Chhattisgarh Swami Vivekananda Technical University, Bhilai (C.G.)

Scheme of teaching and examination

M.Tech. (Nanotechnology) in the Department E&TC

1st Semester

S. No	Board of Study	Subject Code	Subject	Period s per Week			Scheme of Examination			Total Marks	Credit L+(T+P) / 2
							Theory / Practical				
				L	T	P	ESE	CT	TA		
1	E&TC	547111 (28)	Basics of Nanotechnology	3	1	-	100	20	20	140	4
2	E&TC	547112 (28)	Structure, Bonding & Quantum mechanics of Electronics	3	1	-	100	20	20	140	4
3	E&TC	547113 (28)	Nanotechnology for Energy Systems	3	1	-	100	20	20	140	4
4	E&TC	547114 (28)	Science and Technology of Thin Films	3	1	-	100	20	20	140	4
5	***Refer Table – I***		***Elective –I***	3	1	-	100	20	20	140	4
6	E&TC	547121 (28)	Nanotechnology for Energy System - Lab	-	-	3	75	-	75	150	2
7	E&TC	547122 (28)	Simulation Lab	-	-	3	75	-	75	150	2
Total				**15**	**5**	**6**	**650**	**100**	**250**	**1000**	**24**

L- Lecture T- Tutorial P- Practical ESE- End Semester Exam CT- Class Test

TA- Teacher's Assessment

TABLE –I

ELECTIVE -I

S. No	Board of Study	Subject Code	Subject
1	E & TC	547131 (28)	Mathematical Modelling and Simulation
2	E & TC	547132 (28)	Opto Electronics
3	E & TC	547133 (28)	Lithography Techniques

Chhattisgarh Swami Vivekanand Technical University, Bhilai (C.G.)

Semester: **M. Tech. I Sem.** Branch: **ET & T.**
Subject: **Basics of Nanotechnology** Code: 547111 (28)
Total Theory Periods**: 40** Total Tutorial Periods: **12**
Total Marks in End Semester Exam. : **100**
Minimum number of class test to be conducted: **02**

Unit – I: Nanostructures: Zero-, One-, Two- and Three- dimensional structure, Quantum dots, Semi conducting nanoparticles, Energy bands and gaps in semiconductors, Fermi surfaces, Localized particles, Donors, Acceptors, Deep traps, Excitons, Mobility, Size dependent effects.

Unit–II: Optical properties: Photonic crystals, Quantum confinements, Luminescence, Photoluminescence, Fluorescence, Optically excited emission, Electroluminescence, Photo fragmentation and columbic explosion.
Thermo Electric Materials (TEM): Concept of phonon, Thermal conductivity, Specific heat, Exothermic & Endothermic processes.

Unit – III Magnetic properties: Basics of ferromagnetism – Ferro magnetic resonance and relaxation, Magnetic properties of bulk nanostructures, Magnetic clusters, Dynamics of nanomagnets, Nanopore containment of magnetic particles.

Unit-IV Carbon Nano Structures: DLCs, Fullerenes, C60, C80 SWNT and MWNT; Properties: Mechanical, Optical and Electrical properties.

Unit-V Ceramics: Dielectrics, ferroelectrics and magnetoceramics, Nanopolymers: Nanoparticles polymer ensembles; Applications of Nanopolymers in Catalysis. Nanocomposites: Metal-Metal nanocomposites, Polymer-Metal nanocomposites, Ceramic nanocomposites: Dielectric and CMR based nanocomposites.

Textbooks:
1. Introduction to Nano Technology by Charles. P. Poole Jr & Frank J. Owens. Wiley
2. Nanoscale Materials by Liz Marzan and Kamat, World Scientific Publishing company
3. Nanostructures and Nanomaterials: Synthesis, Properties and Applications by Guozhong Cao, World Scientific Publishing Company

Reference books:
1. Nano Technology and Nano Electronics – Materials, devices and Measurement Techniques by WR Fahrner , Springer
2. Nanotechnology: A Gentle Introduction to the Next Big Idea by Ratner and Ratner ,Prentice Hall
3. Nano Technology - Science, Innovation and Opportunity by Lynn E. Foster, Pearson Education.

Chhattisgarh Swami Vivekanand Technical University, Bhilai (C.G.)

