SPIE Armenian Students Chapter's NEWSLETTER
№ 2: February 2010

Nanotechnology Application Centre

The "Nanotechnology Application Centre (NAC)" was established under the scientific leadership of Prof. Avinash Chandra Pandey in 2004 as a Department of Science & Technology funded research centre under Intensification of Research in High Priority Areas (IRHPA) scheme.

The Centre has focused research priorities and broad visions in frontline research and cutting edge technologies in the premier area of Nanoscience and Technology which includes nanoparticles for light emitting diodes (LEDs), Solar cells, Plasma Display Panel, Hyperthermia, MRI contrast agent, Targeted Drug Delivery, etc.

Pandey Avinash Chandra: MSc (Physics, Mathematics), MTech(Computer Science), DPhil, Associate (ICTP), Professor & Head of Department of Atmospheric & Ocean Sciences, University of Allahabad, and Principal Investigator in more than ten externally funded projects worth multi crore at K. Banerjee Centre of Atmospheric & Ocean Studies, M.N. Saha Centre of Space Studies and Nanophosphor Application Centre has built up at University of Allahabad two distinct groups dealing with various aspects of mathematical modeling of atmosphere and ocean with special reference to oceanic system memory and non-linear chaotic system.

He has promoted the growth of user facility and capacity building in front ranking areas by developing state of art facility through project funding that includes High Performance Computing Facility for Simulation Experiments, Wet Laboratory with clean room, Sophisticated Instrumentation including 300 KV HR TEM, SEM, AFM, STM, MFM, NSOM, Micro RAMAN, TMA/TG-DTA, Nano Indenter, XRD /SAXS, PL/PLE/UV-Vis spectrometer, High Performance Computing Facility for Simulation Experiments. He is currently applying his expertise of nano science in understanding the self assembly in diatoms.

His innovative leadership has resulted in creation of two new disciplines in Physics department as its off-shoots in University of Allahabad. In another significant achievement Prof. Pandey's proposal to fill the gap in accelerator grid in India through High Fluence Ion Beam Facility (Ion Implanter) in University System is a trend reversal.

Prof. Pandey has been involved with industrial research for over 10 years. Over the years, he has been involved in the research and development of opto-electronics including LEDs, medical research, electronic materials, optical recording, displays and nanotechnology. In 2004 he established Nanophosphor Application Center to develop applications of Nanophosphors and other Nanomaterials in the field of lighting, imaging and displays. Through his pioneering work on quantum confined atom based nanomaterials, he has been successful in modifying properties of a single atom by caging it in 2 nm nanocrystal. This is expected to impact next generation nanomaterials like nanophosphors, nanomagnets and their applications.

Prof. Pandey's publications are mostly related with synthesis and characterization of nanoparticles and surface modifications, with recent emphasis being on modifications at nanoscale using both the approaches viz. top-down and bottom-up. Many novel in-situ, online techniques (such as in-situ XRD, online ERDA and QMA) have been used in experiments related to swift heavy ions induced material engineering and characterization (SHIMEC). Many interesting new results have been reported from these studies such as formation of conducting carbon nano-wires, SHI induced ferromagnetism in fullerene films, anisotropic sputtering and carbon nano-tube formation on

HOPG surface. Many novel SPM variants such as Conducting-AFM, MFM, LFM have been used in the studies besides standard tool such as AFM, STM, PL, micro-Raman etc.

During the last five years Prof. Pandey has conducted research by guiding students in his projects and he mainly worked on the study of surface modifications and formation of various structures on HOPG in order to understand ion matter interactions and answer some of the basic questions: How does the electronic energy loss (Se) affect the surface morphology? How does the electronic energy loss (Se) affect the electronic structure? Does Sn play any role at all in the energy ranges where Se is dominant? What is the role of bonding structure on sputtering? Is the sputtering yield isotropic in all the directions or is it dependent on angle of measurement? Is it possible to create conducting tracks or magnetic ordering in HOPG or other similar carbon allotropes such as fullerenes? In another exhaustive work he has conducted systematic research on the "sputtering yield measurements" and understanding the ion solid interaction mechanism at nano-dimensional scale [in particular Nanometric Halide thin films (10-265 nm thin) of two stoichiometries (1:1 & 1:2)] by focusing on following aspects:

1) Dependence of electronic sputtering on charge state of ions.
2) Dependence of electronic sputtering on film growth parameters (grain size and thickness of the film and strain induced during film growth).
3) Dependence of electronic sputtering on the substrate.
4) Dependence of electronic sputtering on irradiation temperature and
5) In addition, SHI induced effects in nanometric thin films viz. structural (surface and depth) and optical modifications formed the matter of investigation.

