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(2014) with CGPA-3.16

Revised Syllabus For

M.Sc. Part-I Nano Science & Technology

(Sem. – I and II)

Syllabus to be implemented from June 2015-16 onwards.

SHIVAJI UNIVERSITY, KOLHAPUR

SNST – 701 T

School of Nanoscience and Technology

(5 year integrated multidisciplinary 10 semester course)

M.Sc.-I, Semester – VII

Title of the paper: Semiconductor Physics

Unit Number	Total credit: 3	No. of lectures
I)	**Energy Bands and Charge Carriers in Semiconductors:** Bonding forces and energy bands in solids, Direct and Indirect semiconductors, variation of energy bands with alloy composition, Charge carriers in semiconductors: electrons and holes, effective mass, intrinsic and extrinsic materials, electrons and holes in quantum wells, The Fermi level, carrier concentration at equilibrium, temperature dependence, space charge neutrality, conductivity and mobility, Drift and resistance, effects of temperature and doping on mobility, High field effects.	12
II)	**Excess Carriers in Semiconductors:** Optical absorption, Luminescence, Direct recombination of electrons and holes, Indirect recombination and trapping, steady state carrier generation and Quasi Fermi levels, Diffusion processes, Diffusion and Drift of carriers, built-in fields, The continuity equation, steady state carrier injection, diffusion length, The Haynes-Shockley experiment.	13
III)	**Junctions-I:** Fabrication of p-n junctions; Thermal oxidation, diffusion, Rapid thermal processing, Ion implantation , CVD, Photolithography, etching, metallization, The contact potential, Space charge at a junction, qualitative description of current flow at a junction, Carrier injection, reverse-bias breakdown, Zener and Avalanche breakdown.	10
IV)	**Junctions-II:** Capacitance of p-n junctions, the Varactor diode, effects of contact potential on carrier injection, recombination and generation in the transition region, ohmic losses, graded junctions, shottky barriers, rectifying contacts, ohmic contacts, heterojunctions, AlGaAs-GaAs heterojuction.	10

Reference Books:

1. Solid state electronic devices by B. G. Streetman.
2. Physics of semiconductor devices by S. M. Sze.
3. Solid State and Semiconductor Physics by Mc Kelvey.
4. Principles of Elecronic Materials and Devices by S.O. Kasap

SHIVAJI UNIVERSITY, KOLHAPUR

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M.Sc.-I, Semester – VII

Title of the paper: Carbaneous materials

Unit Number	Total credit: 3	No. of lectures
I)	**Graphene:** Introduction of graphene, Graphite, Definition and structure of graphene, Types of graphene: stacking AA, BB, AB dispersion relation, Single layer, Bi-layer, Few layer, Properties of graphene; Optical: thickness dependency, optical conductivity, electric filed tunable transparency, plasmons and polaritons, carrier multiplication. Electrical: Boltzmann equation, ambipolar conduction, density of states and doping (electrostatic and chemical), quantum hall effect, Klein tunneling, diamagnetism, magneto-resistance and spin current, thermal conductivity. Mechanical, Surface phenomenon. Characterization of graphene: Transmission electron microscopy (TEM), Scanning tunneling microscopy (STM), Raman Spectroscopy, Electrical measurements: electric field effect, temperature dependent resistivity measurement.	12
II)	**Preparation and Characterization of graphene:** Epitaxial growth of graphene on Silicon carbide, Chemical deposition (CVD) growth of graphene films, Chemically drived graphene, Synthesis of graphene oxide: Hummer's method, Modified Hummer's method, Reduction of graphene oxide: Chemical methods, Physical methods, Electrochemical exfoliation, Nanotube slicing, from solid state carbon sources. **Applications of graphene:** Graphene in the energy application: Li-ion batteries, Supercapacitors, Photovoltaic, Radio-frequency transistor, Photodetector, Modulator, Mode locked lasers, Other applications of graphene: Anti-corroison coating, Anti- bacterial coating, catalyst, Sensors, Transparent Conductors	**13**
III)	**Carbon Nanotubes:** Introduction of Carbon Nanotube (CNT): Introduction and definition of CNT, Bonding of carbon atoms, SP^3, SP^2, Deformed SP^2 , Structure of Carbon Natotubes, Chiral Vector, Armchair, Zig-Zag and Chiral tubes, Properties of Carbon Nanotubes: Electronic, Optical and Optoelectronic, Mechanical, Chemical and Electrochemical, Opening, wetting and filling, doping, intercalation, Thermal and Thermoelectric.	**10**
IV)	**Carbon Nanotubes:** Synthesis Methods and Growth Mechanisms: High temperature method, Arc discharge, General technical features of the production process, Growth Mechanism, Laser Ablation of Graphite, Low temperature method, Chemical Vapor deposition (CVD) process, Vapor liquid solid model, Catalytic role. **Purification and functionalization:** Methods of Purification, Methods of Functionalization (Chemical and Physical), Advantage of purification and functionalization, Separation of cnts: based on chirality, semiconducting, metallic, Applications of Carbon nanotube, Field emission, Li-ion battery, Supercapacitor, Sensors, Solar cell , CNT-polymer composite and avionics EM shielding	**10**

Reference Books:

1) Graphene: Carbon in Two Dimensions, by Mikhail I. Katsnelson (http://www.amazon.com/Graphene-Dimensions-Mikhail-I-Katsnelson/dp/0521195403)

2) Physics of Graphene, Editors: **Aoki**, Hideo, **S. Dresselhaus**, Mildred (Eds.) http://www.springer.com/in/book/9783319026329

3) Graphene: Synthesis, Properties, and Phenomena, by C. N. R. Rao (Editor), Ajay K. Sood (Editor), http://www.amazon.com/Graphene-Synthesis-Properties-Phenomena-Rao/dp/3527332588/ref=pd_sim_b_2?ie=UTF8&refRID=1BE9W35KXA6TXMMMXVEP

