Delhi, Modi Rubber Ltd., Meerut, Punjab University ChandiGarh, Birla Institute of Technology & Science Pilani and Jamia Milla Islamia, New Delhi.

INSTRUMENTATION SERVICE FACILITIES

More than 200 instruments were tested and evaluated for checking their workability and performance before return to C/stores, Four major repairs undertaken. Technical assistance was rendered to various in house projects. Inward inspection was also made for electronic and electrical stores.

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PATENTS

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APPENDICES

SPONSORED/SUPPORTED PROJECTS

TITLE	AGENCY	AMOUNT RECEIVED Rs. (Lakhs)
NEW		
Comprehensive programme of manpower development Associateship/Fellowships programmes.	DOD	0.603
Scientific programmes relating to Indian Antarctic Scientific research of various laboratories of CSIR	DOD	13.000
Deformation behaviour of composite materials (Aluminius alloy matrix composites) Jointly with 11Sc (Bangalore) and RPL (Trivandrum)	DST	15.741
Design, development & fabrication of dopler MINI-ACOUSTIC SODAR (MINI SODAR) for studies of the Atmop B. Layer sea surf.	DST	3.135
Development of a superconducting magnet system With a long bold dewar for a 100MHZ NMR Spectrophotometer	DST	9.000
Simple technology development for a heat pipe room heaters from ground heat	DST	1.500
Establishment of CD-ROY based information service (INFPHYS) on physics at NPL	DST	0.800
High resolution X-ray diffraction imaging for materials characterisation	DST (Indo-US)	36.450
Charge carrier transport in crystalline materials-metrological applications	DST (Indo-US)	11.170
Development of aerospace quality carbon fiber.	DST (TIFAC)	
Electroluminescent pannel for backlighting of liquid crystal displays.	DST (TIFAC)	0.500
Enviromental impact assessment studies of noise polution.	Min. of Env. Forests	3.244

Indigenous development of ultrasonic tran sducers for seismic physical modelling studies	ONGC	0.515
Ultrasonic standards for support to Indian BRITISH COUNCIL Industries. (£54,795)		.....
Joint collboration programme between CEERI (CSIR) and NPL on the development of a semiconductor processing equipment.		.....

CONTINUING

Design & fabrication of plasmsa CVD system, for deposition of a-Si films on large area.	DNES	.....
Development of process for fabrication of 15% efficiency single crystal and multicrystal solar cells.	DNES	15.00
Development of graphite reinforced carbon biploar plates for fuel cells.	DNES	2.3
preparation and characterization of halogen intercalated carbons.	DST (Indo-French)	4.609
Development of high strain to failure and high modulus carbon fibres.	ARDB	.....
Design and fabrication of plasma CVD system for deposition of diamond like carbon films on Ge.	IRDE	.....
Indigenous development of distrometer for study of tropospheric propagation parameters over selected sites in India.	DOE	.....
Development of ionospheric models for high reliability HF systems.	DRDO	1.400
Development of software packages on rain effects in the microwave & mm wave bands in selected regions over India.	DRDO	.....
Monitoring of monsoon circulation.	DST (Indo-USSR)	.....
National methane campaign for actual methane measurement during the year 1991.	Env. & Forests	4.00
Preparation of Solar UV-B Contour maps.	Env. Forests	.....
Development of warm forging & hot extrusion processes for metal matrix composites.	ARBD	0.40

Calibration service programme under National Coordination of Testing & Calibration Facilities.	DST	15.00
Study of the tropical boundary layer metrology at Jodhpur using monostatic acoustic sounder and instrumented tower.	DST	.....
Metrological studies on standards on measurements	DST (Indo-US)	10.000
Interaction of small gas molecules with semiconductor metal interfaces as studies by surface analytical techniques.	DST (Indo-US)	.....
Establishment of transfer leak standards in Vaccum metrology.	DST (Indo-US)	.....
R & D in laser frequency standards.	DST. (Indo-USSR)	3.648
Development of technology of indigenous manufacture of retro-reflective sheeting/tape.	Sur. Transp.	.....
Technical feasibility and concept proving in the area of biomolecular electronic devices.	DST	8.100
Volatile metal organic compounds	DST (Indo-USSR)	.....
Development of high X-ray sensitive photo receptors for dose reduction in xero-radiography.	DOE	0.800
DOE-NPL Centre for characterization of materials for electronics.	DOE	.....
Growth of nearly perfect crystals of oxides like lithium niobate.	DST (Indo-USSR)	.....
Nationals superconductivity fellows (National superconductivity programme)	DST	1.063
Preparation characterization and precision measurements of semiconducting materials	DST (Indo-US)\	1.350
Study on high temperature superconductivity	DST (Indo-USSR)	.....
Development of Stirling engines for power production:	DNES	.....

Laser heterodyne system of the study of ozone and other minor constituent in Antarctica.	DOD	.....
A gound based millimeter wave technique for ozone observations at Antarctica	DOD	.....
To monitor solar infrared radiation for studying minor constituents in atmosphere.	DST	0.255
Development & decay of scintillation Producing irregularities and gravity wave propagation in low latitudes.	DST	0.600
Very long baseline interferometry.	NGRI	.....

COMPLETED

Photolithographic mask aligner using modified Moire technique	DOE	13.280
Development of laser resistant carbon fibre composites.	ARDB	0.503
Study of electrical conductivity of mantle forming rock minerals under high temperature environment	DST	.....
Synthesis, characterization & application of some conducting polymers.	DST (Indo-EEC)	7.636
Data base on electronic materials	DST (Indo-USSR)	.....
Superconducting magnetic separator	DST	5.000
Synthesis of high Tc superconductive materials through eutectic melt.	DST	0.700

R & D COLLABORATION

The laboratory maintained scientific collaboration and liaison with other scientific institutions, universities, government departments, CSIR laboratories and international institutes regarding various activities. The names of the organisations and the areas of collaboration are listed below:

INDIA

Aeronautical Research & Development Board, New Delhi.

Bharat Heavy Electricals Ltd, Hyderabad. (Super Conductivity Carbon)

BITS, Pilani.

Central Arid Zone Research Institute, Jodhpur. (Acoustic Standard)

Central Electronics Engineering Research Institute, Pilani

(High Tc. Superconductors, Characterization)

CSIO, Chandigarh (Transducer for Mechanical Sector)

Centre for Liquid Crystal Research, Bangalore

(Electro Lumine Scent Panel)

Delhi College of Engineering, Kashmere Gate, New Delhi.

Defence Matallurgical Research Laboratory, Hyderabad. (Carbon)

Department of Science & Technology, New Delhi. (Biosensor)

Directorate of Weights & Measures

Graphite India Ltd. Bangalore/Calcutta.

Hindustan Aeronautics Ltd, Bangalore.

Indo French Centre, New Delhi.

Indian Institute of Science, Bangalore.

Indian Institute of Technology, Hauz Khas, New Delhi.

Indian Institute of Tropical Meteorology, Pune.

