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

Scheme of teaching and examination

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

IInd 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	547211 (28)	Chemistry of Nanomaterials & Fabrication	3	1	-	100	20	20	140	4
2	E&TC	547212 (28)	Synthesis of Nanomaterials	3	1	-	100	20	20	140	4
3	E&TC	547213 (28)	Material Characterisation Techniques	3	1	-	100	20	20	140	4
4	E&TC	547214 (28)	Electronics & Photonics	3	1	-	100	20	20	140	4
5	Refer Table-II		Elective - II	3	1	-	100	20	20	140	4
6	E&TC	547221 (28)	Synthesis Nanomaterials Lab-II	-	-	3	75	-	75	150	2
7	E&TC	547222 (28)	Characterisation of Nanomaterials	-	-	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 –II			
ELECTIVE –II			
S. No	**Board of Study**	**Subject Code**	**Subject**
1	E & TC	547231 (28)	Carbon Nanotubes & its Functionalization
2	E & TC	547232 (28)	Laser Technology
3	E & TC	547233 (28)	Nanosensors : Principle, Design and Applications

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

Semester: **M. Tech. II Sem.** Branch: **E & TC.**
Subject: **Chemistry of Nanomaterials & Fabrication** Code: 547211 (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

Atomic and Molecular Basics: The scope, The nanoscale systems, Defining nano dimensional materials, Size effects in nano materials, Application and technology development, General methods available for the synthesis of nano dimensional materials.
Particles and Bonds, Chemical bonds in Nano technology, The shapes of molecules, additional aspects of bonding, Molecular geometry: VSEPR Model, Hybridization, Van der Waals interactions, Dipole–Dipole Interactions, Ionic Interactions, Metal bonds, Covalent bonds, Coordinative bonds, Hydrogen bridge bonds and polyvalent bonds.

UNITII

Building Blocks of Nanotechnology: covalent architecture, coordinated architecture and weakly bound aggregates, Interactions and topology,
Chemical Properties: The effect of nanoscale metals on chemical reactivity, Effect of nanostructure on mass transport, Metal nanocrystallites , Supported nanoscale catalysts.

UNIT III

The effect of chemistry of nanostructures: Modification of nanoparticles, Langmuir Blodgett films, Self assembled surface films, Binding of molecules on solid substrate surfaces, Molecular nanostructures, Strategies of molecular construction, Synthetic supramolecules.

UNIT IV

Applied chemistry of nanomaterials:
Application to fundamenatal studies. Industrial applications: Photographic materials, Ceramic materials, Magnetic particles for recording media, Catalysts, Fuel cells electrocatalysis, Pigments, Nanostructured materials as new chemical reagents, Nanocomposite polymers, Fluids, inks and dyes, Block copolymers and dendrimers. Analytical and Environmental chemistry of nanoparticles.

UNIT V

Fabrication: Crystal growth and wafer preparation, Defects, Clean room concept, Wafer cleaning techniques, Oxidation, Diffusion, Epitaxy, Ion implantation, Metallization, Lithography, Etching, Masking sequences and bipolar and MOS device fabrication process flow, Integration of unit process, Process modeling, Topological design rules, Passive device such as registers and capacitors and their non idealities, Fabrication of nanoelectronics structures.

Text Books :

1. *Physical Chemitry* by P. W. Attkins , Oxford Press
2. *Introduction to Modern Colloid Science* by Robert J. Hunter, Oxford University Press.
3. Nanoscale Materials in Chemistry by Kenneth J. Khabhunde (ed.) Wiley Interscience.

References:

1. *Nanotechnology – An introduction to nanostructure of technique* by Michel Kohler and Wolfgang Frittsche , Wiley VCH
2. Materials Engineering by V. Raghavan, Prentice Hall.

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

Semester: **M.Tech. II Sem.** Branch: **E & TC.**
Subject: **Synthesis of Nanomaterials** Code: 547212 (28)
Total Theory Periods: **40** Total Tutorial Periods: **12**
Total Marks in end Semester Exam.: **100**
Minimum number of class tests to be conducted: **02**

Unit-I Basics of Synthesis: Introduction to synthesis of nanostructure materials, Bottom-up approach : Bulk materials, Thin films , Heterostructures, Top-down approach : Nanocrystals, Molecular Wires, Proteins.