Semester: **M. Tech. I Sem.** Branch: **ET & T.**
Subject: **Structure, bonding & Quantum mechanics of electronics** Code: 547112 (28)
Total Theory Periods**: 40** Total Tutorial Periods: **12**
Total Marks in End Semester Exam. : **100**
Minimum number of class test to be conducted: **02**

Unit-I Crystal structure: Crystalline and amorphous solids, Crystal lattice and crystal structure, Translational symmetry, Space lattice, Unit cell and primitive cell, Symmetry elements in crystal, Seven crystal systems, Some imperfections in crystals, Wigner-seitz cells, Miller indices, Miller-Bravais indices, Indices of a lattice direction, The spacing of a set of crystal planes.

Unit-II Reciprocal lattice and crystal imperfections: Bragg law, Reciprocal lattice , Properties of Reciprocal lattice, Reciprocal lattice of simple cube, Reciprocal lattice of bcc, Reciprocal lattice of fcc, Diffraction conditions, Brillouion zones, Importance of lattice imperfections, Types of imperfection, Point defects, Dislocations.

Unit-III Introduction to quantum mechanics: Matter waves, Length scales , De-Broglie hypothesis – wave particle duality, Heisenberg's uncertainty principle, Schrodinger wave equation , General postulates of quantum mechanics, Particle in one dimensional box.

Unit-IV Quantum mechanics of electronics: Electron as particle and electron as wave, Time independent Schrodinger equation and boundary contestation on the wave function, Analogies between quantum mechanics and classical electromagnetic, Probabilistic current density, Multiple particle systems.

Unit-V Free and confined electrons: Free electrons, Free electron gas theory of metals, Electrons confined to abounded region of space and quantum numbers , Electrons confined to atom, The hydrogen atom and the periodic table, Quantum dots, Quantum wires, Quantum wells.

Textbooks:

1. An introduction to Solid States Electronic Devices by Ajay Kumar Saxena Macmillan India Ltd
2. Solid state Physics by Charles Kittle, Wiley
3. Quantum Mechanics by L. I. Schiff, Tata Mc-Graw Hill
4. Fundamentals of Nanoelectronics by George W. Hanson Pearson Education

Reference Books:

1. Introduction to Nanotechnology by Charles P. Poole Jr & Frank J. Owens; Wiley India Pvt. Ltd
2. The Feynman Lectures on Physics; Vol I to III, Publisher Basic Books
3. Nano Technology and Nano Electronics – Materials, Devices and Measurement Techniques by WR Fahrner – Springer
4. Hand book of Nano structured Materials; Vol I to V by Branch A. Brody & H. Tristram Engelhardt. Jr; Pearson Education
5. Quantum physics by A. Ghatak, Kluvar Academic Publisher

Chhattisgarh Swami Vivekanand Technical University, Bhilai (C.G.)

Semester: **M. Tech. I Sem.** Branch: **ET & T.**
Subject: **Nanotechnology for Energy System** Code: 547113 (28)
Total Theory Periods**: 40** Total Tutorial Periods: **12**
Total Marks in End Semester Exam. : **100**
Minimum number of class test to be conducted: **02**

Unit–I Battery materials and batteries: Battery anode, Battery cathode, Battery electrolyte, Lithium Ion based batteries, Chargeable Lithium ion batteries, Non-chargeable Lithium ion batteries, Modern batteries.

Unit–II Renewable energy Technology: Energy challenges, Nanomaterials and nanostructures in energy harvesting, Developments and implementation of nanotechnology based renewable energy technologies, Solar cell structures: quantum well and quantum dot solar cells, Photo- thermal cells for solar energy harvesting, Thin film solar cells, CIGS solar cells, Die sensitized solar cells.

Unit–III Hydrogen storage Technology: Hydrogen production methods and purification, Hydrogen storage methods and materials: metal hydrides and metal-organic framework materials, Volumetric and gravimetric storage capacities, Hydrating and dehydrating kinetics, High enthalpy formations and thermal management during hydrating reaction, Multiple catalytic – degradation of sorption properties, Automotive applications.