4) Graphene Nanoelectronics, Metrology, Synthesis, Properties and Applications, Editors: **Raza**, Hassan (Ed.) http://www.springer.com/in/book/9783642204678

5) Graphene Nanoelectronics: From Materials to Circuits, Editors: **Murali**, Raghu (Ed.) http://www.springer.com/in/book/9781461405474

6) Carbon Nanotube and Graphene Device Physics, by H.-S. Philip Wong (Author), Deji Akinwande (Author) http://www.amazon.com/Carbon-Nanotube-Graphene-Device-Physics/dp/0521519055%3FSubscriptionId%3D1VXT0MZ5J2QQ5RY3VV02%26tag%3Dgrapheneinfo-20%26linkCode%3Dxm2%26camp%3D2025%26creative%3D165953%26creativeASIN%3D0521519055

7) Carbon Nanotube Electronics (Integrated Circuits and Systems) by Ali Javey (Editor), Jing Kong (Editor), http://www.amazon.com/Nanotube-Electronics-Integrated-Circuits-Systems/dp/0387368337%3FSubscriptionId%3D1VXT0MZ5J2QQ5RY3VV02%26tag%3Dgrapheneinfo-20%26linkCode%3Dxm2%26camp%3D2025%26creative%3D165953%26creativeASIN%3D0387368337

8) Polymer-Graphene Nanocomposites, **Editor(s):** Vikas Mittal http://pubs.rsc.org/en/content/ebook/978-1-84973-567-4#!divbookcontent

9) **Physics and Chemistry of Graphene: Graphene to Nanographene,** Toshiaki Enoki, Tsuneya Ando. http://www.crcpress.com/product/isbn/9789814241489

SHIVAJI UNIVERSITY, KOLHAPUR

SNST – 703 T

School of Nanoscience and Technology

(5 year integrated multidisciplinary 10 semester course)

M.Sc.-I, Semester – VIII

Title of the paper: Functional Nanomaterials

Unit Number	Total credit: 3	No. of lectures
I)	**Semiconductor quantum dots:** Growth mechanism, shape and composition control of semiconductor nanocrystals, Synthesis of semiconductor nanocrystals in organic solvents, Aqueous synthesis of semiconductor nanocrystals, Multishell semiconductor nanocrystals, Layer-by-layer (LBL) assembly with semiconductor nanoparticles and Nanowires, Fluorescence spectroscopy of single CdSe nanocrystals, Applications of quantum dots in biomedicine	**13**
II)	**Nanotubes and nanowires:** Fabrication of TiO_2 Nanotube Arrays by Electrochemical Anodization: Four Synthesis Generations, Material Properties of TiO_2 Nanotube Arrays: Structural, Elemental, Mechanical, Optical, and Electrical, Applications, Boron Nitride Nanotubes: Synthesis and Structure, One-Dimensional Semiconductor and Oxide Nanostructures, Inorganic nanowires	**12**
III)	**Nanofibers and Metal Oxide Frameworks**: Introduction, The Electrospinning Process, Key Processing Parameters, Nanofiber Yarns and Fabrics Formation, Potential Applications of Electrospun Fibers, Nanofibers for Tissue Engineering Scaffolds, Nanofibers for Chemical/Bio Protective Membranes, Nanocomposite Fibers for Structural Applications. Metal Oxide Frameworks, definitions, advantages, disadvantages, methods of synthesis, Structural originality of MOFs, properties, Applications	**10**
IV)	**Polymer nanocomposites:** Introduction and review of Polymer, Introduction to Block copolymers, Properties of polymers; solid, glass transition temperature, crystalline-melting temperature, thermal transitions, viscoelasticity and rubber elasticity. Polymer additives: plasticizers, fillers and reinforcement: Polymer blends, toughen plastics and phase separated blends. Polymer composites: mechanical properties and composite fabrication. Introduction to polymer nanocomposites: Basic materials for polymer nanocomposite technology. Fabrication techniques: Solution intercalation, melt intercalation, roll milling, emulsion polymerization, in-situ polymerization and high-shear mixing. Characterization of polymer nanocomposites,	**10**

	Properties of polymer nanocomposites: Thermoplastic nocomposites, Thermoset Nanocomposites, Elastomer Nanocomposites. Applications of polymer nanocomposites in: high temperature, paint formulation, Automobiles, Aerospace, Injection Molded Products, Coatings, Adhesives, Fire-retardants, Packaging Materials, Microelectronic Packaging, Optical Integrated Circuits, Drug Delivery, Sensors, Membranes, Medical Devices, Consumer Goods	

Reference Books:

1) TiO_2 Nanotube Arrays: Synthesis, Properties, and Applications by Craig A. Grimes and Gopal K. Mor, Springer Publisher
2) Nanotubes and Nanofibers; Advanced Materials Series, Series Editor: Yury Gogotsi, Drexel University, Philadelphia, Pennsylvania, USA, Nanotubes and Nanofibers by Yury Gogotsi
3) Hybrid porous solids: past, present, future by Gerard Ferey, Chemical Society Reviews, 37 (2008) 191-214. DOI: 10.1039/b618320b
4) Semiconductor Nanocrystal, Quantum Dots: Synthesis, Assembly, Spectroscopy and Applications by Andrey L. Rogach (Ed.), Springer Publisher
5) Nanotubes and Nanowires, CNR Rao and Govindraj, RSC Publishers
6) Quantum well, wires and dots, Paul Harison, Wiley Publisher
7) Joel R. Fried; Polymers Science and Technology, Prentice-Hall of India Pvt. Ltd. New Delhi, 2002.
8) Vasant R. Gowariker, N. V. Viswanathan, Jayadev Sreedhar; Polymer Science, New Age International Pvt. Ltd., New Delhi, Reprint 2005.
9) Joseph H. Koo, Polymer Nanocomposites: Processing, Characterization, and Applications, McGraw-Hill, New Delhi, 2006.
10) Suprakas Sinha Ray and Mosto Bousmina, Polymer Nanocomposites and Their Applications, American Scientific Publishers, 2006.