India Petro Chemicals Ltd, Baroda.

Indian Statistical Institute, Calcutta.

Indian Space Research Organisation (ISRO), SHAR Centre

(Fluorescent Screens and Particle Size Analysis)

M.D. University, Rohtak (Characterization)

Ministry of Non-Conventional Energy Sources (MNES), New Delhi.

Ministry of Susrface Transport, Govt. of India and PTB Germany.

Nuclear Research Centre, Delhi.

Poona University, Pune (Superconductivity)

PRL Ahmedabad (Planetary atmospheres)

PTB, Collaboration Programme Phase II

Regienal Research Laboratory, Trivendrum.

TIFAC, DST, New Delhi.

University of Delhi, Delhi. (Characterization, Instrumentation)

OVERSEAS

FRANCE

Centre de Recherche Paul Fascal, CNRS, Bordeaux

GERMANY

Physikalisch Technische Bundesanstalt,

Braunschweig, (Semi automatic Calibration facilities)

RUSSIA

Institute of Atmospsheric Physics, Moscow.

P.N. Lebedev Institute, Moscow. (Length Standard)

VNIIFTRI, Moscow Region,

USA

College of Engineering & Applied Science, University of Wisconsin Milwaukee

Department of Mechanical & Aero space Engg.

Univ. of California, Irvine (Materials Characterization)

U.K.

CLARENDON Laboratory, Deptt. of Physics University of Oxford, England

CALIBRATION/TESTING CHARGES

(Realised during 1992-93)

ACTIVITY	AMOUNT (Rs.)	REPORTS (No.)
PHYSICO MECHANICAL STANDARD		
Force & Hardness	12,39,095	718
Dimensional Metrology	7,39,600	410
Optical Radiation	5,27,450	85
Pressure & Vacuum	4,25,150	89
Temperature	3,47,150	255
Mass, Density, Volume & Viscosity	3,46,150	393
Acoustic	1,24,700	58
Length	31,550	5
Ultrasonic	12,550	4
ELECTRICAL STANDARDS		
AC, LF & HF Impedance	4,10,140	176
DC	2,80,100	121
HF & MW Power, Voltage, Freq. & Noise	2,29,625	49
HF & MW Attenuation & Impedance	21,500	9
Time & Frequency	19,600	11
MATERIALS CHARACTERIZATION	1,91,900	42
TOTAL	**49,46,270**	**2,425**

PROCESS RELEASED

PROCESS	LICENCEE	TERMS
STFS Decoders	M/s Sertel Electronics (P) Ltd., T.Nagar, Madras	Premium-Rs. 50,000 Royalty-Nil
Aviation grade brushes	M/s Neotech Consultants & Enginrs., Varanasi	Premium-Rs. 50,000 Royalty-5%
Thermal Stabilisation of PAN fibre	M/s Standard Clutches & Spares (P) Ltd., Bombay-400078	Premium-Rs. 50,000 Royalty-2.5%
Liquid nitrogen containers	M/s Shefa Engineers (P) Ltd., New Delhi.	Premium-Rs. 25.000 Royatly-3%
Recovery of silver from waste hyposolution	M/s Vivek Chemical Works, Faridabad	Premium-Rs. 10,000 Royalty-Nil

CONSULTANCY

TITLE	PARTY	AMOUNT (Rs.)
STANDARDS		
1. Sodar studies at Jamshedpur	NEERI, Nagpur - 440020	2,50,000
2. Inversion studies at Doon Valley	NEERI, Nagpur - 440020	2,50,000
3. For putting Rb vapour frequency reference of Hewlett Packard Rb frequency standard to optimum working condition.	Deptt. of lighthouse & lightships, Ministry of Surface Transport, New Delhi-110066	99,800
4. Noise/Vibration control in Bombay High	ONGC Regional Centre, Bombay	76,000
5. Boundary Layer studies.	Indian Petrochemical Corpn. Ltd., Nagothane	60,000
6. Acoustic treatment of multipurpose hall.	ALTTC, Ghaziabad	30,000
7. Optimisation of the performance of UV visible spectrophotometer.	SSV (PG) College, Hapur	3,600
TECHNICAL INFRASTRUCTURE		
1. Upgradation of electronic smoke density instruments.	Envirotech Instruments (P) Ltd., New Delhi.	31.500
2. Optimisation of the performance of instruments.	M/s technology Products, Gurgaon-122015	5,200

PREMIA & ROYALTIES
(1.4.91 to 31.3.92)

PROCESS	LICENCEE	TOTAL AMOUNT (Rs.)	LAB SHARE (Rs.)
Indelible ink	M/s Mysore Paint & Varnish Ltd. Mysore.	20,07,176	6,82,429
Hard ferrites	M/s Ferrite & Electronic Components (P) Ltd. Lucknow	38,632	13,135
Silver impregnated graphite contact	M/s Jyoti Refinery, Bombay	25,449	8,653
Microwave components	M/s Vidyut Yantra Udyog, Modi Nagar	12,000	4,080
	M/s The Scientific Instrument Co. Ltd., Ghaziabad	6,436	2,188
Carbon Thrust bearing	M/s Perfect Carbons, Hyderabad	7,500	2,550
Film thickness monitor	M/s Vacuum Instrument Co. Ltd., New Delhi	2,564	872
Reconditioning of T. V. Picture Tube	M/s Videotronics,	1,650	561

HUMAN RESOURCES

SCIENTISTS OFFICERS

(in order of Gp. IV to Gp. III as on 1.4.93)

DIRECTOR
ESR GOPAL

PHYSCO MECHANICAL STANDARDS

LENGTH DIMENSIONS
VD Dandawate, Sc EII
RP Singhal, Sc EII
VT Chitnis, Sc EI
Om Prakash, Sc EI
VG Kulkarni, Sc EI
LS Tanwar, Sc C
Shanta Chawla (Smt.), Sc C
M Karfa,, Sc B
V Roonwal (Smt.), TOC
NK Aggarwal, TOB
AK Kanjilal, TOB
BK Roy, TOB
Ram Narain, TOB
SL Thind, TOB
VD Sharma, TOA

MASS
DC Sharma, Sc EI
SN Nangia, Sc C
Tripurari Lal, Sc, C
ML Das, Sc C
CP Singh, TOC
S Verma (Smt.), TOA

FORCE
JR Anand, Sc F
RS Sharma, Sc EI
JK Dhawan, Sc C
MK Chaudhary, Sc C
Anil Kumar, Sc C

PRESSURE VACUUM
JKN Sharma, Sc G
AC Gupta, Sc EI
KK Jain, Sc EI
AK Bandyopadhyay, Sc EI
BR Chakraborty, Sc EI
DR Sharma, Sc EI
Pardeep Mohan, Sc C
SM Sivaprasad, Sc C
SP Sharma, TOA

TEMPERATURE
VP Wasan, Sc EI
KN Bhatnagar, Sc EI
RK Luthra, Sc EI
N.K. Srivastava, Sc C
TK Saxena, Sc C
YP Singh, Sc C
Mansha Ram, Sc B
NK Kohli, TOC
SK Nijhawan, TOB

