SS850 PHYSICS OF NANOSTRUCTURED MATERIALS 4 0 0 4

Pre-requisites:

Recommended previous knowledge

1. Quantum Physics
2. Condensed Matter Physics
3. Statistical Mechanics

Course syllabus:

Unit 1 - Introduction to Nanophysics – limits of smallness – quantum nature of Nano world.

Unit 2 – Nanostructures - Properties of nanomaterials - size effect - particle size, particle shape, particle density, melting point, surface tension, wettability, surface area and pore – Metal and dielectric - nanoparticles and nanoclusters- plasmonic excitations at surfaces and in nanoparticles – Semiconductor nanostructures - quantum dots - electronic and optical properties - Optical properties of quantum wells- excitons in confinement- Semiconductor-metal interface. Semiconductor heterostructures. Quantum Interference Effects in Transport Properties- Localization: weak localization and Anderson transition - Quantum Hall Effect - Conduction in channels: Landauer's formulas, quantum point contacts – Electron phase coherence - Coulomb blockade and single electron transistor – Spin qubits, Kondo effect - quantum computation - self assembled nanostructures.

Unit 3 - Physics-based Experimental Approaches to Nanofabrication and Nanotechnology – Classification of fabrication methods- top to bottom approach, bottom to top approach - physical and chemical methods of preparation – Growth techniques, Epitaxy - LPE, MBE, - Chemical vapour deposition - MOCVD, PLD – Lateral patterning and bonding - Wet chemical process - precipitation, sol-gel method, etc- self-assembly.

Unit 4 - Characterisation of nanoparticles- X-Ray diffraction-FTIR- basic principles, methodologies and accessories-SEM- basics and primary mode of operation, applications-TEM- HRTEM -basic principles-STM- basic principles and instrumentation- AFM- basic, modes of operation and applications- Photoluminescence- basic principles- Secondary ion mass spectroscopy (SIMS), X-ray spectroscopy (XPS) - Energy Dispersive X-ray Spectroscopy (EDX/EDS) elemental microanalysis - Electron Energy Loss Spectroscopy (EELS) and Energy Filtered TEM (EFTEM) - Cryogenics. Theoretical techniques**:** elements of density functional theory (DFT), Boltzmann transport equation, spin and charge diffusion equations, Landauer-Büttiker scattering formalism, non-equilibrium Green function techniques.

Unit 5 – Carbon nanostructures – Carbon structures, fullerenes, CNTs, graphene - their properties and applications.

Unit 6– Looking on to future - quantum-dot-based electronic and photonic devices - MEMS, NEMS and devices. Molecular electronics – OLEDs, OTFTs, Quantum Cascade Lasers, GMR and Spintronic, Dilute magnetic semiconductor - MRI contrast enhancement – Magnetic hyperthermia, multiferroics, and Smart materials - Soft nanotechnology – Biomolecular structure predictions.

TEXT BOOKS/ REFERENCE:

1. Ch. Poole Jr., F. J. Owens, Introduction to nanotechnology, John Wiley & Sons, 2003.
2. Makio Naito, Toyokazu Yokoyama, Kouhei Hosokawa, Kiyoshi Nogi, Nanoparticle Technology Handbook, 3 ed., Elsevier, 2018.
3. W.R Fahner (Ed.), Nanotechnology and Nano electronics – Materials, Devices, Measurement Techniques, , Springer, 2004.
4. S V Gaponenko, P.L Knight & A. Miller, Optical Properties of Semiconductor Nanocrystals, Cambridge University press, 1998.
5. T Pradeep, Nano: The Essentials-Understanding Nanoscience and Nanotechnology, TMH, 2007.
6. E. L. Wolf, Nanophysics and nanotechnology: An introduction to modern concepts in nanoscience, Wiley-VCH, 2008.
7. R. W. Kelsall, I. W. Hamley and M. Geoghegan, Nanoscale science and technology, 2005.
8. Vladimir V. Mitin, Dmitry I. Sementsov, Nizami Z. Vagidov, Quantum Mechanics for Nanostructures, Cambridge University Press, 2010.
9. Frank J. Owens, Physics of Magnetic Nanostructures, John Wiley & Sons, Inc, 2015.
10. Marius Grundmann, The Physics of Semiconductors: An Introduction Including Nanophysics and Applications, Springer, 2006.
11. T. Chakraborty, F. Peeters, U. Sivan, Nano-Physics and Bio-Electronics: A New Odyssey, Elsevier, 2002.