

# School of Materials Science and Engineering National Institute of Technology Calicut

## Vision and Mission

**Vision:** Pioneering Innovations with passion for Knowledge

**Mission :** To develop high quality technical personnel with a sound footing on basic scientific and engineering principles, innovative research capabilities ,exemplary professional conduct and adherence to ethical values, who undertake a leadership role in applying Nanoscience and Nanotechnology for the progress of mankind

## Profile

The School of Materials Science and Engineering (SMSE) at National Institute of Technology Calicut (NITC), India, fosters a scientific community dedicated to higher learning and research in Nanotechnology. The faculty, students and research scholars are involved in learning and research to explore, understand and improve materials, processes and systems, with a fundamental perspective. The varied interests of the school include study and application of nanoscale physical phenomena in engineering systems, development of nanomaterials for targeted drug delivery, investigations on carbon nanotubes, optical measurements in size-affected domains, exploration of combustion and nanoparticle fuel additives, and discrete computation to predict the structure and behavior of nanosized systems. The school conducts a full-time four-semester Master of Technology program in Nanotechnology, as well as research programs leading to Doctoral degree. Apart from academic research, the school also carries out funded research projects sponsored by various research agencies and industries.

## History

SNST was established as an independent School at NITC in 2009, prior to which the faculty members of the school had been pursuing research in Nanotechnology at other departments of the institute. A Nanotechnology Research Laboratory was functioning at the institute since 2005, and a Master's Program was started in Nanotechnology in 2008, both under the department of Mechanical Engineering. Subsequent to the formation of the School, these were brought under it. The activities were further expanded by establishing various laboratories pertaining to different streams of work. Presently there are five research laboratories in the School. It also coordinates the Microscopy Center of the institute. The School functions in collaboration with the other departments of the institute through academic courses, interdisciplinary student research projects and collaborative research with faculty members. Most of the alumni of the school have opted for higher studies and research careers. The school has ongoing collaborative research with prominent universities and institutes at the international level.

### Faculty

#### **C. B. Sobhan, Ph. D., Professor**

Ph. D. Mechanical Engineering (Heat Transfer), IIT Madras, India

**Post Doctoral Research:** Purdue University, USA

#### **Research Areas:**

Microscale and Nanoscale Heat Transfer, Thermal Phenomena in Nanofluids, Optical Measurements ,M.D, Carbon Nanotubes

#### **Visiting Fellowships/Visiting Faculty**

**Assignments:** NTU Singapore, University of Wisconsin, USA Rensselaer Polytechnic Institute, USA

University of Colorado, USA  
Georgia Institute of Technology, USA

(collaborative research with President G. P. Peterson)

#### **N. Sandhyarani, Ph.D., Professor**

Ph. D. Chemistry (Nanomaterials), IIT Madras, India

#### **Post Doctoral Research:**

University of Notre Dame, USA Cornell University, USA

#### **Research Areas:**

Nanomaterials for Energy and Environmental Remediation Nano-enabled Sensors, Targeted Drug Delivery Systems

#### **Soney Varghese, Ph.D., Associate Professor**

Ph.D. Chemistry (Nanofabrication) University of Eindhoven, The Netherlands

#### **Research Areas:**

Characterization of Nanopatterns, Liquid Crystal Display Conducting Polymers

#### **V. Sajith, Ph.D., Associate Professor**

Ph.D. Mechanical Engineering (Optical Measurements), NIT Calicut, India

#### **Research Areas:**

Optical Measurements, Microchannel flows, Nanofluids Nanotechnology in Combustion and Fuels, IC Engines