OPTICAL RADIATION

KC Joshi, Sc F

JS Vaishya, Sc EI

S Manrai (Smt.) Sc C

HC Kandpal, Sc C

TK Chakraborty, Sc C

Jai Bhagwan, TOA

INFRARED RADIATION

SP Varma, Sc. EII

Joginder Singh, Sc EI

RS Ram, Sc EI

D Gupta, Sc C

ACOUSTICS

SP Singal, Sc F

V Mohanan, Sc EI

DR Pahwa, Sc EI

BS, Gera, Sc EI

Omkar Sharma, Sc EI

RM Khanna, Sc C

HLB Bhaskar, Sc C

Mahavir Singh, Sc B

OP Sharma, TOA

ULTRASONICS

TK Saksena, Sc EII

SC Gupta, Sc EII

Janardan Singh, Sc EI

Ashok Kumar, Sc EI

SK Jain, Sc EI

RP Tandon, Sc EI

Ved Singh, Sc C

Harish Bahadur, Sc C

Mukesh Chandra, Sc C

Subhash Chandra, TOB

NN Swamy, TOB

Jagdish Lal, TOA

FLOW MEASUREMENT

MK Dasgupta, Sc F

JN Som, Sc EI

Raj Singh, Sc C

OP Bhola, TOC

Virendra Babu, TOC

TESTING & CALIBRATION SERVICES PROGRAMME

HK Thadani, SC EII

Mahesh Chandra, Sc EI

Sudarshan Kumar, Sc C

HS Dahiya, Sc C

SD Bahl, TOB

GK Kapoor, TOA

ELECTRICAL STANDARDS TIME & FREQUENCY

BS Mathur, Sc G

P Banerjee, Sc EI

GM Saxena, Sc EI

A Sengupta, Sc EI

AK Hanjura, Sc EI

A Chatterjee (Smt.), Sc C

M Saxena (Smt.) Sc C

GK Goel, TOC

Gurdial Singh, TOB

AK Suri, TOA

JOSEPHSON VOLTAGE

Ashok K Gupta, Sc EII

VS Tomer, Sc EI

NS Natrajan, Sc EI

ND Kataria, Sc EI

Manmohan Krishan, Sc C

VN Ojha, Sc C

VK Gumber, Sc C

Neeraj Khare, Sc C

D C MEASUREMENT

SK Mahajan, Sc EI

PK Mittal, TOB

B Sircar, TOB

H F IMPEDANCE & AC, LF

SL Dahake, Sc F

Omkar Nath, Sc EI

Gurmej Ram, Sc EI

SR Gupta, Sc C

MK Mittal, Sc C

MR Nagar, Sc C

AK Saxena, Sc C

Kewal Krishan, Sc C

Naib Singh, Sc B

JC Biswas, Sc B

TR Aroa, TOB

AR Kaushik (Smt.) TOB

H F & MW VOLTAGE, POWER FREQUENCY & ATTENUATION

VK Agrawal, Sc F

RS Yadav, Sc EII

PC Kothari, Sc EII

Ram Swarup, Sc EI

VK Rastagi, Sc EI

AK Govil, Sc EI

Ritander Aggarwal, Sc C

HM Bhatnagar, Sc C

PS Negi, Sc C

RL Mendiratta, TOA

MATERIALS DEVELOPMENT SILICON, CERAMICS SUPERCONDUCTOR

BK Das, Sc F

SK Sarkar, Sc EII

AC Rastogi, Sc EII

SN Singh, Sc EI

RB Tripathi, Sc EI

Balbir Singh, Sc EI

PK Ashwini Kumar, Sc EI

ST Lakshmi Kumar, Sc EI

Mohan Lal, Sc EI

BR Awasthy, Sc C

NK Arora, Sc C

BC Chakrawarty, Sc C

SB Manmohanan, Sc C

Satbir Singh, Sc C

ML Sharma, Sc C

RK Kotnala, Sc C

Kiran Jain, (Smt.), Sc C

Ram Kishore, Sc C

PK Singh, Sc C

Ravi Kumar, Sc A

NS Bangari, TOC

SM Khullar, TOC

HS Kalsi, TOC

RC Goel, TOC

BS Khurana, TOB

SK Sharda, TOB

HP Gupta, TOB

Prem Prakash, TOB

KS Balakrishnan (Smt.), TOB

MK Banerjee, TOA

T Podikunju, TOA

TR Pushpangadan, TOA

AP Gera, TOA

LUMINESCENT MATERIALS

PK Ghosh, Sc F

HP Narang, Sc EII

V Shankar, Sc EI

Harish Chander, Sc EI

DISPLAY DEVICES

Subhas Chandra, Sc F

SC Jain, Sc EI

SS Bawa, Sc EI

SN Ekbote, Sc EI

MN Kamalasanan, Sc EI

SC K Misra, Sc EI

Suresh Chand, Sc EI

AM Biradar, Sc EI

CP Sharma, Sc EI

SA Agnihotri (Smt.), Sc C

KK Saini, Sc C

NS Verma, Sc C

Ramadhar Singh, Sc C

VS Panwar, Sc C

BD Malhotra, Sc C

Ranjana Mehrotra (Ms.) Sc C

RK Sharma, Sc B

RC Bhateja, TOB

CARBON PRODUCTS

RL Seth, Sc F

OP Bahl, Sc F

Gopal Bhatia, Sc EI

RK Aggarwal, Sc EI

RB Mathur, Sc EI

CL Verma, Sc EI

TL Dhami, Sc C

V Raman, (Smt.), Sc C

Chhote Lal, Sc C

P Sivaram, Sc C

RK Kulshrestha, Sc C

SC Dhakate, Sc B

THIN FILM SYSTEMS

R Bhattacharya, Sc EII

Devindra Singh, Sc EI

A Basu, Sc EI

BS Verma, Sc EI

M Kar (Smt.), Sc C

PN Dixit, Sc C

OS Panwar, Sc C

C Anandan, Sc C

HIGH PRESSURE TECHNOLOGY

MM Bindal, Sc EII

AK Aggarwal, Sc EII

BP Singh, Sc EI

SK Singhal, Sc C

Rajeev Chopra, Sc C

RK Nayar, TOC

Dharam Chand, TOB

METALS & ALLOYS

Anil K Gupta, Sc EII

RC Anadani, Sc C

Ajay Dhar, Sc C

IA Malik, TOC

HB Singh, TOA

Rajiv Sikand, TOA

Jaswant Singh, TOA

MATERIALS CHARACTERIZATION

CHEMICALS & POROSITY

DC Parashar, Sc F

PK Gupta, Sc F

VK Amar, Sc EI

JN Bohra, Sc EI

JC Trehan, Sc EI

R Ramachandran (Smt.), Sc EI

AK Sarkar, Sc EI

AK Aggarwal, Sc EI

PK Gupta, Sc C

Mewa Singh, Sc C

IR & EPR SPECTROSCOPY

MM Pradhan, Sc EII

SK Gupta, Sc EI

RK Garg, Sc C

S Parthasarathi, TOC