11) S. C. Tjong and Y.-W. Mai, Physical Properties and application of polymer nanocomposites, A volume in Woodhead Publishing Series in Composites Science and Engineering, 2010.
12) F. Gao, Advances in Polymer Nanocomposites, A volume in Woodhead Publishing Series in Composites Science and Engineering, 2010.

SHIVAJI UNIVERSITY, KOLHAPUR

SNST- 704 T

School of Nanoscience and technology

(5 year integrated multidisciplinary 10 semester course)

M.Sc.-I, Semester – VII

Title of the paper: Nanocoatings and applications

Unit No.	Credits- 3	No. Of Lectures
I	**Introduction to Nanocoatings:** Why Go Nano? Or Need of Nano, A Great Future for Nanocoatings, Finding the Perfect Solvent, Applications of Nanocoatings. **Anti-fingerprint Nanocoatings:** Introduction, Types of Anti-fingerprint Nanocoatings, Applications of anti-fingerprint coatings. **Anti-corrosion Nanocoatings:** Introduction, Principle of prevention & protection of Corrosion, Advantages and disadvantages of Anti-corrosion Nanocoatings, Advanced protective coatings for aeronautical applications	10
II	**Self-cleaning Sol-Gel Nanocoatings:** Introduction, lotus effect, Self-Cleaning Glasses, Self-cleaning smart nanocoatings, Applications of Self-cleaning (bionic & photo catalytic) Sol-Gel Nanocoatings. **Anti-fouling & easy to clean Nanocoatings:** Introduction, Applications of Anti-fouling & easy to clean Nanocoatings. **Abrasion & wear resistant Nanocoatings:** Introduction, Necessity of abrasion & wear resistant nanocoatings, Applications of Abrasion & wear resistant Nanocoatings.	10
III	**Anti-icing Nanocoatings:** Introduction, Need of anti-icing nanocoatings, Applications of Anti-icing Nanocoatings. **Thermal barrier and flame retardant Nanocoatings:** Introduction, Applications of Thermal barrier and flame retardant Nanocoatings. **Anti-microbial Nanocoatings:** Introduction, Nano-Coating Use Against SARS Virus, Application of Ag Nanoparticles as Antibacterial Coating, Using TiO_2 Nano-Particles to Decrease Environmental Contaminations,	12
IV	**UV-resistant Nanocoatings:** Introduction, Necessity of UV-resistant nanocoatings, Types of UV-resistance Nanocoatings, Applications of hydrophobic nanocoatings. **Conductive Nanocoatings:** Introduction, Necessity of Conductive Nanocoatings, Conductivity fundamentals, Coating Build-Up, Control of optoelectronic properties, Methods of Coatings Characterization, Properties of Coatings, Applications of conductive nanocoatings. **Super hydrophobic Nanocoatings:** Introduction, Biomimic Superhydrophobic Surface, Applications of hydrophobic nanocoatings.	13

Reference Books:

1. **Nanocoatings: Principles and practice**
   By steven abbott and Nigel Holmes
2. **Nanocoatings and Ultra Thin Films**
   By Abdel salam Hamdy Makhlouf and Ion Tiginyanu
3. **Nanocoatings Size Effect in Nanostructured Films**
   Mahmood Aliofkhazraei
4. **The Science and Engineering of Thermal Spray Coatings**
   Lech Pawlowski
5. **The Handbook of Nanomedicine**
   Kewal K. Jain
6. **Optical thin films and coatings**
   Angela Piegari and François Flory
7. **Bioinspired Intelligent Nanostructured Interfacial Materials**
   Lei Jiang and Lin Feng

SHIVAJI UNIVERSITY, KOLHAPUR

SNST – 705 T

School of Nanoscience and Technology

(5 year integrated multidisciplinary 10 semester course)

M.Sc.-I, Semester – VII

Title of the paper: Nanobiotechnology

Unit Number	Total credit: 3	No. of lectures
I)	**Biological synthesis:** Biological synthesis of nanoparticles using bacteria, fungi, plants, purified enzymes and biological templates, S layer. Silver nanoparticles, gold nanoparticles, cerium oxide nanoparticles, titanium oxide and zinc oxide nanoparticles. Application of inorganic nanoparticles, Biological applications of inorganic nanoparticles.	12
II)	**biological nanoparticles and their applications:** Introduction to biological nanoparticles and their applications: Exosomes, lipoproteins, ferritin, magnetite viruses. Biological nanomotors and Machines, mechanisms of biological machines, protein assemblies: muscle myosin, kinesin, nerve, ATPase, bacteriorhopsin, haemoglobin dynein, cilia. Bacterial flagella: structure and function; nanomotor. Ion channels: nanopores of high specificity. Bioinspired nanomaterials: DNA and peptide based. Interaction between biomolecules and nanoparticle surfaces.	13
III)	**Biosensor and nanobiosensor:** Biosensor and nanobiosensor basic concepts, characterization, perception, Enzyme–metal NP hybrids for biosensing and for the generation of nanostructures, Biomolecule–semiconductor NPs for biosensing, Different types of nanobiosensors; Nanobiosensors for medical diagnostics. Nanoprobes for analytical applications.	10
IV)	**Nanotechnology and its application in food industry:** Nanotechnology and food packaging, natural biopolymers, advantages of nanomaterials in food packaging applications, nanosensors, outstanding issues, risks and regulations, public perception. Nanotechnology in Agriculture, Precision farming, Smart delivery system, Insecticides using nanotechnology, Potential of nano-fertilizers.	10

Reference Books:

1. K. Youell and Firman, Nanotechnology perception 3 (2007) 75,96. Comprehensive overview of motors in biology
2. Jeremy Ramsden, Essentials of nanotechnology
3. Rammohan Devulapally and Ramasamy Paulmurugan Polymer nanoparticles for drug and small silencing RNA delivery to treat cancers of different phenotypes *WIREs Nanomed Nanobiotechnol* 2014, 6:40–60. doi: 10.1002/wnan.
4. Itamar Willner, Bernhard Basnar and Bilha Willner Nanoparticle–enzyme hybrid systems for nanobiotechnology FEBS Journal 274 (2007) 302–309.
5. Nanotechnology :Technology Revolution of 21st Century by Rakesh Rathi, published by S. Chand.
6. Introduction to Nanoscience, by Stuart Lindsay.
7. Introduction to Nanomaterials and nanotechnology by Vladimir Pokropivny, Rynno Lohmus, Irina Hussainova, Alex Pokropivny and Sergey Vlassov.
8. Nanomaterials by A.K. Bandyopadhyay; New Age International Publishers.
9. Nanotechnology by Mark Ratner and Daniel Ratner, Pearson Education.
10. Nano Essentials, T.Pradeep/TMH
11. Bharat Bhusan, “Springer Handbook of Nanotechnology”, springer, Newyork, 2007.
12. Hari Singh Nalwa, “Encyclopedia of Nanotechnology”, USA 2011.
13. James A. Schwarz, Cristian I. Contescu, Karol Putyera, “Dekker encyclopedia of nanoscience and nanotechnology” CRC Press, 2004.
14. Charles P. Poole Jr. and Franks. J. Qwens (2003) Introduction to Nanotechnology,Wiley
15. Ehud Gazit (2007) Plenty of Room for Biology at the Bottom: An Introduction to
16. Bionanotechnology. Imperial college Press
17. Bharat Bhushan (2007) Springer Handbook of Nanotechnology. Springer Verlag.
18. Challa S., S. R. Kumar, J. H. Carola (2006) Nanofabrication towards biomedical
19. application: Techniques, tools, Application and impact. John Wiley and sons.
20. Robert A. Freitas Jr (2003) Nanomedicine, Vol. I: Basic Capabilities.
21. Neelina H. Malsch (2005) Biomedical Nanotechnology. Taylor and Francis. CRC press.
22. Patrick Boisseau, Marcel Lahmani (2009) Nanoscience: Nanobiotechnology and
23. Ralph S. Greco, Fritz B. Prinz, R. Lane Smith (Editors) (2004) Nanoscale Technology in
24. Biological Systems. CRC Press
25. Harry F. Tibbals (2010) Medical Nanotechnology and Nanomedicine. CRC Press

SHIVAJI UNIVERSITY, KOLHAPUR

SNST – 706 T

School of Nanoscience and Technology

(5 year integrated multidisciplinary 10 semester course)

M.Sc.-I, Semester – VII

Title of the paper: Computational Nanoscience

Unit Number	Non credit course	No. of lectures
I	**Computational tools for Nanoscience** Programming fundamentals, design an algorithm, flowchart and pseudocode, Programming with Matlab, Introduction to open source tools for Nanoscience (Nanohub, Molecular Workbench, Ninithi, Scilab, Octave, Avogadro), Introduction to proprietary software: MATLAB, Mathematica, COMSOL Multiphysics, Virtual Nanolab & Atomistix ToolKit (ATK), Advantage disadvantages of Open source and Proprietary software's, High performance computing structure (HPC) and Introduction to parallel computing.	**10**

Reference Books:

1. Jerry Banks, John S. Carson, Barry L Nelson, David M. Nicol, Discrete-Event System Simulation, Prentice Hall Publishers.
2. R. H. Landau, M. J. Jose, C. R. Bordeianu, A Survey of Computational Physics (2008), Princeton University Press.
3. Musa, S. M. (Ed.). (2011). Computational Nanotechnology: Modeling and Applications with MATLAB®. CRC Press.
4. Xie, C., & Lee, H. S. (2012). A visual approach to nanotechnology education. International Journal of Engineering Education, 28(5), 1006.
5. N. J. Giordano and H. Nakanishi, Computational Physics, Pearson Prentice Hall.
6. Network for Computational Nanotechnology, Available at: http://ncn.purdue.edu/wps/portal/pagr/o/
7. Gould, Tobochnik et al, Introduction to Computer simulation methods. (Addition weekly-2006)
8. M. Rieth and W. Schommers, Handbook of Theoretical and Computational Nanotechnology.

SHIVAJI UNIVERSITY, KOLHAPUR

SNST – 711 P

School of Nanoscience and Technology

(5 year integrated multidisciplinary 10 semester course)

M.Sc.-I, Semester – VII

Title of the paper: Laboratory Course- I

Total Credit: 2

1	Resistivity of thin film by two point probe method
2	TEP of a semiconductor-I
3	Estimation of band gap of semiconductor
4	Resistivity by Vander Pauw method
5	Studies on PN junction Si-solar cell
5	Studies solar simulator
6	Studies on BJT device
7	Studies on FET device
8	Studies on MOSFET device
9	Magnetic susceptibility
10	Haynes - Shockley experiment

SHIVAJI UNIVERSITY, KOLHAPUR

SNST – 712 P

School of Nanoscience and Technology

(5 year integrated multidisciplinary 10 semester course)

M.Sc.-I, Semester – VII

Title of the paper: Laboratory Course-II

Total Credit: 2

1	Functionalized CNT and identification of groups		
2	Functionalized Graphene and identification of groups		
3	Synthesis of Graphene Oxide by modified Hummer's method		
4	Modeling and simulation of CNT		
5	Simulation of ballistic transport in CNT-FET		
6	Effect of Series resistance and temperature on solar cell- (Simulation)		
7	Measurement of surface area of nanomaterial using multipoint BET		
8	Comparison of surface area of activated carbon and CNTs		
9	Hall mobility of CNT and Graphene		