A number of important findings listed below are the significant contribution to Science:

1) The dependence of electronic sputtering yield on stoichiometry, irradiation and growth parameters.
2) The variation in sputtering yield with grain size, thickness and its explanation.
3) Correlation between point defects/ dislocations/ strain induced and electronic sputter yield.
4) Dependence of electronic sputtering on charge state at equilibrium charge state /normal charge state.
5) Two-stage coloration process and formation of color centers, their relation with fluence and temperature.

Incorporation of impurities or defects into semiconductor lattices (dopants) can be used to control electrical conductivity, optical, luminescent, magnetic and other physical properties of the semiconductor depending on the type of impurity. Because of immense importance to understand doping in nanoscale semiconductors as this class of materials is going to evolve into practical applications in electronics and photonics applications an insight into the doping of compound semiconductor nanostructures and optimize the process with its properties has also been explored by Prof. Pandey in detail. To explore the same following aspects have been investigated:

a) Preparation of regular zinc oxide nanostructures on a thin film and a comparison of its properties with pure sample.

b) Preparation of doped zinc oxide by solid state reaction and optimization of reaction conditions with photoluminescence spectroscopy.

c) Recrystallization of Eu implanted zinc oxide films by Swift Heavy ions.

To improve upon the efficiency of the nano-system significantly by caging an atom in a nanocrystals referred as 'Quantum Confined Atom (QCA)' a DST funded research proposal has been implemented by Prof. Pandey. In QCA, a single atomic-ion is caged in a host-nanoparticle of 2-10nm and under the influence of the spatial-confinement provided by the host-nanoparticle, the properties of a single atomic ion are modified to achieve high quantum efficiency nanophosphors. Examples of such materials are ZnS:Mn2+, ZnO:Mn2+, Y2O3:Eu3 (line-emitters), etc. ternary QCA-system ZnOS, ZnCdS with impurities. The studies have focused on device applications in order to develop QCA-nano-phosphors for variety of applications like High Brightness Light Emitting Diodes for Solid-state White Lamps, Plasma Display Panels, Field Emission Displays, Down converter UV/ Blue LED's to white LED's, and in Biology like Drug Delivery System etc. One of the major goals is to develop nano-phosphors by artificially designing new materials by engineering of different properties like Band gap. The nano-materials so produced are characterized by in house different techniques such as X-ray Diffraction (XRD), Small Angle X-ray Scattering (SAXS), Transmission Electron Microscopy (TEM), Energy/ Wavelength Dispersive Analysis, Raman Scattering, Atomic Force Microscopy (AFM), Scanning Tunneling Microscopy (STM), X-ray Photoelectron Spectroscopy (XPS) -Vis Absorption Spectrophotometery, Near Field Optical Microscopy (NSOM) etc.

Infrastructure at NAC

Nanomaterial Characterization Facility

- X-ray Diffractometer (XRD)
- Small Angle X-ray Scattering (SAXS)
- Nanoindentor Florescence spectrometer (LS 55)
- UV-Vis spectrophotometer (Lambda 35)
- VUV spectrophotometer
- Differtial Scanning Calorimeter (DSC)
- Thermal Gravimetric Analyzer (TGA)
- Differential Thermal Analyzer (DTA)
- Micro Refrigerated Centrifuge
- Homogenizer
- LB Unit
- Spin Coating Unit
- Nano Solver Software

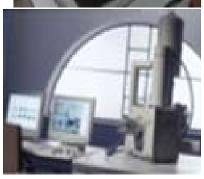
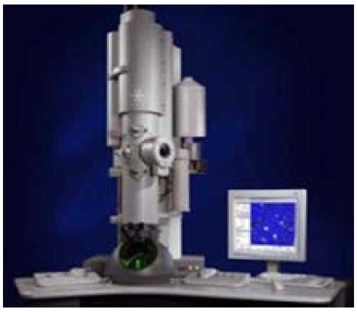
Microscopy facility at NAC