Unit–IV Fuel cell Technology: Fuel cell Principles, Types of fuel cells (Alkaline Electrolyte, Phosphoric acid, Molten Carbonate, Solid oxide and Direct Methanol and Proton Exchange Fuel Cells), Principle and operation of Proton Exchange Membrane (PEM) fuel cell, Materials and fabrication methods for fuel cell technology, Micro fuel cell power sources, Biofuels
Unit–V Micro fluidic Technology: MEMS & NEMS technology for micro fluidic devices, Micro and nano engines and driving mechanism, Power generation, Micro

channel battery pump , Piezoelectric membrane and their applications.

Text Books :

1. Hydrogen from Renewable Energy Source by D. Infield, Elsevier
2. Fundamentals of Industrial Catalytic Process by C.H. Bartholomew and Robert J. Farraoto, John Wiley & Sons Inc.
3. Fuel Cell Technology Handbook by Hoogers, CRC Press

References :

1. Renewable Energy Resources by J. T. Widell and T. Weir, E & F N Spon Ltd. London
2. Fuel Storage on Board: Hydrogen Storage in Carbon Nanostructures by R.A. Shatwell, Wiley
3. Hand Book of Fuel Cells: Fuel Cell Technology and Applications by Vielstich, CRC Press

Chhattisgarh Swami Vivekanand Technical University, Bhilai (C.G.)

Semester: **M. Tech. I Sem.** Branch: **ET & T.**
Subject: **Science and Technology of Thin Films** Code: 547114 (28)
Total Theory Periods**: 40** Total Tutorial Periods: **12**
Total Marks in End Semester Exam. : **100**
Minimum number of class test to be conducted: **02**

Unit – I Vacuum technology: Principles of vacuum pumps in range of 10 -2 torr to 10-11 torr, Principle of different vacuum pumps: Roots pump, Rotary, Diffusion, Turbo molecular pump, Cryogenic-pump, Ion pump, Ti-sublimation pump, Importance of measurement of vacuum, Concept of different gauges: Bayet- Albert gauge, Pirani guage, Penning and Pressure control.

Unit – II Conditions for the formation of thin films: Environment for thin film deposition, Deposition parameters and their effects on film growth, Formation of thin films (sticking coefficient, formation of thermodynamically stable cluster – theory of nucleation), Capillarity theory, Microstructure in thin films, Adhesion, Properties of thin films: Mechanical, electrical, and optical properties of thin films, Few applications of thin films in various fields.

Unit-III Physical Vapor deposition techniques: Thermal evaporation, Resistive evaporation, Electron beam evaporation, Laser ablation, Flash and Cathodic arc deposition

Unit -IV Electrical discharges used in thin film deposition: Sputtering, Glow discharge sputtering, Magnetron sputtering, Ion beam sputtering, Ion plating, Difference between thin films and coating.

Unit –V Various deposition techniques: Electro deposition, Molecular beam epitaxy and laser pyrolysis. Chemical vapor deposition techniques: Advantages and disadvantages of Chemical Vapor deposition (CVD) techniques over PVD techniques, Reaction types, Boundaries and flow, Different kinds of CVD techniques: Metallorganic CVD (MOCVD), Thermally activated CVD, CVD, Spray Pyrolysis.

Text Books:

1. Thin Film Phenomenon by K.L. Chopra, McGraw Hill
2. Methods of Experimental Physics (Vol 14) by G.L.Weissler and R.W. Carlson, "Vacuum Physics and Technology", Academic Press

References :

1. A User's Guide to vacuum Technology by J.F.O'Hanlon, John Wiley and Sons
2. Vacuum Physics and Techniques by T.A. Delchar, Chapman and Hall

Chhattisgarh Swami Vivekanand Technical University, Bhilai (C.G.)

Semester: **M. Tech. I Sem.** Branch: **ET & T.**
Subject: **Mathematical Modelling and Simulation (Elect-1)** Code: 547131 (28)
Total Theory Periods**: 40** Total Tutorial Periods: **12**
Total Marks in End Semester Exam. : **100**
Minimum number of class test to be conducted: **02**

Unit I FUNDAMENTAL PRINCIPLES OF NUMERICAL METHODS: Scientific Modeling, Numerical data and Numerical operations ,Numerical Algorithms , Numerical Programs ,Numerical Software , Approximations in Mathematical Model building , Numerical integration , Differentiation -Variational finite element methods , Rayleigh's method, Ritz method.