#### **T. Hanas, Ph.D., Assistant Professor**

Ph.D. Materials Science, IIT Madras, India

#### **Research Area**

Bionanomaterials

#### **Shijo Thomas, Ph.D., Assistant Professor**

Ph.D. Mechanical Engineering , NIT Calicut, India

#### **Aparna Zagabathuni, Ph.D., Assistant Professor**

Ph.D. Mechanical Engineering , IIT Kharagpur, India

#### **Vinod E. Madhavan, Ph.D., Assistant Professor**

Ph.D. Physics, IISc, Bangalore, India

#### **C.N. Shyam Kumar, Ph.D., Assistant Professor**

Ph.D. Mechanical Engineering , Technical University Darmstadt, India



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## Academic Programs

### Doctoral Degree Program

Candidates with Master's degree in various streams of science and engineering can perform research leading to Ph.D. degree at the School. The Doctoral research scholars are Master's degree holders in different

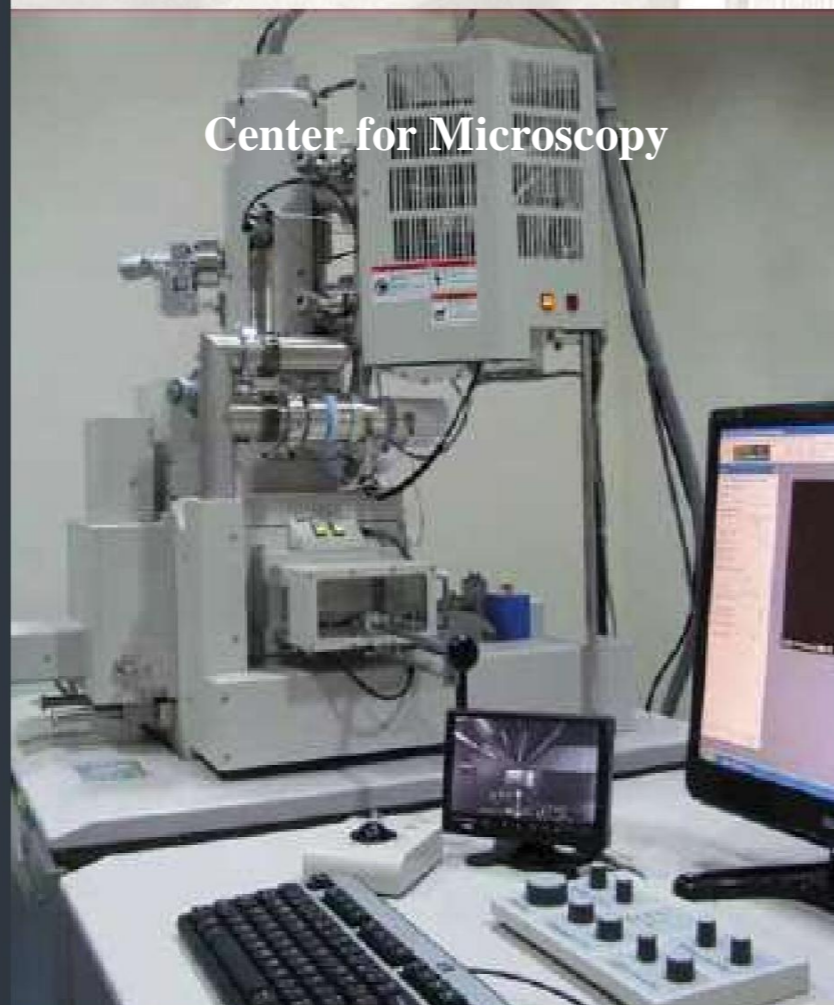
Engineering branches, Materials Science, Nanotechnology, Physics and Chemistry. Being an interdisciplinary School, there is large flexibility in the background disciplines of the candidates. All selected research scholars are entitled to fellowships from the Government of India. Project Associates working in the funded projects in the School also can enroll for the Ph.D. program, if they meet the academic eligibility criteria.