SHIVAJI UNIVERSITY, KOLHAPUR

SNST – 713 P

School of Nanoscience and Technology

(5 year integrated multidisciplinary 10 semester course)

M.Sc.-I, Semester – VII

Title of the paper: Laboratory Course- III

Total Credit: 2

1	Synthesis of CdSe-ZnO core shell QD by hot injection method
2	Synthesis of CdSe-CdS core shell QD by hot injection method
3	Electrochemical anodization of TiO_2 nanotubes
4	Preparation of anodosed aluminium oxide (AAO)
5	B-H hysteresis loop study
6	Electro deposition of MnO_2 by potentiodynamic method
7	Electrochemical Quartz Crystal Microbalance study of MnO_2
8	MnO_2-PEDOT nanocomposites
9	Metal oxide frameworks
10	Nanocoatings by DC sputtering
11	Nanocoatings by RF sputtering

SHIVAJI UNIVERSITY, KOLHAPUR

SNST – 714 P

School of Nanoscience and Technology

(5 year integrated multidisciplinary 10 semester course)

M.Sc.-I, Semester – VII

Title of the paper: Laboratory Course- IV (Nano-Bio-I)

Total credit: 2
1. Preparation of nanoparticles using biological source 2. Preparation of nanoparticles using bacterial cells, its extracellular proteins and characterization 3. Preparation of nanoparticles using fungi, its extracellular proteins and characterization 4. Preparation of nanoparticles using plant extract and its characterization 5. Preparation of various metal nanoparticles for the study of their biological activity 6. Estimation of antibacterial activity of metal nano particles 7. Estimation of antifungal activity of metal nano particles 8. Preparation of glasswares, plasticwares, media and fine chemicals for animal cell cultures. 9. Culturing, maintenance and passaging of stock of animal cell cultures 10. Synthesis of gold nanoparticles and its assembly/Conjugation with biomolecules i. e. BSA 11. SDS PAGE gel shift assay for study of nanoparticle- biomolecule assembly

SHIVAJI UNIVERSITY, KOLHAPUR

SNST – 801 T

School of Nanoscience and Technology

(5 year integrated multidisciplinary 10 semester course)

M.Sc.-I, Semester – VIII

Title of the paper: Solid State Electronic Devices

Unit Number	Total credit: 3	No. of lectures
I)	**Transistors and Microwave Devices:** Bipolar junction transistor (BJT), frequency response and switching of BJT, Single electron transistor, Field effect transistor (JFET), MOSFET and MESFET devices: structure and its operation, Tunnel diode, Resonant tunneling and NDR effects in nanostructures, Transferred electron devices -Gunn diode, Nano-CMOS technology,	**13**
II)	**Photonic Devices:** Radiative transitions and optical absorption, Light emitting Diodes, OLED, Infrared LED, Photodetector, Photoconductor, Photodiode, Semiconductor Lasers, Laser operation, population inversion, carrier and optical confinement, optical cavity	**12**
III)	**Nanopiezotronics and nano-generators:** Piezoelectric, Electrostrictive and magnetostrictive effects, important materials exhibiting these properties and their applications in sensors and actuator devices, Piezoelectricity of ZnO nanowires, combination of piezoelectric and semiconducting properties, Piezotronic nanodevices using ZnO nanowires, chemical/humidity nanosensors, ZnO nanowires nano-generator, Flexible nano-generator and power fiber,	**10**
IV)	**Micro-Electro-Mechanical-Systems (MEMS):** What is MEMS, MEMS technology, A brief history of MEMS, Introduction to MEMS sensors, physical/chemical/biological MEMS sensors, Resonent mechanical sensors, accelerometers, gas flow sensors, sensing principle, MEMS design, MEMS in automobiles	**10**

Reference Books:

1. Semiconductor devices: Physics and Technology 2nd Edition, S. M. Sze
2. Modern Digital Electronics, R. P. Jain
3. Introduction to Semiconductor devices by M. S. Tyagi
4. Optical electronics by Ajoy Ghatak and K. Thyagrajan, Cambridge University Press.
5. Microsystems and nanotechnology, Springer, by Z. Zhou, Z. L. Wang and L. Lin

SHIVAJI UNIVERSITY, KOLHAPUR

SNST – 802 T

School of Nanoscience and Technology

(5 year integrated multidisciplinary 10 semester course)

M.Sc.-I, Semester – VIII

Title of the paper: Energy Conversion and Storage Devices

Unit Number	Total credit: 3	No. of lectures
I)	**Solar Photovoltaics:** P-N junction under illumination, Light generated current, I-V equation, Characteristics, Upper limits of cell parameters, losses in solar cells, equivalent circuit, effects of various parameters on efficiency, Solar cell design, Design for high Isc, Antireflective coating (ARC), Design for high Voc and fill factor, Analytical techniques; solar simulator, Quantum efficiency, Minority carrier life time and diffusion length measurement. Thin film solar cells: Advantages, materials, a-Si, CdTe, CIGS	12
II)	Sensitized and Polymer Photovoltaics: Dye sensitized solar cells, advantages and disadvantages, Quantum dot sensitized solar cells, Perovskite sensitized solar cells, Planar and bulk heterojunction polymer solar cells, Exciton generation and dissociation, Advantages, disadvantages and types of materials.	**13**
III)	**Batteries and Fuel cells:** Primary batteries, Rechargeable batteries, Electrochemical energy storage: cell reaction, Laws, Parameters, thermodynamics parameters, kinetic parameters, Polarization, Heat effects, Types of batteries (Lead-acid, Ni/Cd, Ni/metal hybrid), charging methods and techniques, characteristic curves, Lithium batteries, chemistry and Physics of lithium batteries, anode and cathode materials, applications, Introduction to fuel cells.	**10**
IV)	**Supercapacitors:** Similarities and differences between supercapacitors and batteries, Energetics, Double layer electrostatic capacitor, Pseudocapacitance, origin, kinetic theory, RuO_2 as a material for electrochemical capacitors, Regon plot, electrolyte factor, energy density and power density, Impedance of a pseudocapacitance, Technology development, various oxides as pseudocapacitors.	**10**

