Nanotechnology Initiatives by Department of Information Technology, Government of India

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Abstract

India recognizing the importance and value of the nanotechnology for its national development initiated concentrated nanotechnology development programs. This paper gives an account of the nanotechnology initiatives of Department of Information Technology (DIT), Ministry of Communications and Information Technology (MCIT), Government of India.

Key words: nanotechnology, nanoelectronics, nanometrology, centers of excellence, incubation, commercialization

1. Perspective

Government of India has realized the importance of nanotechnology for national development and initiated R&D programs on nanotechnology. The two major programs in India are by Ministry of Science and Technology, and Department of Information Technology, Ministry of Communications and Information Technology while there are also activities initiated by other agencies like Department of Science and Industrial Research.

The Nanotechnology Initiatives Program of Department of Information Technology (DIT) was initiated in 2004 and has been mainly concentrating on nano-electronics aspects. The focus of the program initially is on Institutional capacity building, human resource development, Infrastructure creation and research & development in nano-electronics and nanometrology. The program includes establishment of major centers on nanoelectronics and nanometrology, initiation of R&D projects at academic & R&D organizations across the country and Indian Nanoelectronics User Programs. In the long run, the program is expected to create a synergetic environment for creation of vibrant nanotechnology industry in the country.

2. Centers of Excellence in Nanoelectronics

Technology to manipulate and study matter at small dimensions has grown significantly over the past few years. Several research areas such as MEMS, NEMS, photonics, integrated devices for optical & RF communications, novel silicon electronic devices, bio-MEMS devices to handle and manipulate biological materials in vivo, smart sensors to detect small quantities of toxic gases and harmful germs are driven by practical requirements. There is also opportunity for a deeper understanding of the behavior of materials as a function of their structure at scales between molecular and macro scales. All these endeavors have one thing in common –the availability of a modern, flexible micro and nano processing facility, which enables fabrication of the devices on various substrates.

With this in view, setting of two Centers of Excellence on Nanoelectronics at Indian Institute of Technology Bombay (IIT Bombay) and Indian Institute of Science Bangalore (IISc) was initiated with a cost of Rs. 100 Crores (about US$ 20 million) in the year 2005. The broad objectives of these Centers are as follows:

- Embark on R&D activities in the areas of nanoelectronics including materials, devices and sensors, nanosystems and their characterization and modeling.
- Networking with other agencies, institutions, national labs and industry working in the area of nanoelectronics and create a nanofabrication facility accessible to all researchers
- Generate trained human resources suitable for nanoelectronics research, engineering and manufacturing

- Demonstrate that the nanofab facilities created and human resources generated can be used to develop socially relevant systems with nanostructured materials and systems.
- The deliverables at the Center of Excellence at IIT Bombay include development and establishment of sub 100 nanometer CMOS process, development of nanosystems for Healthcare and environmental monitoring, development of organic and biopolymer devices, GaN devices, and characterization, modeling and simulation of nanoelectronic devices
- The deliverables at IISc include magnetic materials for LC resonator, acoustic sensors, ferroelectrics for FRAMs and phase shifters, rare earth metal oxides for MOS gate dielectrics, molecular rectifiers based on organic thin films.

3. Nanometrology for Nanotechnology

In order to implement the Nanotechnology development program successfully, nanometrology (science of measurement at nanoscales) is a critical requirement. The general trend towards increased miniaturization in manufacturing to micro to nano is not simply a scale problem, but involves facing new physics. For example, the surface of an object considered smooth at micro scale, can no longer be considered smooth at nano scale but is a chaotic rough spread of molecules. The techniques to deal with such materials are entirely new and as a consequence, the methods of measurement and testing have to change drastically and this is a major challenge to nano-metrology.

A project has been taken up at National Physical Laboratory, New Delhi to address the issues of nanometrology by establishing a National nanometorlogy laboratory. This laboratory continuously develops both facilities and expertise in tune with new developments in instrumentation & metrology for measurement of properties at nanoscale such as Nano-characterization, Nano-mechanics, Nanoelectronics, nano-magnetics& nano-photonics, Nanofabrication and Nano-manufacturing. This laboratory is also expected to significantly contribute to research and development of computational tools & techniques for nanometrology.

This laboratory provides calibration and traceability for physical dimensions like linewidth, step height, surface texture and calibration of electrical parameters like low voltages in nanovolts, low currents in picoamperes, electric charge in fC. This laboratory is expected to caters to the nanoscale measurements for various industrial applications including automotive, biomedical and semiconductor industry. This facility would actively participate in the development of international standards on Nanotechnology and inclusion of India specific requirements. This laboratory is providing training to scientists and engineers on nanometrology and collaborating with various organizations in the R&D work on nanometrology. A Software has been developed for calculating uncertainty in measurements at nanoscale.