### Master of Technology Program

The Master of Technology (M.Tech.) program in Nanotechnology is designed to impart state-of the art knowledge, and has an objective of training the students to make them capable of addressing the challenges of the emerging technological field of Nanotechnology. The program is offered to students with a Bachelor Degree in Mechanical/Production/Chemical/Civil Engineering. Students are selected based on their performance in the national level Graduate Aptitude Test in Engineering (GATE) and is provided with the National Scholarship. The program consists of two semesters of course work and two semesters of project work. The course work emphasizes on the fundamentals and applications of the subject. The study materials include subjects such as

Physics of Materials, Thermodynamics of Nanomaterials and Systems, Microscale and Nanoscale Heat Transfer, Nanosized Structures, Experimental Techniques in Nanotechnology and Micro Electro Mechanical Systems, and a number of elective subjects ranging from Computational Nanotechnology to Composite Materials from which students can choose, according to their background and interest. Laboratory courses dealing with production, characterization and application of nanoparticles, nanofluids and nanocomposites as well as giving exposure to discrete computational analysis of nanoscale phenomena are also offered as part of the curriculum. The specialization in Nanotechnology holds a very high potential for employment in research organizations, academics and industries, as well as provides a gateway to pursue higher research in various sub-topics of Nanotechnology.

## Center for Microscopy



Center for Microscopy houses a high resolution Scanning Electron Microscope and an Atomic Force Microscope

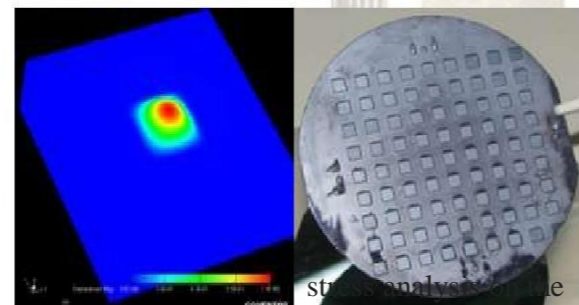


## RESEARCH

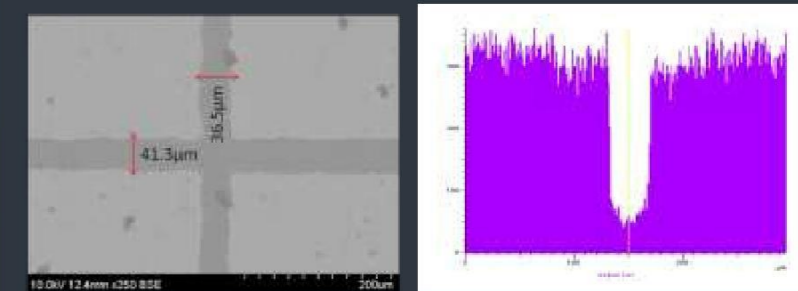
### Investigations on Micropatterning and Liquid Crystals (Nano and Display Research Laboratory)

The key areas of work in the laboratory are:

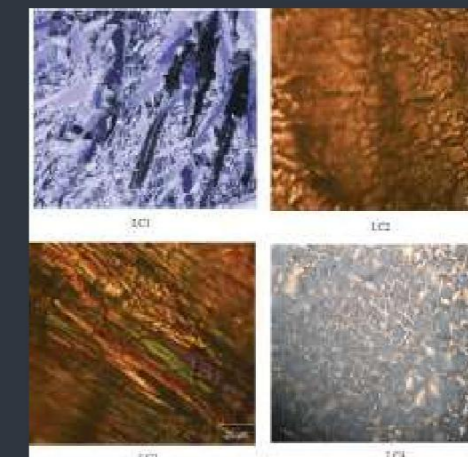
- Berkovich nano-indentation on polymer-CNT nanocomposites to study the stress strain behavior of thin films.
- Micropatterning of transparent electrodes using laser ablation for in-plane switching liquid crystal displays
- Development of thermotropic liquid crystals for non-linear optics.
- Investigations on pressure sensor based Piezoresistive behaviour of Polysilicon film on Si <100> for MEMS devices.



stress analysis of a fabricated array of bulk micromachined diaphragms on silicon by the back to front alignment



SEM image of the laser ablated ITO pattern and its EDS elemental (In,Tn) scan across the pattern.