MK Dasgupta, TOA

X-RAYS

KD Kundra, Sc F

U Dhawan (Smt.), Sc EI

DK Suri Sc EI

Rashmi (Km.), Sc C

RP Pant, Sc B

ELECTRON MICROSCOPY

SK Sharma, Sc F

Narendra Kumar, Sc EII

SUM Rao,Sc EI

CRYSTAL GROWTH

Krishan Lal, Sc Dir Gd

RV Ananthamurthy, Sc EI

Vijay Kumar, Sc EI

SK Haldar, Sc EI

G Bhagavannarayana, Sc C

SNN Goswami (Smt.), Sc C

LOW TEMPERATURE PHYSICS SUPERCONDUCTIVITY

AV Narlikar, SC G

MS Hedge, Sc EII

RG Sharma, Sc EII

YS Reddy, Sc EI

BV Reddi, Sc EI

BV Kumaraswami, Sc EI

PK Dutta, Sc EI

UC Upreti, Sc C

Ratan Lal, Sc C

SK Aggarwal, Sc C

PL Upadhyay (Km.), Sc B

SB Samantha, TOB

VS Yadav, TOA

CRYOGENIC SYSTEMS

AP Jain, Sc F

SC Gera, Sc EI

RS Khandekar, Sc EI

RB Saxena, Sc EI

Hari Kishan, Sc C

Kasturi Lal, Sc C

SS Verma, Sc C

NK Babbar, Sc C

Ganga Prasad, Sc C

GS Bhambra, TOA

THEORY

Ramji Rai, Sc EI

Prof. R.Prasad, Telecommunication and Traffic Control systems, Netherland.	Code division multiple access systems for personal communication networks, Nov. 25.
Prof. J.N.Desai, Physical Research Lab., Ahmedabad.	Evolution, theory and technique of fabry-Perot spectroscopy PRI, Dec. 2, 8, 11, & 14.
Prof. A Mackay, University of London, UK.	Flexi-crystallography, Dec. 4.
Dr. S.Chandra, NASA, USA.	Antarctic zone hole, Dec. 23.
Prof. H. Tenstiege, Federal Inst. for material Research & Testing, Berlin	Spectral distribution of fluorescent lamps and simulation of day light and global radiation, jan. 4.
Prof. M.R.Kundu, University of Maryland, USA.	High energy solar physics via millimeter observations of solar flares, Jan. 20.
Prof. E.Gmelin, Max Plowek Inst., Stuttgant, Germany.	Low temperature calorimetry techniques, some new specific heat results and cryogenics, Feb. 23, 25, & Mar. 15.
Prof. Christopher, R. Low, Cambridge University, UK.	Biosensors, Mar. 23.

FC Khullar, Sc C

Indra Tewari (Smt.), Sc B

SS Bhakri, TOB

TR Tomer, TOB

SC Verma,TOA

LIBRARY

SM Dhawan, Sc EII

SK Phull, Sc EII

Sawanti Lal, TOA

Hasan Haider, TOA

COMPUTER

VK Batra, Sc EII

Ravi Mehrotra, Sc EI

Sanjeev Raizada, Sc B

WORKSHOP

HNP Poddar, Sc EI

Ravi Khanna, TOB

MG Sehgal, TOB

Harish Chand, TOB

MK Chibber, TOB

Kewal Krishan, TOB

TR Marwah, TOA

Ram Swarup, TOA

JP Sharma, TOA

GLASS WORKSHOP

VP Varma, Sc EI

MC Jusht, TOC

Mohan Lal, TOC

Shashi Bhushan, TOC

Chandan Singh, TOC

JP Vashisht, TOC

GS Hans, TOB

Kani Ram, TOB

Karnail Singh, TOB

INSTRUMENTATION

VR Singh, Sc EII

I Banaudha, TOC

DS Sachdeva, TOB

YPS Negi, TOA

SERVICES

CSP Kumar, Sc EII

S Dwivedi, Sc C

JC Sharma, Sc C

OP Tagra, TOC

KV Krishnamurthy, TOB

PK Garg, TOB

SL Sharma, TOB

RS Singh, TOB

SS Kapur, TOA

KL Ahuja, TOA

JS Dhama, TOA

ON DEPUTATION

AR Jain

J Kar

LM Manocha

Ranjit Singh

RP Tandon

SCIENTISTS, FELLOWS, RESEARCH ASSOCIATES & POOL OFFICERS

KS Bartwal, Sc (DST)

RN Chaudhury, Sc (DST)

S Govindarajan, Sc (DST)

SK Gupta, Sc (UGC)

V Soni, Sc (UGC)

VV Janki (Smt.), Fellow

R Kothari, Fellow
A Srinivasan, Fellow
PK srivastava, Fellow
Manju M Vergheese (Km.), Fellow
R Agrawal, RA
G Beig, RA
S Bhattacharya (Smt.), RA
DR Chaubey, RA
S Chaudhury (Smt.), RA
S Chauhan (Km.), RA
Archana Garg (Km.), RA
Chetan Kaw (Km.), RA
Rashmi Mitra, (Km.), RA
J Mittal, RA
KC Nandi, RA
GK Padam (Km.), RA
AK Padama (Km.), RA
Rashmi Paul (Smt.), RA
Renuka Rajput (Km.), RA
GS Reddy, RA
Kanchan Saxena (Km.), RA
Rina Sharma (Smt.), RA
Manoj Gupta, PO
Jaivir Kaudinya, PO
Keshav Kumar, PO
RM Krishna, PO
SP Pandey, PO
Anju Ratna (Km.), PO
Nirupa Sen (Smt.), PO
C Sharma, PO
NS Sunderason, PO
JS Thakur, PO

ADMINISTRATION ACCOUNTS

MM Sharma, Sr. COA
OP Juneja, SFAO (SG)
T Qutubuddin, AO
JM Sardana, SPO
OP Kakkar, FAO
AK Ghosh, TOA
Anil Kumar, SO
NK Bajaj, SO (F&A)
Dharam Raj, SO
OP Meni, SO
Jitender Parasar, SO
Sardara Singh, SO
KG Sharma, SO (F&A)
RK Sharma, SO
RL Sharma, SO (F&A)
S Sharma (Smt.), H. Offr.
RC Gupta, Dy. SPO
Brijesh Sharma, Dy. SPO
RK Bhasin, SPA
BB Chopra, SPA
Jagdish Kumar, SPA
SA Joseph (Smt.), SPA
Prem Nath, SPA
DV Sharma, SPA
Sis Ram, SPA
Vijay Kumar, Sec. Offr.