4. Indian Nanoelectronics User Program

The Indian Nanoelectronics User Program (INUP) has conceived and initiated by the Department of IT to facilitate and support generation in India of expertise and knowledge in nanoelectronics through participation and utilization of the facilities established at the Centres of Excellence in Nanoelectronics at IISc and IIT Bombay by external users. The program aims to:

- Impart hands-on training in nanoelectronics to researchers from other institutions in the country and help train researchers in Nanoelectronics. Users from academic, research and industrial R&D institutions will be trained through this project at three levels.
    - Short term workshops to disseminate the outcome of the research activities. These workshop are also expected to provide exposure and awareness.
    - Hands-on training for selected researchers
    - Execution of collaborative research projects by external users by providing support for fabrication and expert guidance
- Assist in the initiation of research in nanoelectronics at various institutions in

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the country by enabling the execution of the work of external users at these centres

- Collaborate with research teams at various Indian organizations and develop joint projects in nanoelectronics.
- Provide a platform for researchers in Naoelectronics to come together and benefit from complementary expertise.
- This INUP programme aims to generate more than 750 trained students, professional scientists and engineers etc at various levels and take up about 40 research projects in nanoelectronics

5. Nanoelectronics Technology Development

The Department of Information Technology has taken up quite a few projects on nanoelectronics/nanotechnology at various academic and research organizations in the country (India) for creation of infrastructrure and technology development. These include projects at Indian Institutes of Technology at New Delhi, Chennai, Mumbai, Kanpur, Kharagpur and Roorkee, IISc Bangalore, MET Pune, CEERI Pilani, CSIO Chandigarh, Punjab University, Jadavpur University Kolkata, Jamia Milia Islamia, Visvevaraya Institute of Technology Nagpur etc. The R&D areas include carbon nanotubes for drug delivery and other applications; nano silver oxides for optical memories; synthesis of nano particles of noble and transition metals for applications in electronic packaging and optoelectronics; tin oxide powders and films for gas sensing applications; novel nano-structured ceramics for gas sensing applications; nanostructured silicon MEMS for pressure sensors; quantum well infrared photo detectors with Si/SiGe nanostructures; organic thin film transistors; characterization, modeling and simulation techniques and software for nanostructures and nanodevices; Some of the technologies developed are as follows:

- Porous nanocrystalline silicon for MEMS pressure sensors
- A process for the generation of Silver Nano powder at 200gms batch level useful for electronic packaging and optoelectronics.
- Technology for growing size and shape controlled Ge quantum dots with excellent optical properties
- Technology for fast and stable dispersion and functionalization of Carban Nano Tubes(CNTs)
- Technology for interfacing bio-molecules and quantum dots with CNTs for applications in predictive diagnosis and preventive treatment including drug delivery
- A complete bio-sensor platform for cardiac diagnostics suitable for integration towards a complete lab-on-chip development for cardiac diagnostics
- A Silicon Locket for efficient and intelligent remote health care system for cardiac diagnostics, embedded into an ultra small form factor.
- Silicon nano particles synthesized on silicon substrate with different insulating layers SiO_2/Si_3N_4, by two different processes viz. LPCVD and PECVD
- Software for the calculation of nano measurement uncertainty

6. Patents

Generation of intellectual Property and Patents is emphasized in the R&D projects. Some of the patents filed recently are as below:

- Single Halo DeMOS for robust protection in advanced high voltage CMOS
- A DeMOS Device realized using dual STI process
- Microheater based explosive sensor
- Independently Driven Double Gate (IDDG) nonvolatile floating gate analog memory cell
- Method and device for determining ionizing radiation
- A novel dry method of surface modification of SU8 for immobilization of biomolecules using hotwire pyrolytic process

- Method for doping a fin based semiconductor device
- Integrated pressure and temperature sensor based on porous silicon

7. Industry Participation and Commercialization

While the R&D infrastructure is established, the Department of Information Technology is now contemplating and focusing on development of technology and products for practical applications, commercialization and industry promotion of nanotechnology. A framework is to be put in place for participation of industry both in pre-competitive and competitive research and development. A mechanism for incubation is being contemplated for encouraging new enterprises on nanotechnology.

8. Summary and conclusion

Department of Information Technology, Government of India has made concerted efforts for establishing Nanotechnology and Nanoelectronics base in the country for technology and product development. Two Centers of Excellence in Nanoelectronics have been established and facilities have also been established across the country for technology development. Now, attention is focused on commercialization of technologies, industry promotion and industry participation.

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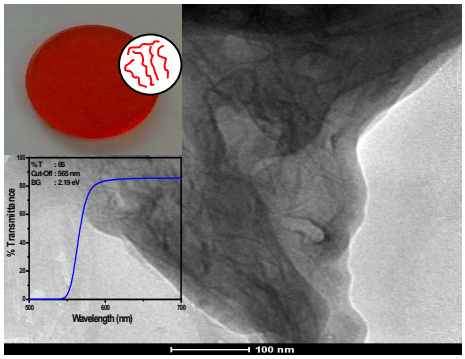
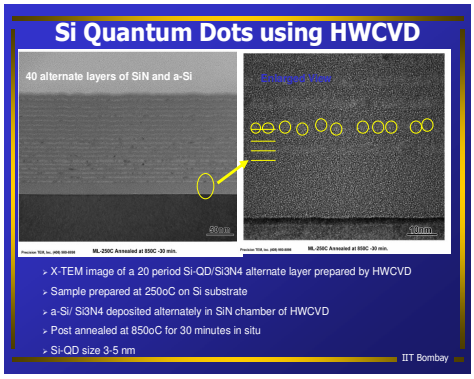
Nanoelectronics Center IIT Bombay



Q-CdSSe-Semiconductor-glass nanocomposite



Silicon Q dots 3-5nm at IIT Bombay

Transferred Arc Plasma System C-MET Pune