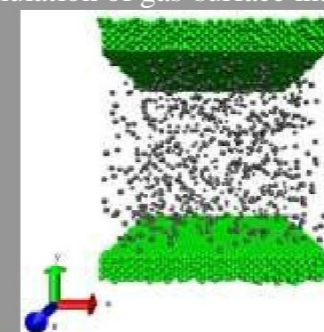


Polarized optical microscopy images of different liquid crystals developed at the Display Research Laboratory exhibiting non linear optical behavior

### Simulation of Nanoscale Phenomena (Computational Nanotechnology Laboratory)

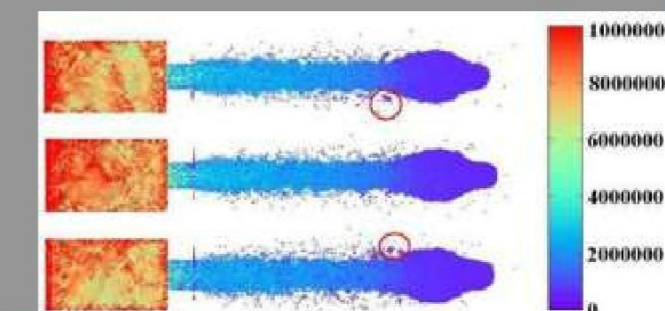
- Direct imulation Monte Carlo (DSMC) analysis of solid rocket motor (SRM) exhaust
- Thermal modeling of carbon nanotube based electronic devices
- Molecular Dynamics (MD) simulation of gas-surface interaction at nanoscale
- Molecular Dynamics simulation of transport properties, and transport through nanostructures

MD simulation of gas-surface interactions



### Funded Project

DSMC Simulations of Solid Rocket Exhaust Plumes, Aerospace Research and Development Board, Government of India.



MD simulation of Nanojets

The course structure and the syllabi of B.Tech. MSE is designed to provide an in-depth understanding and hands-on research experience in the advanced materials technology with an emphasis on rapidly growing areas such as health care, polymer, energy and environment. In addition to the theory/laboratory courses, the students will take up a major theoretical/experimental project in the final year related to materials science and engineering. The program provides a solid platform to develop critical thinking, problem-solving skills, communication skills and project management. Graduates of this programme will be ready to take up jobs in industry (energy, environment, polymer/rubber, healthcare, nanotechnology, etc.), as well as to develop a research-based career.

## RESEARCH

### *Application of Catalytic Nanoparticles in Hydrocarbon Fuels (Fuels and Combustion Laboratory)*

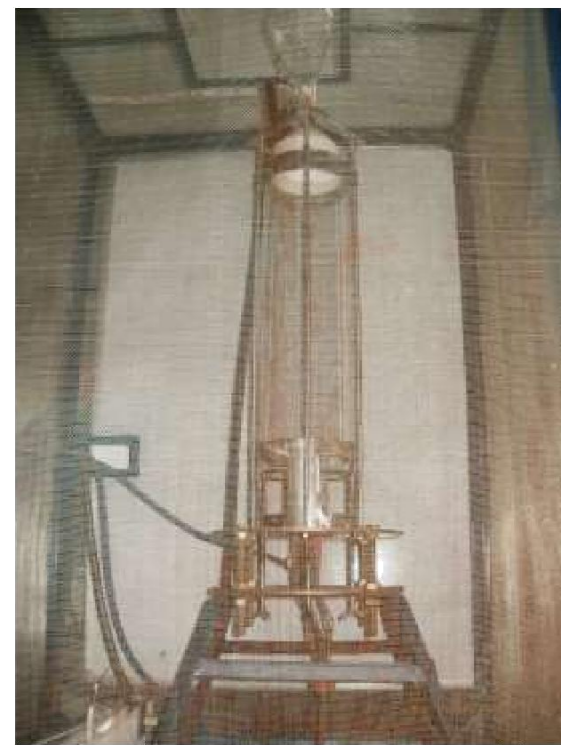


Catalytic oxide nanoparticles synthesized through chemical route

The aim of the research is to obtain results that will help in understanding the effect of nanoparticle additives on Diesel and Biodiesel in improving the energy conversion capability and reducing the level of harmful emissions from the engine. The use of certain oxide catalysts in the nanopowder form is found to enhance the combustion phenomenon, while considerably reducing emissions.