RETIRED

Sarla Sonsi (Smt.), SO, April
Daulat Singh, Tech VII, April
RS Sharma, Tech VII, April
Auodhya Praksh, Asstt.,April

JP Sharma, Asstt. April
Ram Gopal, W/S Asstt., April
Anand Prakash, SMA, May
RS Yadav, SMA, June
BG Mathur, Sc EI ,June
PL Sharma, TOA, June
Vishwamittar, Tech.VII, June
Ved Prakash, Asstt. June
Kailash Chand, Sc C, July
Ganga Ram, SMA, July
Bal Kishan, Tech VIII July
Nathi Singh, Tech VIII July
Bharat Singh, Tech VIII Aug.
Bansi Lal, W/S Asstt. Aug.
Sharwan Kumar, Sc EII, Sept.
Ganpat Singh, TOB, Oct.
SN Upreti, Tech VIII, Oct.
Aftab Ahmed, Sc EI, Nov.
SS Hanspal, Sc EI, Nov.
Desa Singh, SMA, Nov.
Gurpiara Ram, SMA, Nov.
Krishan Lal, Tech VII, Nov.
SR Gurung, W/S Asstt. Nov.
ML Shakdhar, Sc EI,Dec.
RC Dhawan, TOC, Dec.
Brij Lal, Tech VIII, Dec.
RH Bhawalkar, Sc EI, Mar.
VC Jain, Sc EI, Mar.
CJ Chacko, Tech VIII, Mar.
RP Chopra, Asstt. Mar.
Joginder Singh, Asstt. Mar.
Shanti (Smt.), Mar.

OBITUARIES

RC Bhalla, SP Asstt. April 6
A. Daulat, Tech VII, April 21
AK Suryavanshi, SRF, June 13
JR Kundra, Tech VII, Aug.8
Mam Raj, W/S Asstt. Nov. 5

STAFF STRENGTH

(as on 1.4.93)

Category	Grade	Number
SCIENTIFIC		
Group IV	IV (1) to Director (Scientist)	**285**
TECHNICAL		
Group V	V (3) to V (4) (A.Ex.Engr.)	4
Group III	III (3) to III (5) Tech. Officer)	93
Group III	III (1) to III (2) & V (1) to V (2) (Tech. Asstt.)	83
Group II	II (1) to II (4) (Technician)	386
Group I	I (1) to I (3) (Helper)	122
		688
ADMINSTRATIVE		
Officer	25	
Establishment	148	
Group D	133	
		306
	Total	**1279**

VISITS ABROAD

(1.4.92 to 31.3.93)

Scientist	Country	Purpose & Month
Prof. E.S.R. Gopal	Syria	Leader of Indian delegation for finalization of programme in S & T Cooperation with SERC. April.
Dr. D. Gupta	USA	To avial guest research position at NIST. April 92-March 93.
Dr. A. K. Gupta	USA	Under Indo-US fellowship scheme to work on advance materials, May-June.
Dr. K. K. Mahajan	USA	On short-term assignment to Goddard space Flight Centre, Maryland, May-June.
	USA	Attended STEP symposium and COSPAL meeting at Washington, Aug.
Dr. D. R. Lakshmi	Canada	Attended meeting and solar terrestrial predictions workshop, May
Sri R. S. Khanduja	Germany	NPL-PTB (Phase II), Techl. Cootn. Programme and attended a course, May-July.
Dr. B. R. Chakraborty	USA	Received training at Pennsylvania University under UNDP project, May-Oct.
Dr. T.K. Saksena	Germany	NPl-PTB (Phase II), Techl. Cooptn. Programme, May-Aug.
Dr. P. Banerjee	Germany	Attended International symposium on Environmental & Biological Materials at Aachen, May.
Dr. V. Mohanan	Russia	For intercomparison of national stdds. of sound pressure under Indo-Soviet Cooptn. in S & T, May.
Dr. S. P. Singhal	Greece & Turkey	Attended international symposium at Athens and visited Istanbul Techl. University, May-June.
Dr. Harish Bahadur	USA	Attended IEEE annual symposium on frequency control, May.

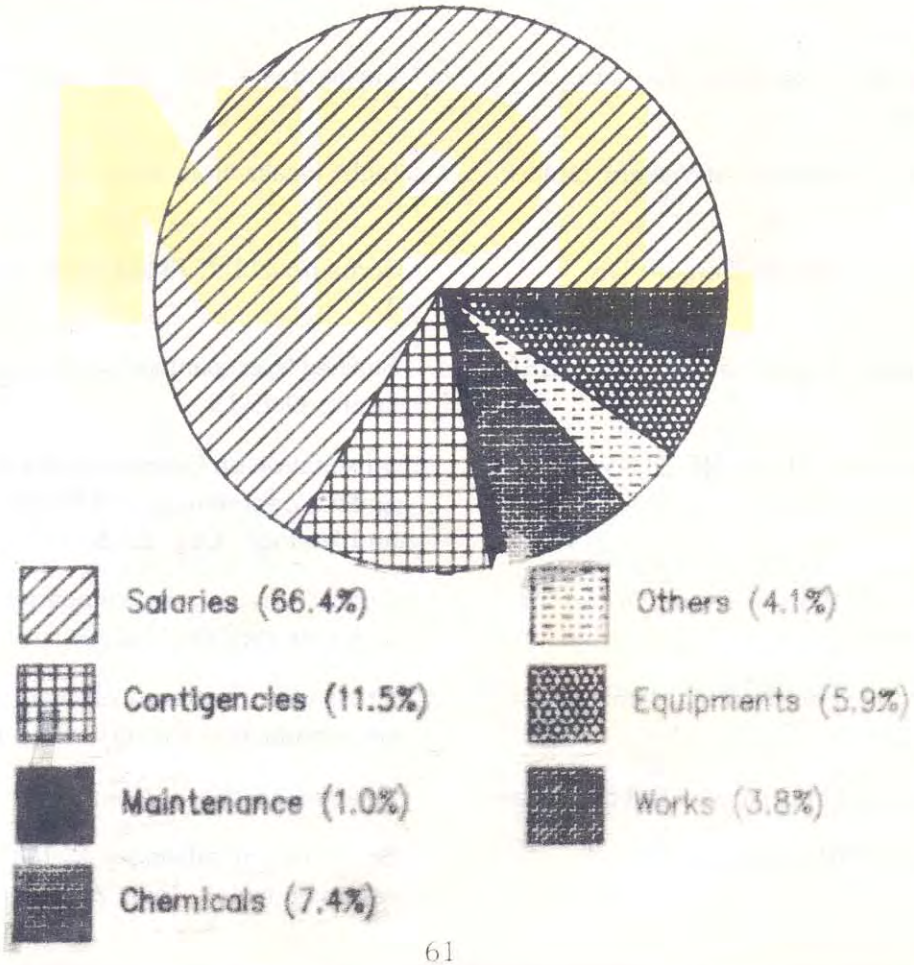
Dr. A. Sengupta	USA	To work on MASER at NIST Under Indo-US Programme, may-Dec.
Dr. P. C. Kothari	Germany	NPL-PTB (Ph.II) Techl. Cooptn. Programme, June-Dec.
Dr. S. T. Lakshmi Kumar	USA	To work at Rensselaer Polytechnic, Yew York as Raman Research Fellow, June-Dec.
Dr. S. L. Jain	USA	Attended quardennial zone symp. and visited Langley Research Centre, NASA, June.
Sri Y. P. Singh	Germany	NPL-PTB (Ph.II), Techl. coopn. Programme
Dr. A. V. Narlikar	Germany	NPL-PTB (Ph.II), Techl. Coopn. Programme regarding quantum Hall resistance activity. July-Aug.
Dr. T. R. Tyagi	USA & Germany	Attended international beacon satellite studies symp. at MIT and visited Max Planck Inst., July.
	Taiwan	Attended workshop on Radio Sciene, March
Sri M. K. Chaudari	Germany	NPL-PTB (Ph.II), Techl. Coopn. Programme regarding Force Stdd., Aug.-Oct.
Sri V. S. Yadav	USA	For equipment training, Aug.
Dr. S. K. Sharma	China	Attended 5th Asia Pacific electron microscopy conference, Aug.
Dr. O. P. Bahl	Australia	Attended international workshop on advances in inorganic fibre technology., Aug.
Sri D. C. Sharma	Germany	NPL-PTB (Ph.II), Tech,. Cooptn. Programme regarding training in Mass, Density & Viscosity stdds., Aug.-Sept.
Dr. D. R. Sharma	Germany	To work in assembling a combined equipment for SNMS/SIMS and RGA, Sept.-Feb.
Dr. M. M. Pradhan	Germany	Under CSIR-DAAD Exchange Programme, Oct.-Nov.
Sri V. Babu & Sri I. S. Taak	Germany & UK Netherland	NPL-PTB (Ph.II) T.C.P. for training in Flow Measurement, Sept.-Nov.