- High Resolution Transmission Electron Microscopy (HRTEM)
- Scanning Electron Microscope (SEM)
- NSOM with Confocal System
- Micro Raman Spectrometer
- Scanning Tunneling Microscope (STM)
- Atomic Force Microscope (AFM)

Wet Laboratory

- Clean Room of Class 1000
- Liquid Nitrogen Plant
- LB Unit for Thin Film Deposition
- Spin Coating Unit
- Laminar Flow Bench
- Tube Furness
- Desktop Cooling Centrifuge
- Fume Hood (s)
- Autoclave
- Incubators
- Microbalances
- Double Distillation Water Plant
- Drying Oven
- Vacuum Oven
- Digital pH Meter
- Ultrasonic Cleaner
- Homogenizer
- Glove Box with Coating



The Nanotechnology Application Center is visited by a number of great scholars from time to time that include Armenia, Canada, Germany, Italy, Japan, South Africa, United States, etc.

Nanotechnology Application Center, Allahabad, India.

University of Allahabad, India.

From left to right: Prof. Avinash Pandey, Dr. Sarita Tripathi, and Narine Gevorgyan. University of Allahabad, India.

Some paths to explore for Nanotechnology Applications

Magnetic Nanophosphors (MNP) can become a vehicle for highly efficient, targeted drug delivery systems and this application of MNP is being pursued vigorously by the scientific community in an effort to achieve a medical breakthrough for early detection (diagnosis) and treatment of cancer. Targeted drug delivery once proven will have many other medical applications because it will revolutionize the medical practice from a statistical mode as practiced today to a mode of greater specificity and greater certainty of the outcome.

NanoTechnology Application Center has demonstrated that when nanomagnets are deployed in Magnetic Resonance Imaging (MRI), a high contrast of cancerous tumor images in mice are revealed. Upon concentrating the nanomagnets with the use of external magnetic field, the MRI showed extraordinary details of the tumor. The tumor identification and drug delivery systems based on the use of MNP stem from significant advantages such as:

(i) the ability to target specific locations in the body

(ii) the reduction of the quantity of drug needed to attain a particular concentration in the vicinity of the target

(iii) the reduction of the concentration of the drug at non-target sites minimizing severe side effects.

The MNP developed at Centre have size in the range of few nm up to 20nm, which places them at dimensions that are smaller than or comparable to those of a cell (10–100 nm), a virus (20–450 nm), a protein (5–50 nm) or a gene (2nm wide and 10–100 nm long). This suggests that they can 'get close' to a biological entity of interest. Thus, MNP offer some attractive possibilities in biomedicine because:

(i) They can be functionalized with biological molecules to make them interact with or bind to a biological entity i.e. 'tagging' or addressing.

(ii) When functionalized MNP's are attached to a drug/antibody, the modified drug/antibody can be delivered precisely to a given location under external magnetic field. This reduces the dosage significantly and thereby minimizes the side effects to other organs.

(iii) They can be made to resonantly respond to a time-varying magnetic field, with advantageous results related to the transfer of energy in the form of heat from the magnetic nanoparticles to a cluster of cells in a tumor.

(iv) Since MNP's are magnetic and emit a strong characteristic light under exciting UV source, one can identify the spread of cancer in-vitro and during surgical procedure.

From left to right: Priya Mishra, Rupali Mishra, Monika Mall, Raghavendra Yadav, Manvendra Kumar, Prashant Sharma, Ranu Dutta, Ruchi Sethi, Sohan Lal Pradhan, Ashish Keshari, Vivek, Vyom Parashar. University of Allahabad, India.

Prof. Pandey has been involved in coordinating materials science research at Allahabad University in close collaboration with IUAC, and developing national user facility of international standards with state-of-art sophisticated equipments. When comparing Prof. Pandey with other people in this field, as well national as international people, one can adjudge Prof. Pandey among the best 10 people in this field worldwide, because of his extended experience in the field of material analysis and his innovative ideas for new applications.

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