The extensive investigation involves preparation of the catalytic nanoparticles by chemical and physical synthesis methods, their characterization, blending and stabilization in fuels, quantification of the modified fuel in engines, fundamental analysis of the combustion flames using optical measurements, study on impact on engine parts, and toxicological effects on the emission.

Monochrome schlieren system and test rig for flame analysis



Flame Pyrolysis of catalytic nanoparticles

## LABORATORIES AND FACILITIES

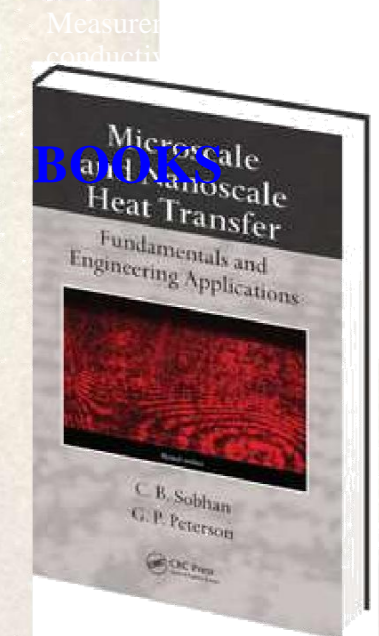
- **Nanotechnology Research Laboratory:** Focuses on Nanofluids, Thermal engineering applications, Thermophysical property measurement, Carbon Nanotechnology. (Dr C B Sobhan)
- **Nanoscience Research Laboratory:** Involved in research on Bio-sensors, Targeted drug delivery systems, Environmental problems. (Dr N Sandhyarani)
- **Fuels and Combustion Laboratory:** Dedicated to research on the application of nanotechnology in fuels, leading to efficient combustion and reduction of emission. (Dr Sajith V)
- **Nano and Display Research Laboratory:** Carries out research in nanopatterning, Non-linear optics applications and Liquid crystal Displays. (Dr Soney Varghese)
- **Computational Nanotechnology Laboratory:** Focuses on discrete computational methods for the simulation and analysis of nanoscale phenomena. (Dr Sarith P Sathian)
- **The Microscopy Center** houses a high resolution Scanning Electron Microscope and an Atomic Force Microscope. (Dr Soney Varghes)



Chemical Vapor Deposition of carbon nanotubes

## INTERNATIONAL COLLABORATION

- **Georgia Institute of Technology, USA:** Two Phase Heat Transfer Laboratory, George W. Woodruff School of Mechanical Engineering. The research group is headed by **Professor G. P. Peterson, President, Georgia Tech.**
- **Purdue University, USA:** Cooling Technologies Research Center, School of Mechanical Engineering. Collaboration with the Center headed by **Professor Suresh V. Garimella,** Distinguished Professor, Purdue University.
- **Rice University, USA:** Research group headed by **Professor Pulickel M. Ajayan,** Benjamin M. and Mary Greenwood Anderson Professor of Engineering and Material Science. Department of Mechanical Engineering and Materials Science.



C. B. Sobhan and G. P. Peterson, *Microscale and Nanoscale Heat Transfer: Fundamentals and Engineering Applications*, CRC Press/Taylor and Francis, USA (2008)