Unit II MATHEMATICAL MODELING: Mathematical modeling , Physical simulation , Advantages and limitations, Process control , Transport phenomena, Concept of physical domain and computational domain, Assumptions and limitations in numerical solutions, Finite element method and Finite difference method.

Unit III DIFFERENTIAL EQUATIONS & APPLICATIONS: Euler method, Runge - Kutta method, Multi step - differential equations ,Boundary values, Elliptic equations , One dimensional parabolic equation, Hyperbolic equation , Partial differential equations , Sseparation of variables , Wave equation , Laplace equation , Nonlinear partial differential equations, Approximation methods of nonlinear differential equations.

Unit IV SIMULATION: Basic concepts of simulation , Data manipulation, Data exchange of the structure, Properties and processing of materials, Three dimensional models for capillary nanobridges and capillary forces , Molecular dynamics simulation.

Unit V MONTE CARLO METHODS: Basics of the Monte Carlo method , Algorithms for Monte Carlo simulation , Applications to systems of classical particles , modified Monte Carlo techniques , Percolation system , Variation Monte Carlo method , Diffusion Monte Carlo method , Quantum Monte Carlo method.

Text Books:

1. Discrete Event System Simulation by Jerry Banks, John. S. Carson, Barry .C. Nelson and David. M. Nicol, Printice Hall,.
2. Simulation Modeling and Analysis by Averill. M. Law, McGraw Hill.
3. Advanced Engineering Mathematics by Erwin Kreyzig, Wiley.

Reference Books:

1. Applied Numerical Methods for Engineers using MATLAB and C by R.J. Schilling and S.L. Harris, Thomson publishers,
2. Understanding molecular simulation from algorithm to applications by D. Frenkel and B. Smith, Academic Press
3. Computational Materials Science from Ab initio to Monte Carlo Methods by , K. Ohno, K. Esfarjani and Y. Kawazoe , Springer-Verlag,

Chhattisgarh Swami Vivekanand Technical University, Bhilai (C.G.)

Semester: **M. Tech. I Sem.** Branch: **ET & T.**
Subject: **Opto Electronics (Elect-1)** Code: 547132 (28)
Total Theory Periods**: 40** Total Tutorial Periods: **12**
Total Marks in End Semester Exam. : **100**
Minimum number of class test to be conducted: **02**

Unit 1

Semiconductor-Light Generation & Amplification: Semiconductor physics background, GaAs lasers, Laser structures, Gain and absorption in semiconductors, Direct current modulation, Integrated optoelectronics, Semiconductor optical amplifiers, LEDs, Organic LEDs.

Unit 2

Electro-Optic Modulation: Linear electro-optic effect, Electro-optic phase and amplitude modulation, High frequency considerations, Electro-absorption and modulators based on it, Electro-optical effect in liquid crystals, Acousto-optical effect, scattering of light by sound, Bragg diffraction.

Unit 3

Optical Resonators & Oscillations: Fabry-Perrot Etalons and lasers, Resonators with spherical mirrors, Resonant frequencies, Losses, Ring resonator, Multicavity Etalons, Oscillation frequency, Three & four layer lasers, Power in oscillators, Multimode oscillation and mode locking.

Unit 4

Detection of Optical Radiation: Transition rates, Photomultiplier, Noise mechanism, Heterodyne detection, Photoconductive detectors, Photodiodes, Avalanche photodiodes, Power fluctuations and noise in lasers. Organic photo-detectors

Unit 5

Light Wave Propagation in Guided Medium: Dielectric slabs and fibers, TE and TM modes, Dispersion in waveguides, Propagation in periodic media, Bloch-waves, Spectral filters, Waveguide Coupling.

Text Books:

1. Photonics-Optical Electronics in Modern Communication, A. Yariv & P. Yeh. Oxford University Press.
2. Organic electronics-Sensors & Biotechnology, R. Shinar & J. Shinar, McGraw-Hill.

Reference Books:

1. Integrated Silicon Optoelectronics, H. Zimmermann, Springer.
2. Semiconductor Optoelectronics –Physics & Technology, Jasprit Singh Mc-Graw-Hill.
3. Fundamentals of Optoelectronics, C.R. Pollock, Wiley.
4. Optoelectronics, E. Rosencher & B. Vinter, Cambridge University Press.