Reference Books:

1. Solar photovoltaics, Fundamentals, Technologies and Applications by Chetan Singh Solanki, PHI Learning Private Limited, Delhi-110092.
2. Polymer photovoltaics, a practical approach by Fredrik C. Krebs, Spie Press, Bellingham, Washington USA.
3. Organic Solar Cells, Theory, Experiment, and Device Simulation by Wolfgang Tress, Springer.
4. Dye Sensitized Solar Cells by K. Kalyansundaram, EPFL Press, A Swiss academic publisher distributed by CRC press.
5. Solar cells- Dye-sensitized Devices by Leonid A. Kosyachenko, Published by Intech, Janeza Trdine 9, 51000 Rijeka, Croatia.
6. Battery Technology Handbook by H. A. Kiehne , Marcel Dekker, Inc. , New York, Basel.
7. Electrochemical Supercapacitors, Scientific fundamentals and Technological Applications by B. E. Conway, Kluwer Academic/ Plenum Publishers, New York, Boston, Dordrencht, London, Moscow.

SHIVAJI UNIVERSITY, KOLHAPUR

SNST – 803 T

School of Nanoscience and Technology

(5 year integrated multidisciplinary 10 semester course)

M.Sc.-I, Semester – VIII

Title of the paper: Nanocatalysis

Syllabus	
Unit-I (15 L)	Introduction to catalysis, classifications, heterogeneous catalysis, reaction on the solid surfaces, adsorption isotherms, physisorption and chemisorptions., reaction mechanism and kinetics of the heterogeneous catalytic reactions, activation energy (Arrhenius equation, Eyring equation).
Unit-II (10 L)	Catalytic activity (bulk and nanoscale), catalytic activity determination for metal/metal oxide nanostructures. Langmuir-Hinshelwood mechanism for nanocatalyst, Mass transport, diffusion controlled process, catalytic efficiency and turnover frequency, inhibition. Application of metal nanoparticles in organic reactions (Heck and Suzuki-Maurya reactions), environmental remediation.
Unit-III (10)	Introduction of photocatalysis, Basics of electrochemistry and photochemistry, Electronics structure and photoabsorption, Kinetics and photocatalytic activity, Jablonskii diagram, Structure of photocatalysts and solar spectrum analysis. Fundamental understanding of semiconductor interfaces, Principles and relevance to photoelectrochemical and photocatalysis mechanism, Properties of good photocatalysts, Advantages of photocatalysts, types of photocatalysts, Homogeneous, heterogeneous, carbonaceous and plasmonic photocatalysts.
Unit-IV (10)	Photocatalysts design and synthesis, Application of photocatalysis, Self cleaning, purification of water and air, Photoreduction of CO_2 and fuel production, antimicrobial use. Characterization and performance of photocatalysts, Fabrication of water purification reactor, Industrial development of photocatalysts, Environmental remediation, Future possibilities

References

(1) J. P. Simons, Photochemistry and Spectroscopy, Wiley, 1971.

(2) J. G. Calvert, J. N. Pitts, Photochemistry, Wiley & Sons, New York, 1966.

(3) N. Serpone, E. Pelizzetti (Eds.), Photocatalysis. Fundamentals and Applications, Wiley, New York, 1989.

(4) K. K. Rohatgi-Mukherjee, Fundamentals of Photochemistry, Wiley, New York, 3rd Edition, 2002.

(5) Nick Serpone and Ezio Pelizzetti, Photocatalysis: Fundamentals and Application, Wiley Interscience, 1st Edition, 1989

(6) Photoelectrochemistry, Photocatalysis and Photoreactors Fundamentals and Developments, Schiavello, Mario (Ed.) Springer,1985.

(7) Photoelectrochemical solar cells, Suresh Chandra, Gordon and Breach Science Publishers, 1985.

(8) Physical Chemistry of Surfaces , W. Adamson, Wiley Intersciences,(5th edition) 1990.

(9) Physical chemistry - Peter Atkins, Julio de Paula , 7th Edition
Oxford University Press.

(10) Catalytic Chemistry, B.C. Gates, John Wiley and Sons Inc. (1992)

(11) Nanoparticles and Catalysis; D. Astruc, Wiley-VCH, 2008

(12) Heterogeneous Catalysis, D.K. Chakrabarty and B. Viswanathan, New Age Publishers

SHIVAJI UNIVERSITY, KOLHAPUR

SNST – 804 T

School of Nanoscience and Technology

(5 year integrated multidisciplinary 10 semester course)

M.Sc.-I, Semester – VIII

Title of the paper: Nanomagnetism and spintronics

Unit Number	Total credit: 3	No. of lectures
I)	**Magnetism basics and nanomagnetism** Magnetic quantities and units, magnetism of free atoms and ions, Hund's rules and the Landé factor, localized electron magnetism in solids, itinerant electron magnetism in metals, band theory of magnetism, indirect exchange interaction, magnetic anisotropy, magnetization and magnetic materials, domains, magnetic energies (magnetostatic energy, magnetocrystalline energy, magnetostrictive energy), domain walls, demagnetizing field, magnetization process. **Magnetism in small structures** Single domain particles, superparamagnetism, blocking temperature, magnetic ultrathin films, magnetic surface and interface anisotropies.	**13**
II)	**Introduction to spin electronics, Giant Magnetoresistance (GMR):** mechanism of GMR, spin dependent scattering of electrons, interlayer exchange coupling (RKKY coupling), exchange biasing, spin valves, quantum tunneling, tunneling magnetoresistance (TMR), magnetic oxides and phase transformations: colossal magnetoresistance (CMR), magnetic semiconductors, multiferroics.	**12**
III)	**Magnetic data storage**: Magnetic recording overview, recording medium, particulate recording media, thin film recording materials, longitudinal versus perpendicular recording, write heads, read heads, magnetic random access memory (MRAM), outlook and fundamental limits to recording, patterned media	**10**
IV)	**Nanobiomagnetism:** Materials for biomagnetism, targeting, functionalization of magnetic nanoparticles, magnetic separation, manipulation of magnetic particles in fluids magnetic twizzers, drug and gene delivery, magnetic resonance imaging, hyperthermia, magnetic biosensors, biological assay system, lab-on-a-chip concept.	**10**

Reference Books:

1) Modern magnetic materials, Robert C. O'Handley, John Wiley & Sons Inc., 2000.