V. Sajith and Shijo Thomas, *Internal Combustion Engines*, Oxford University Press, 2017

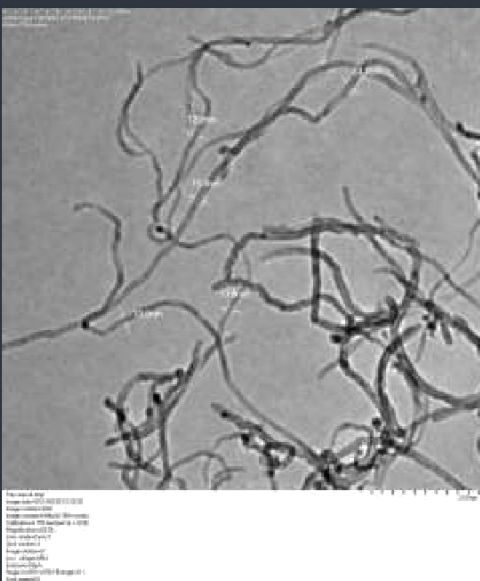
## Funded Research Project

- Investigations on the application of catalytic nanoparticles as diesel and biodiesel additives: Funded by Hindustan Petroleum Corporation, Government of India

## Convection studies in nanofluid loops

## Funded Research Projects

- Experimental studies on convective heat transfer performance of water-based nanofluids in liquid loops, Board of Research in Nuclear Science, Government of India
- Design, development and optimization of miniature and micro heat pipes for thermal management of avionic devices, Aerospace Research and Development Board, Government of India
- Development and application of water-based nanofluids as coolants for steel industry, Tata Steel, India



Transmission Electron Micrograph of Carbon Nanotubes synthesized in the Nanotechnology Research Laboratory using Chemical Vapor Deposition method

## RESEARCH

### Nanofluids and Engineering Applications (Nanotechnology Research Laboratory)

Extensive investigations are being conducted on the application of nanofluids as coolants in engineering systems. Research involves studies on forced and free convection loops with nanofluids, application of nanoparticles in lubricating oils and refrigerants, measurement of thermophysical properties of nanofluids, preparation of stabilized nanofluids and their characterization, and experiments on heat transfer phenomena in nanofluids such as evaporation and boiling. Theoretical studies using molecular dynamic simulation and multi-scale modeling of thermal phenomena are also performed. Optical measurements such as laser interferometry are applied to dilute nanofluids to analyze their heat transfer behavior in size-affected domains. Research is also ongoing in related areas such as microchannels and micro heat pipes, focusing on the applicability of nanofluids as working media.

### Carbon Nanotube Synthesis (Nanotechnology Research Laboratory)

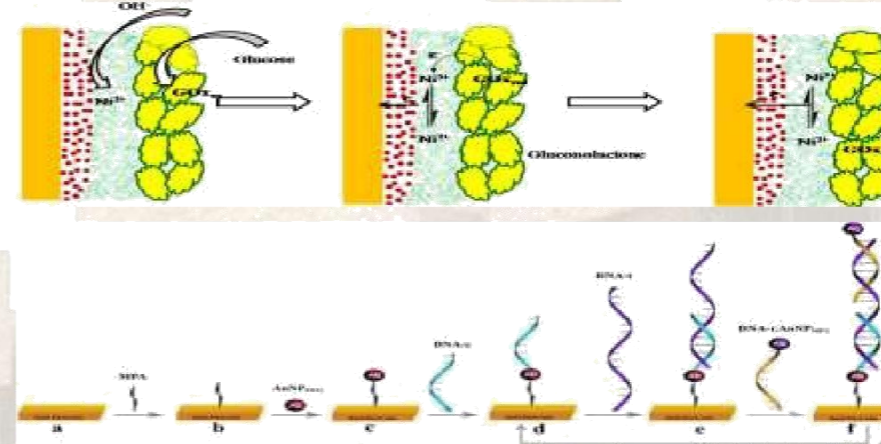
Theoretical and experimental investigations on the synthesis of carbon nanotubes using chemical vapor deposition are being performed in the Nanotechnology Research Laboratory. The theoretical studies involve chemical kinetics modeling to predict the deposition parameters, and molecular modeling to simulate the deposition process of carbon nanotubes. Results have been benchmarked using a chemical vapor deposition system developed in the lab. The research work is primarily focused on optimizing the process of CVD synthesis, based on the results of the theoretical model. Current work involves investigations on aspects such as the structure and defects in carbon nanotubes through appropriate modeling techniques.