Chhattisgarh Swami Vivekanand Technical University, Bhilai (C.G.)

Semester: **M. Tech. I Sem.** Branch: **ET & T.**
Subject: **Lithography Techniques (Elect-1)** Code: 547133 (28)
Total Theory Periods**: 40** Total Tutorial Periods: **12**
Total Marks in End Semester Exam. : **100**
Minimum number of class test to be conducted: **02**

Unit 1
Resist Technology: Conventional photo resists, Deep UV resists, radiation resists, Future resists, Resists and develop track fabrication, DUV and resist wafer tracks,

Unit II
Optical Lithography: Diffraction and gratings, Abbe's theory of image formation, Transfer functions, Image effects, Image quality, Image placement, Mask issues.

Unit III
Electron & Ion Microbeam Lithography: Physics of exposures, Electron optical systems, Novel electron beam technologies, Positive electron beam resists, multilayer resist strategies, Ion surface interaction, Focused ion beam lithography, Masked ion beam lithography, Ion projection lithography

Unit IV
X- Ray Lithography: X-Ray printing methods, System components, Mask technology and construction, Resist, Metrology, X-ray systems.

Unit V
Nanolithography: Multispacer patterning, Patterning and ordering with nanoimprint technology, Nanoelectronic lithography, Extreme ultraviolet lithography

Text Books:

1. Handbook of VLSI Microlithography by J.N Helbert, Noyes Publications
2. Handbook of Nanophysics- Nanoelectronics and Nanophotonics, by K.D Sattler, CRC Press

Reference Books:

1. Microlithography Science & Technology by J.R Sheats & B.W Smith, Marcel & Dekker
2. Silicon Processing for VLSI Era, by Wolf, Lattice Press
3. Thin Film Phenomenon by K.L Chopra, McGraw-Hill

Chhattisgarh Swami Vivekanand Technical University, Bhilai (C.G.)

Semester: **M.Tech. I Sem.** Branch: **E & TC**
Subject: **Nanotechnology for Energy System-Lab** Code: 547121 (28)
Total Marks in End Semester Exam. : **75** Total Lab Periods: **40**

List of Experiments

1. Fabrication and study of characteristics of dye-sensitized solar cell.
2. Fabrication and study of characteristics of alkaline electrolyte fuel cell
3. Fabrication and study of Proton Exchange membrane (PEM) fuel cell.
4. Study of various characteristics of Li-ion based batteries.
5. Fabrication and study of solid oxide fuel cells
6. Fabrication and study of micro fuel cell power sources.
7. To study solar energy harvesting using photo-thermal solar cells.
8. To study the volumetric and gravimetric storage capacities of hydrogen storage nano materials
9. Study of various characteristics of MEMS
10. Study of various characteristics of NEMS
11. Study of efficiencies and other parameters of various solar cell structures and their comparasion.
12. Study of the behaviour of the piezoelectric membranes and their applications.

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Semester: **M.Tech. I Sem.** Branch: **E & TC**
Subject: **Simulation Lab** Code: 528122 (28)
Total Practical Periods: **40**
Total Marks in End Semester Examination: **75**

List of Experiments

Use appropriate simulation software to study the following.

1. Use appropriate simulation software to study the Molecular Dynamics simulations of nano-materials
2. Simulate ballistic transport properties in 3D Carbon Nano Tube Field Effect Transistor (CNTFET) devices
3. Use appropriate simulation tool to compute molecular electronic spectra.
4. Simulate Coulomb Blockade through Many-Body Calculations in a single and double quantum dot system
5. Compute by simulation the electronic structure of various materials in the spatial configuration of bulk (infinitely periodic),
6. Apply simulation technique to compute the electronic structure of quantum wells (confined in one dimension)
7. Simulates pull-in behavior of Carbon nanotube based NEMS with fixed-fixed boundary conditions, with and without Vander Waal's effect .
8. Apply simulation techniques to visualise the surface texture of nanostructured ZnO material.
9. Express graphically the states of molecular vibrations in silver nanomaterials using simulation techniques.
10. Use simulation methods to study the characteristics of quantum dots
11. Use simulation methods to study the variation of energy band gap with size of nanomaterials.
12. Use simulation method for study of variation of surface energy with size of the nanoparticles.