Dr. S. L. Dahake	Czechoslovakia & Germany	NPL-PTB (Ph.II) T.C.P. Sept.
Sri M. K. Mittal	Germany	NPL-PTB (Ph.II) T.C.P. for training in Power Energy Stdds.
Dr. Hari Kishan	France	Under French Govt. Fellowship, Sept.-Feb.
Dr. R. P. Singhal	Germany &	
Km. S. Rani	Switzerland	NPL-PTb (Ph.II) T.C.P. Sep.-Nov.
Dr. V. R. Singh	China	Attended international Congress of acoustics, Oct.
Dr. G.M. Saxena	France	Under CSIR-CNRS Exchange Programme, Oct.-Dec.
Dr. B. S. Mathur	S. Korea	Attended meeting of Asia-Pacific metrology Programme, Oct.
Dr. Krishan Lal	China	Attended CODATA task group meeting and conference, Oct.
Dr. H. C. Kandpal	USA	Under Indo-US, S & T Fellowship Scheme, Jan.
Dr. D. C. Parashar	Bangladesh & Netherland	Attended conference of Bangladesh chemical society and international workshop, Jan.
Dr. M. V. S. N. Prasad	Italy	Participated in the 3rd ICTP-URSI college, Feb:-Mar.
Smt. Rita Gupta	UK	Under Indo-UK project on Ultrasonic Stdd, Mar.

ACTUAL EXPENDITURE

(1992-93)

Budget Head	Rs. (Lakhs)
Salaries	744.922
Contingencies	128.748
Maintenance	10.966
Chemicals	82.459
Works etc.	43.019
Equipment	66.080
Other	45.595
Total	**1121.789**
Sponsored Projects	**209.635**



SPECIAL LECTURES

SPEAKER	TOPIC
Dr. R.A.Fouracre, University of Strathclyde, UK.	Ageing in dielectrics, April 10.
Prof. M.P.Das, Australian National University.	Hall anomaly-does it provide any clue to high Tc mechanism? April 18.
Dr. K.Hayashi, Gifu University, Japan.	Raman Spectroscopy studies of semiconductors, April 20.
Dr.C.S.Bhatia, Magnetic Recording Inst. of IBM USA.	Electron stimulated desorption studies of perfluorinated polyethylene lubricants, May 26.
Dr. R.N.Bhargawa, Phillips Laboratories, USA.	New Opportunities in blue UV/semiconductor lasers for high density optical recording, June 2 & 3.
Dr. R.Shashidhar, Naval Research Lab., Washington DC	Liquid crystal polymers, July 20.
Prof. P.K.John, University ofWestern Ontario, Canada.	Light localization, Aug. 18.
Dr. G.Love, University of Durham UK.	Some novel L.C Phase modulation devices, Oct. 1.
Mr. Seat conzine, California University, USA.	Strained-layer quantum wells for use in s emiconductor lasers, Oct. 19.
Dr. Ulnich Stumper, Head, RF & MW Standards, PTB, Germany.	Information on Germany calibration service (DKS) and national standards of RF, Power, Attenuation and Voltage, Oct. 22 & 26.
Dr. P. Chaudhari, Watson Research Centre, New York, USA.	Critical currents grain boundaries SQUID in cuprate superconductors, Nov. 5.
Dr. Han-III Yoo, Seoul National University, Korea	Cross effect between electron and ion flows in semiconducting Co_1-O_x, Nov. 6.
Prof. K.Samgwal, University of Dublin, Poland.	Chemical Etching, Nov. 18.
Prof. D.K.Ray, CNRS, France.	Some recent advances in the field of high Tc superconductor, Nov. 24.

Prof. R.Prasad, Telecommunication and Traffic Control systems, Netherland.	Code division multiple access systems for personal communication networks, Nov. 25.
Prof. J.N.Desai, Physical Research Lab., Ahmedabad.	Evolution, theory and technique of fabry-Perot spectroscopy PRI, Dec. 2, 8, 11, & 14.
Prof. A Mackay, University of London, UK.	Flexi-crystallography, Dec. 4.
Dr. S.Chandra, NASA, USA.	Antarctic zone hole, Dec. 23.
Prof. H. Tenstiege, Federal Inst. for material Research & Testing, Berlin	Spectral distribution of fluorescent lamps and simulation of day light and global radiation, jan. 4.
Prof. M.R.Kundu, University of Maryland, USA.	High energy solar physics via millimeter observations of solar flares, Jan. 20.
Prof. E.Gmelin, Max Plowek Inst., Stuttgant, Germany.	Low temperature calorimetry techniques, some new specific heat results and cryogenics, Feb. 23, 25, & Mar. 15.
Prof. Christopher, R. Low, Cambridge University, UK.	Biosensors, Mar. 23.