2) Introduction to magnetic materials, Cullity and Graham, John Wiley & Sons Inc., 2009.

3) Introduction to magnetism and magnetic materials, D. Jiles, Chapman and Hall pub., 1991.

4) Fundamentals of Magnetism, Mathias Getzlaff, Springer, 2008.

5) Spin Electronics, M. Ziese and M.Thornton (Eds.), Springer, 2001.

6) Advanced Magnetic Nanostructures, Sellmyer and Skomski (Eds.), Springer, 2006.

SHIVAJI UNIVERSITY, KOLHAPUR

SNST – 805 T

School of Nanoscience and Technology

(5 year integrated multidisciplinary 10 semester course)

M.Sc.-I, Semester – VIII

Title of the paper: Biomedical applications of Nanobiotechnology

Unit Number	Total credit: 3	No. of lectures
I)	**Cancer as a disease:** Malignant and benign growth in Cancers, difference between normal cell function and malignant cells, Types of cancer, causative agents of cancer, concept of oncogenes, proto-oncogenes, Gross tissue level changes in cancer, cellular events, molecular pathology, Early detection of cancers using nanotechnology, Biomarker development by nanoprobes, Conventional chemotherapy drugs their mechanism and limitations, Nanodrugs in cancer chemotherapy in details (synthesis, action, advantages, examples), Potential of nanotech application in cancer surgery. Introduction to genome /proteome analysis for cancer Nanobiotechnology for drug discovery, protein and peptide based compounds for cancer and diabetes, drug delivery, nanoparticle based drug delivery, lipid nanoparticles, vaccination, cell therapy, Gene therapy.	**13**
II)	**Nanoparticles in Biological systems:** bone substitutes and dentistry, Implants and Prosthesis, Reconstructive Intervention and Surgery, Nanorobotics in Surgery, Photodynamic Therapy, Nanosensors in Diagnosis, Neuro-electronic Interfaces – Protein Engineering, Drug delivery, Therapeutic applications.	**12**
III)	**Nanodiagnostics:** Nanodiagnostics, Nanoarrays for diagnostics, detection of single DNA, self,assembled protein nanoarrays, protein nanobiochip, nanoparticles for molecular diagnostics, DNA nanomachines, Nanobiosensor, CNT biosensor, DNA nanosensor, Nanowire biosensor, application of nanodiagnostics.	**10**
IV)	**Nanodrug delivery/administration:** Nanodrug delivery/administration, Polymer nanoparticles for drug and small silencing RNA delivery to treat cancers of different phenotypes. polymer NPs for miRNA delivery, polymer NPs for antisense miRNA, (antagomir) delivery, polymer NPs for siRNA delivery, polymer NPs for shRNA delivery, advantages and disadvantages associated with the use, of polymer NPs for drug, delivery, mechanism of drugs deliver to tumors by Polymer nanoparticles. Nanodevices for drug delivery and theranostics. Introduction to the potentials applications and challenges of nanomedicine. Nanomedicine and tissue engineering, nanobiomachines and nanorobots.	**10**

Reference Books:

1. K. Youell and Firman, Nanotechnology perception 3 (2007) 75,96. Comprehensive overview of motors in biology
2. Jeremy Ramsden, Essentials of nanotechnology
3. Rammohan Devulapally and Ramasamy Paulmurugan Polymer nanoparticles for drug and small silencing RNA delivery to treat cancers of different phenotypes *WIREs Nanomed Nanobiotechnol* 2014, 6:40–60. doi: 10.1002/wnan.
4. Itamar Willner, Bernhard Basnar and Bilha Willner Nanoparticle–enzyme hybrid systems for nanobiotechnology FEBS Journal 274 (2007) 302–309.
5. Nanotechnology :Technology Revolution of 21st Century by Rakesh Rathi, published by S. Chand.
6. Introduction to Nanoscience, by Stuart Lindsay.
7. Introduction to Nanomaterials and nanotechnology by Vladimir Pokropivny, Rynno Lohmus, Irina Hussainova, Alex Pokropivny and Sergey Vlassov.
8. Nanomaterials by A.K. Bandyopadhyay; New Age International Publishers.
9. Nanotechnology by Mark Ratner and Daniel Ratner, Pearson Education.
10. Nano Essentials, T.Pradeep/TMH
11. Bharat Bhusan, “Springer Handbook of Nanotechnology”, springer, Newyork, 2007.
12. Hari Singh Nalwa, “Encyclopedia of Nanotechnology”, USA 2011.
13. James A. Schwarz, Cristian I. Contescu, Karol Putyera, “Dekker encyclopedia of

    nanoscience and nanotechnology” CRC Press, 2004.
14. Charles P. Poole Jr. and Franks. J. Qwens (2003) Introduction to Nanotechnology. John
15. Wiley and Sons.
16. Ehud Gazit (2007) Plenty of Room for Biology at the Bottom: An Introduction to
17. Bionanotechnology. Imperial college Press
18. Bharat Bhushan (2007) Springer Handbook of Nanotechnology. Springer Verlag.
19. Challa S., S. R. Kumar, J. H. Carola (2006) Nanofabrication towards biomedical
20. application: Techniques, tools, Application and impact. John Wiley and sons.
21. Robert A. Freitas Jr (2003) Nanomedicine, Vol. I: Basic Capabilities.
22. Neelina H. Malsch (2005) Biomedical Nanotechnology. Taylor and Francis. CRC press.
23. Patrick Boisseau, Marcel Lahmani (2009) Nanoscience: Nanobiotechnology and
24. Nanobiology. Springer Publishers.
25. Ralph S. Greco, Fritz B. Prinz, R. Lane Smith (Editors) (2004) Nanoscale Technology in
26. Biological Systems. CRC Press
27. Harry F. Tibbals (2010) Medical Nanotechnology and Nanomedicine. CRC Press

