Approval: 6th Senate Meeting

Course Name : Nano Electronics and Nano –Microfabrication
Course Number : EE-615
Credits : 3-0-0-3
Prerequisites : IC 161-Applied Electronics, EE XX2 Microelectronics Circuits Design Practicum (MCDP), EE XX1 Electronics Devices, PH 501 Solid State Physics
Intended for : UG/MS/PhD
Elective or Core : Elective
Semester : Odd/Even

Preamble: The rapid growth of the integrated circuit (IC) industry has led to the emergence of nano microelectronics process engineering as a new advanced discipline. Thus, there is a need to impart quality education at a sufficiently advanced level in the current state of art Nano electronics and Nano Micro Fabrication and design discipline.

This elective course will help to UG/MS/PhD students earn the basic understanding of nano electronics and followed the advanced understanding of the nano-micro fabrication. It provides a advanced level vast understanding to the device electronics for integrated circuits, a foundation for the device fabrication and various application in the field of sensors technology, optoelectronics, communication and nanotechnology etc.

Learning outcomes of this course are anticipated as follows:

- Students will understand the divers electronic device fabrication.
- Students will have in-depth technical knowledge in one or more areas of specialization.
- Students will have practical understanding of the major engineering concepts and demonstrate application of their theoretical knowledge of the concepts and help to get the academic and industrial jobs.
- Students will be able to interact scientifically with industry both within and outside of a classroom setting.
- Students will develop an appreciation of continuing educational and professional development.
- Students will appreciate their role as engineers in society.

Course Outline:

Nano Electronics and Nano Microfabrication course is designed to encompass all these aspects, viz., nano and micro regime design, simulation and fabrication and all types of IC's, microfludics. It is expected that, after undergoing this course, the students will acquire both theoretical knowledge and practical skills in diverse upcoming areas of current technology and will be able to get into any one of these areas or be a bridge between these advanced areas to face the upcoming challenges and up-liftment of society.

Course Modules:

Unit-I: Tunnel junction and applications of tunneling, Tunneling Through a Potential Barrier, Metal—Insulator, Metal-Semiconductor, and Metal-Insulator-Metal Junctions, Coulomb Blockade, Tunnel Junctions, Tunnel Junction Excited by a Current Source. Spintronics and Foundations of nano-photonics. [6 hrs]

Unit-II: Field Emission, Gate—Oxide Tunneling and Hot Electron Effects in nano MOSFETs, Theory of Scanning Tunneling Microscope, Double Barrier Tunneling and the Resonant Tunneling Diode. [6 hrs]

Unit-III: Introduction to lithography- Contact, proximity printing and Projection Printing, Resolution Enhancement techniques, overlay-accuracies, Mask-Error enhancement factor (MEEF), Positive and negative photoresists, Electron Lithography, Projection Printing, Direct writing, Electron resists. Lithography based on Surface Instabilities: Wetting, De-wetting, Adhesion, Limitations, Resolution and Achievable / line widths etc. Lift off process, Bulk Micro machining. [8 hrs]

Unit-IV: Introduction to MEMS and NEMS, working principles, as micro sensors (acoustic wave sensor, biomedical and biosensor, chemical sensor, optical sensor, capacitive sensor, pressure sensor and thermal sensor), micro actuation (thermal actuation, piezoelectric actuation and electrostatic actuation–micro gripers, motors, valves, pumps, accelerometers, fluidics and capillary electrophoresis, active and passive micro fluidic devices, Pizoresistivity,Pizoelectricity and thermoelectricity, MEMS/NEMS design, processing, Oxidation, Sputter deposition, Evaporation, Chemical vapor deposition etc. [10 hrs]

Unit-V: Introduction – Scaling of physical systems – Geometric scaling & Electrical system scaling. The Single-Electron Transistor: The Single- Electron Transistor Single-Electron Transistor Logic, Other SET and FET Structures, Carbon Nanotube Transistors (FETs and SETs), Semiconductor Nanowire FETs and SETs,Coulomb Blockade in a Nanocapacitor, Molecular SETs and Molecular Electronics. [10 hrs]

Text Book:

1. Stephen D. Sentaria, *Microsystem Design, Kluwer Academic Press*
2. Marc Madou, *Fundamentals of microfabrication & Nanofabrication.*
3. T. Fukada & W.Mens, *Micro Mechanical system Principle & Technology, Elsevier, 1998.*
4. Julian W.Gardnes, Vijay K. Varda, *Micro sensors MEMS & Smart Devices, 2001.*

Suggested Reference Books:

1. Nano Terchnology and Nano Electronics – Materials, devices and measurement Techniques by WR Fahrner – Springe
2. Nano: The Essentials – Understanding Nano Scinece and Nanotechnology by T.Pradeep; Tata Mc.Graw Hill.
3. Spin Electronics by M. Ziese and M.J. Thornton
4. Nanoelectronics and Nanosystems – From Transistor to Molecular and Quantum Devices by Karl Goser, Peter Glosekotter, Jan Dienstuhl
5. Silicon Nanoelectronics by Shunri Odo and David Feny, CRC Press, Taylor & Franicd Group
6. Nanotubes and nanowires by C.N.R. Rao and A. Govindaraj, RSC Publishing
7. Quantum-Based Electronic Devices and Systems by M. Dutta and M.A. Stroscio, World Scientific.
8. James R Sheats and Bruce w.Smith, "Microlithography Science and Technology", Marcel Dekker Inc., New York, 1998.
9. J.P. Hirth and G.M.Pound "Evaporation: Nucleation and Growth Kinetics" Pergamon Press, Oxford, 1963