Ph.D's AWARDED

Name	Title	University	Guides
Pankaj Garg	Structural, Optical and electronic properties of composite ternary compound thin films and interface for photovoltaic applications.	Rajasthan	Dr. M.P.Saksena, Rajasthan University Dr. A.C. Rastogi, NPL
Sudip Ranjan Jha	Thermoelectric power studies on high Tc Superconductors	Delhi	Dr. R.G.Sharma, NPL Sh. R.Nath, Delhi University.
Renuka Rajput (Km.)	Thermoelectric power of BSCCO superconductors temperature variation and percolation aspect.	New Delhi	Dr. R.G. Sharma, NPL Sh. Deepak Kumar, JNU
Kanchan Saxena (Km.)	Studies on the properties and dynamics of molecular reorientation processes in ferroelectric liquid crystals.	Delhi	Dr. Rajrup, Delhi University. Dr. Subhas Chandra, NPL
V.D.Sharma	Ramcharitmanas mein vaigyanick tatva	Awadh	Dr. Ramashankar Tiwari, Retd. Principal
Rashmi Paul (Smt.)	Solar wind interaction at venus effects on dayside electron, ion and neutral temperatures.	Delhi	Dr. K.K.Mahajan, NPL. Prof. M.P.Srivastava, Delhi University.

HONOURS AWARDS

Prof. E.S.R. Gopal was elected the president of Indian Society of Mass Spectrometry for three years, Starting Ist July 1992.

Dr. A.V.Narlikar & Dr. K.K.Mahajan were elected as fellows of the Indian National Science Academy, New Delhi.

Dr. V.N. Ojha and Dr. S.M.Shiva-Prasad were awarded by the CSIR the young Scientist awards.

Dr. Ashok K. Gupta was awarded a prize of Rs. 7500/- by the Materials Research Society of India for contribution in the area of superconductivity.

Sh. M.K.Das Gupta received Technology Award of Rs. 25,000/- from FIE Research Foundation, Maharashtra for Development of 1, MN hydraulic multiplication system.

Dr. S.K.Sharma was nomiated as a member of committee of Asia Pacific Societies of Electron Microscopy (CAPSEM).

Dr. R.G.Sharma was elected as life member of the Instrument Society of India.

Dr. Ramkishore was awarded Associateship of crystal growth centre, Anna University, Madras.

Dr. Tuhi Ram Tyagi was elected co-chairman of the International Beacon Satellite studies group for a period of two years. 1993-94.

KRISHNAN MEMORIAL LECTURE

Prof. D.Kind, President, PTB Germany delivered the 23rd Krishnan Memorial Lecture on Feb 12, 1993 at 3.00 P.M. in the NPL Auditorium. The title of the lecture was "Current Trends towards National and International Metrology System".

Dr. S.K.Joshi, DGSIR, presided over the function. A memento "Sandalwood saraswati" was presented to Prof. D. Kind by Prof. E.S.R. Gopal, Director NPL, New Delhi. Large number of scientists, teachers, research scholars and other staff members from NPL attended the lecture.

RESEARCH COUNCIL

Prof. B.V.Sreekantan, Chairman
National Institute of Advance Studies.
C/O Indian Institute of Science.
Bangalore-560012

Prof. D.Chakraborty Member
Director,
Indian Association for the
Cultivation of Science,
Calcutta-700 032.

Prof. N.Kumar, Member
Deptt. of Physics,
Indian Institute of Science,
Bangalore-560 012.

Prof. P.K.Das Member
A-59, Kailash Colony,
New Delhi-110 048.

Sri K.R.Paramesvar, Member
8138, Pocket 11,
Sector B, Vasant Kunj,
New Delhi-110 030.

Lt. Gen. A.S.Bhullar (Retd.), Member
Director General,
Bureau of Indian Standards,
New Delhi-110 002.

Dr. R.Krishnan, Member
Director,
Gas Turbine Research
Establishment, C.V. Ramana Nagar,
Bangalore-560 093.

Sri N. Vittal, Member
Secretary,
Department of Electronics,
New Delhi-110 003.

Dr. W.S. Khokle, Member
Director,
Central Electronics Engineering
Research Instt.,
Pilani-333 031.

Prof. E.S.R.Gopal, Member
Director,
National Physical Laboratory,
New Delhi-110 -012.

Prof. C.K.Majumdar, Member
S.N.Bose National Centre for
Basic Sciences,
DB-17,Sector 1,
Salt Lake,
Calcutta-700 060.
DG's Nominee

Sri G.K. Arora, Non-Member Secty.
Scientist "F' NPL.

MANAGEMENT COUNCIL

Prof. E.S.R.Gopal, Chairman
Director,
National Physical Laboratory,
New Delhi-110 012.

Sri S.R.Taneja, Member
Scientist,
Central Scientific Instruments
Organisation,
Chandigarh-160 020.

Dr. J.K.N.Sharma, Member
Scientist, NPL,
New Delhi.

Dr. R.Bhattacharya, Member
Scientist, NPL,
New Delhi.

Dr. Ravi Mehrotra, Member
Scientist, NPL,
New Delhi.

Sri O.P.Kakkar, Member
SFAO, NPL,
New Delhi.

Dir. Gen., CSIR or Member
his nominee

Sri M.M.Sharma, Member Secty.
Sr. COA, NPL,
New Delhi.

TRAINING

1. Training in mass measurement was imparted to scientists from Saudi Arabia, Bangladesh, Nepal and Controllers of Weights & Measures Bangalore.

2. Two students from Technical institutes were provided training in instrumentation and electronics.

3. Mr. P.S.Robi of I.I.T. Bombay & Mr. Ravi Kumar of IISC, Bangalore were given assistance to extrusion work.

4. 13 students from different Engg. Institutes carried out project work towards fulfilment of their course.

5. 6 weeks training was given to Mr. Ashish Aggarwal, M.Sc. Student, M.D. University, Rohtak on EPR spectroscopy.

6. Common Wealth India Metrology (CIMET) Individual Training Workshop in metrology 1992 was organised for persons from Pakistan, Namibia, Ghana and Zimbabwe for three months

7. A two week training programme was organised for five persons from Philippines, Gambia, Kenya in the field of legal metrology sponsored by the Deptt. of weights & Measures.

8. A two week programme in temp standard was organised for an officer from BHEL, Jhansi.

9. One week programme in legal Metrology was conducted for two officers sponsored by Deptt. of legal metrology Karnataka.

10. A five week programme was organised for four persons of Saudi Arabia.

11. Two trainees from Pakistan were imparted three weeks training in AC/LF Voltage, current measurement, HF voltage and Power measurements.

12. One trainee from Ghana & other from Syria received training in AC and LF Voltage and current measurement.

13. Mr. Naveen Kumar from Delhi College of Engg. was provided training for one month.

SYMPOSIA

1. About 14 staff members were deputed to attend various symposia and workshops held with in India at BITS, Pilani from April 16 to 22.

   National Symposium on Photonics and Integrated Optics held at Bombay April 16 to 18.

   National Seminar on Vibrational Spectroscopy held at Modi Nagar (U.P.) May 9 to 10.

2. Workshop on Indian Reference Materials held at NPL on 5th & 6th Feb 1993.

   CSIR Golden Jubilee, International Conference of Heads of Scientific Agencies inaugural Function was held on 23-9-92.

   CSIR foundation day and concluding function was held on 26-9-92.