SHIVAJI UNIVERSITY, KOLHAPUR

SNST – 806 T

School of Nanoscience and Technology

(5 year integrated multidisciplinary 10 semester course)

M.Sc.-I, Semester – VIII

Title of the paper: Quantum computation

Unit Number	Total credit: Non credit course	No. of lectures
I)	**Quantum information and quantum computers:** How is a quantum computer different to a classical computer?, How does a quantum computer work?, Writing to an idealised atomic-quantum computer, Read-out from an idealised atomic-quantum computer, Quantum computation, Decoherence — the enemy of quantum computation, The power of quantum computation, Power of a classical computer, Power of a quantum computer. Experimental Implementations of Quantum Computers.	**10**

Reference Books:

1. Massimiliano Di Ventra, Stephane Evoy, James R. Heflin, Introduction to Nanoscale Science and Technology, Springer-2004.
2. Marc Baldo, Introduction to Nanoelectronics, MIT Open Course Ware Publication May 2011.
3. Michael Wilson, K. Smith, Michelle Simmons, Burkhard Raguse, Nanotechnology-Basic Science and Emerging Technologies, CRC Press, 2012.
4. Yoshio Nishi, Advances in Non- volatile Memory and Storage Technology, Woodhead Publishing Series in Electronic and Optical Materials (Elsevier), 2014.
5. Mojtaba Joodaki, Selected Advances in Nanoelectronic Devices: Logic, Memory and RF, Springer, 2010.
6. Introduction to MEMS/NEMS, Wolfson School of Mechanical and Manufacturing Engineering Loughborough University, Loughborough

SHIVAJI UNIVERSITY, KOLHAPUR
School of Nanoscience and Technology
(5 year integrated multidisciplinary 10 semester course)
M.Sc.-I, Semester – VIII
Title of the paper: Laboratory Course –I
Total Credit: 2

SNST – 811P

1	Modeling and simulation of FinFET		
2	Modeling and simulation of MESFET		
3	Modeling of 1D resonant tunneling device		
4	Simulation of harvested electrical power from mechanical vibration using a piezoelectric cantilever beam		
5	Studies on DSC based on TiO_2 and Ru dye		
6	Studies on Quantum dot sensitized solar cells		
7	Studies on perovskite solar cell		
8	Studies on Polymer solar cells		
9	Studies on Li-ion battery		
10	Studies on MnO_2 supercapacitor		

SHIVAJI UNIVERSITY, KOLHAPUR

SNST – 812 P

School of Nanoscience and Technology

(5 year integrated multidisciplinary 10 semester course)

M.Sc.-I, Semester – VIII

Title of the paper: Laboratory Course-II

Total Credit: 2

1	Synthesis of aerogel		
2	Synthesis of Nanophosphor powder		
3	Electrodeposition of electrochromic WO_3		
4	Electrodeposition of electrochromic nanoparticle of PB		
5	Synthesis of Transparent Conducting Oxide coating by spray pyrolysis technique		
6	Synthesis of binary chalcogenide thin films using SILAR		
7	Synthesis of binary chalcogenides using CBD		
8	Synthesis of electrospinning -nanofiber of TiO_2		
9	Synthesis of CuO by hydrothermal method		
10	Synthesis of PANI nanofiber for ammonia gas sensor		
11	Synthesis of new nanoparticle by using microwave reactor		

SHIVAJI UNIVERSITY, KOLHAPUR

SNST – 813 P

School of Nanoscience and Technology

(5 year integrated multidisciplinary 10 semester course)

M.Sc.-I, Semester – VIII

Title of the paper: Laboratory Course-III

Total Credit: 2

1	Photocatalysis- I		
2	Photocatalysis -II		
3	Catalysis -I		
4	Electro deposition of Co-Ag GMR material		
5	Sol-gel deposition of Fe_2O_3 nanoparticle		
6	Spin-coating of nanomaterials		
7	GMR measurement of Co-Ag thin granular films		
8	Synthesis of Dilute magnetic semiconductors		
9	Measurement of resolving power of human eye, optical microscope and electron microscope		
10	Studies on LED and OLED,		
11	Studies on AMOLED		

SHIVAJI UNIVERSITY, KOLHAPUR

SNST – 814 P

School of Nanoscience and Technology

(5 year integrated multidisciplinary 10 semester course)

M.Sc.-I, Semester – VIII

Title of the paper: Laboratory Course- IV(Nano-Bio-II)

Total credit: 2
1. Conjugation of nanoparticles with nucleic acids, DNA/RNA 2. Conjugation between PGLA and tetracycline 3. Preparation of PGLA-tetracycline functional nanoparticles using emulsion diffusion method/ nano-precipitation/dialysis method 4. Characterization of tetracycline modified nanoparticles 5. labeling of live animal cell cultures 6. animal cell culture with quantum dots and its microscopic observation 7. Sunlight-induced rapid and efficient biogenic synthesis of silver nanoparticles using aqueous leaf extract of *Ocimum sanctum* Linn. with enhanced antibacterial activity 8. Synthesis and characterization of colloidal gold using tetrachloroauric acid ($HAuCl_4$) and trisodium citrate ($Na_3 C_6 H_5 O_7 .2H_2O$) 9. Synthesis and characterization of CdS quantum dots by reverse micelles method 10. Synthesis of oil based nanoemulsion drug delivery system