## RESEARCH

### Development of Biosensors Using Engineered Nanoparticulate Systems (Nanoscience Research Laboratory)

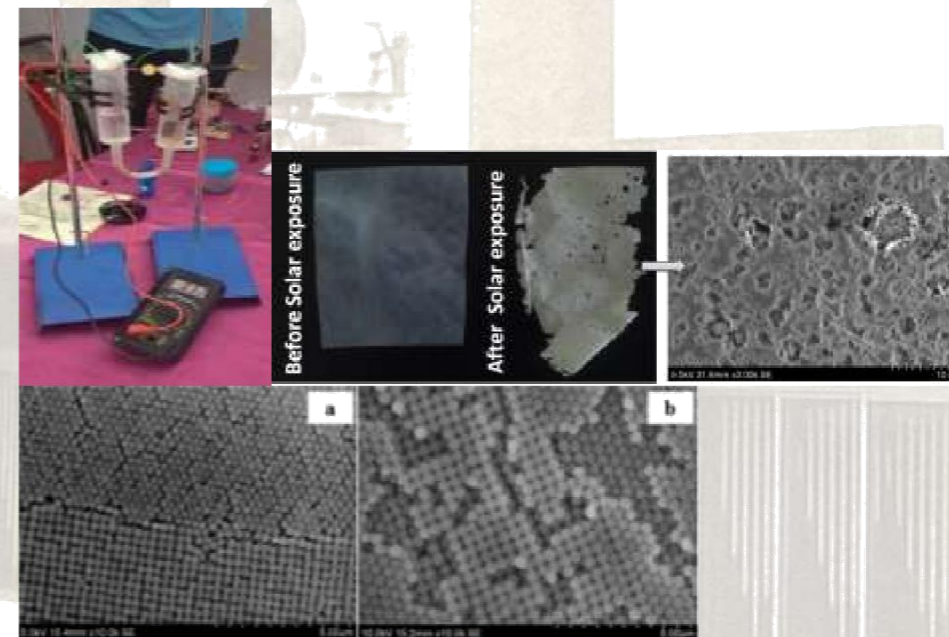
Research work is in progress to develop sensitive, reproducible and selective sensor surfaces. Engineering low cost biosensor surfaces using different nanostructures like gold nanoparticles, gold nanorods, silver nanoparticles and carbon nanotubes is also being done.



Glucose Sensor surface and DNA sensor surfaces

### Development of Nanomaterials for Energy and Environment (Nanoscience Research Laboratory)

The versatility of nanomaterials is being exploited for their applications in the search for alternative energy sources like anodes for fuel cells development of photonic crystals directed towards quick dye degradation, polythene degradation and heavy metal adsorption. The development of energy storage devices like supercapacitors is also being explored.



Working model of the fuel cell and SEM images of the degraded Polythene and Colloidal Photonic Crystals developed in the Nanoscience Research Laboratory

## Nanomaterials Based Sensor for Early Diagnosis of Cancer

Early detection is a prerequisite to the effective reduction of morbidity and mortality from any type of cancer. The Nanoscience Research Laboratory is performing research on developing a nanotechnology based sensor for the detection of different types of cancer from blood samples of the patient in a simple and easy method. The nanoparticle based sensor is like a Biochip with anti-tumor markers coated on it, which provides a method for qualitative and quantitative detection of different tumor markers.

## Funded Research Projects

- Multifunctional Plasmonic Nanoparticles and Nanocomposites for Targeted Drug Delivery: Synthesis, Evaluation and Toxicological Studies, Department of Biotechnology, Government of India
- Enhancement of the sensitivity of peptide nanotube based biosensors using metal nanoclusters, Department of Science and Technology, Government of India

## Environmental Nanotechnology (Nanoscience Research Laboratory)

CVD Furnace for investigations on optimal synthesis of carbon nanotubes