DISTINGUISHED VISITORS

1. Prof. Alan Mackay, FRS, Birkbeck College, University of London, Dec 2, 1992.

2. Mr. Tu. Hailin, Vice President General Research Institute for non-Ferrous Metals China with team, Feb 4, 1993.

3. Prof. Dr. Kamal Inan, Chairman Scientific and Technical Research Council, Turkey, Feb 26, 1993.

OPEN DAY

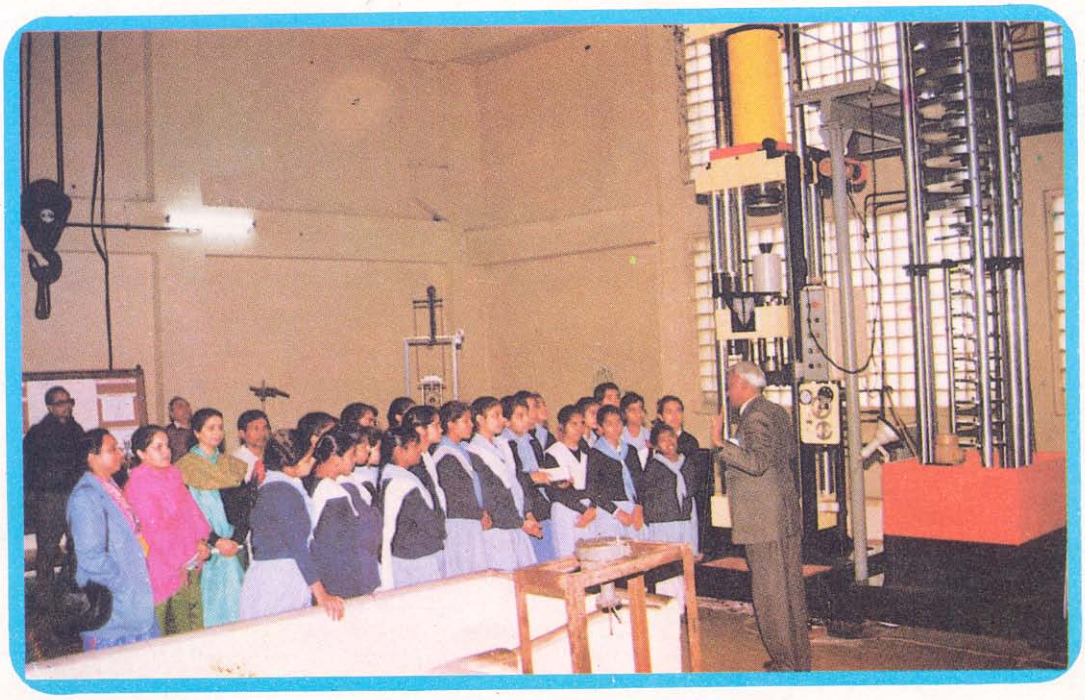
NPL observed its 'Open Day' on 15th January 1993 when all the activities were kept open for science students of senior classes from various schools and colleges of Delhi. About 2000 students accompanied with their teachers visited the various activities of the laboratory in a very disciplined manner.

Some of the activities which attracted the visitors most were planetarium, High Tc Superconductivity and Liquid Helium Plant, carbon fibre and composites, Glass technology, laser, ultrasonic motor, Scanning and transmission electron microscopes, X-ray, characterization of crystals, Antarctic studies, sodar, under water accoustics, green house molecules, satellite radio beacon etc. Film and video shows on various science topics were also arranged.

An exihibition was also arranged on this occasion wherein the activities were displayed using charts, photographs and demonstrations. Teams of volunteers of scientfic and technical staff were on their toes through out the day go guide and welcome the young guests.

Prof. E.S.R. Gopal, Director of the laboratory and many senior members of the staff were on supervision. The entire staff of the laboratory participated and contributed their best to the success of this function.

Adequate arrangements for drinking water, light food, tea and soft drinks were made for the visitors. One doctor with a team of first-aid volunteers and an ambulance were available to attend any emergent medical aid.



1. The students visiting the exhibition on the Open Day.

ABBREVIATIONS

AIIMS	:	All India Institute of Medical Sciences.
ARDB	:	Aeronautical Research Development Board.
ASCA	:	Asian Crystallographic Association.
BARC	:	Bbabha Atomic Research Centre.
BHEL	:	Bharat Heavy Electricals Ltd.
BIS	:	Bureau of Indian Standards.
BITS	:	Birla Institute of Science & Technology.
CCIR	:	International Radio Consultative Committee.
CEERI	:	Central Electronics Engineering Research Institute.
CEL	:	Central Electronics Ltd.
CFC	:	Chloro Fluoro Carbon.
CSIRO	:	Commonwealth Scientific and Industrial Research Organisation.
CSIR	:	Council of Scientific and Industrial Research.
CSIO	:	Central Scientific Instruments Organisation
DAAD	:	German Academic Exchange Service.
DMRL	:	Defence Metallurgical Research Laboratory.
DNES	:	Department of Non-Conventional Energy Sources.
DOD	:	Department of Ocean Development.
DOE	:	Department of Electronics.
DRDO	:	Defence Research and Development Organisation.
DST	:	Department of Science & Technology.
DXS	:	Diffuse X-ray Scattering.
EPR	:	Electron Paramagnetic Resonance.
FTIR	:	Fourier Transform Infrared.
IARI	:	Indian Agricultural Research Institute.
IIT	:	Indian Institute of Technology.
IISC	:	Indian Institute of Science.
IMD	:	Indian Meteorological Department.
INMARSAT	:	International Maritime Satellite.
INSA	:	Indian National Science Academy.
IPCL	:	Indian Petrochemicals Corporation Ltd.
IRDE	:	Instrument Research Development Establishment.
ISRO	:	Indian Space Research Organisation.
JNU	:	Jawaharlal Nehru University.
KDMIPE	:	K D Malviya Institute of Petroleum Exploration.
MCF	:	Master Control Facilities.
MST	:	Mesospheric Stratospheric & Tropospheric.
LOS	:	Line Of Site.
NBRI	:	National Botanical Research Institute.
NEERI	:	National Environmental Engineering Research Institute.
NCTCF	:	National Coordination of Testing and Calibration Facilities.
NGRI	:	National Geophysical Research Institute
NIAES	:	National Institute of Agro-Environmental Studies.
NIST	:	National Institute of Standards & Technology.
ONGC	:	Oil and Natural Gas Commission.
PTB	:	Physikalisch Technische Bundesanstalt, Braunschweig.
SEM	:	Scanning Electron Microscope.
SHAR	:	Shriharikota Rocket Launching Station.
STFS	:	Standard Time & Frequency Signal.
UCMS	:	University College of Medical Sciences.

4. Prof. E.S.R. Gopal, Director, Planting a sapling in the lawns during the Qaumi Ekta Week.

5. Inaugration of stds Block in TEC Building by Prof. D. Kind, PTB Germany.