Unit-II Fabrication of Nanomaterials by Physical Methods: -Inert gas condensation, Arc, Plasma arc technique, RF plasma, MW plasma, Ion sputtering, Laser ablation, Laser pyrolysis, Ball Milling, Molecular beam epitaxy, Chemical vapour deposition method and Electro deposition.

Unit III Chemical methods: Chemical Routes for synthesis of nanomaterials: Chemical precipitation and coprecipitation; Metal nanocrystals by reduction, Sol-gel synthesis; Micro emulsions or reverse micelles, Solvothermal synthesis; Thermolysis routes, Microwave heating synthesis; Sonochemical synthesis; Electrochemical synthesis; , Photochemical synthesis,

Unit – IV Self Assembly and Catalysis: Process of self assembly, Semiconductors islands, Monolayers, nature of catalysis, Porous materials, Pillared clays, Colloids, Biometrics. Thermolysis route - spray pyrolysis and solvated metal atom dispersion, Sol-gel method, Solvothermal and hydrothermal routes, Solution combustion synthesis, Chemical vapor synthesis.

Unit – V Biological methods : Use of bacteria, fungi, actinomycetes for nano-particle synthesis, Magnetotatic bacteria for natural synthesis of magnetic nano-particle.

Textbooks:

1. Inorganic Materials Synthesis and Fabrication by J.N. Lalena, D.A. Cleary, E.E. Carpenter, N.F. Dean, John Wiley & Sons Inc.
2. Introduction to Nano Technology by Charles P. Poole Jr and Frank J. Owens. Wiley India.
3. The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Vol-I by C.N.R. Rao, Wiley

Reference books:

1. Encyclopedia of Nanotechnology by M.Balakrishna Rao and K.Krishna Reddy, Vol I to X, Campus books.

   Nano: The Essentials – Understanding Nano Scinece and Nanotechnology by T.Pradeep; Tata Mc. Graw Hill

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

Semester: **M.Tech. II Sem.** Branch: **E & TC.**
Subject: **Material Characterization Techniques** Code: 547213 (28)
Total Theory Periods: **40** Total Tutorial Periods: **12**
Total Marks in end Semester Exam.: **100**
Minimum number of class tests to be conducted: **02**

Unit – I

Compositional and structural Characterization techniques:

X-ray Photoelectron Spectroscopy (XPS), Energy Dispersive X-ray analysis (EDAX), Principles and applications of X-ray diffraction; electron diffraction, Electron probe microanalysis (EPMA), Ion beam techniques.

Unit – II

Surface characterization Techniques:

High resolution microscopy; Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Atomic force microscopy (AFM), Scanning tunneling microscopy (STM).

Unit – III

Spectroscopic techniques:

Fourier Transform infrared (FTIR) spectroscopy, Raman spectroscopy techniques: micro Raman and laser Raman.

Unit – IV

Electrical characterization techniques:

Measurement of resistivity by 4-prob method, Hall measurement, Seebeck coefficient measurements, nano indentation techniques, electron beam induced current measurement (EBIC).

Unit-V

Thermal and Magnetic characterization:

VSM, Thermal analysis, impedance and ferroelectric measurements

Text books:

1. Nano: The Essentials -Understanding Nano Scinece and Nanotechnology by T.Pradeep, Tata McGraw Hill
2. Introduction to Nano Technology by Charles. P. Poole Jr and Frank J. Owens, Wiley
3. A Practical Approach to X-Ray Diffraction Analysis by C.Suryanarayana, Springer
4. Electron Microscopy and Analysis by P.J. Goodhew and F.J. Humpreys, Springer

Reference Books:

1. Nanotechnology: Principles and Practices by Sulabha K. Kulkarni , Capital Publishing Company
2. Specimen preparation for Transmission Electron microscopy by John & Bravmno et al, Published by MRS
3. Photoelectron spectroscopy by JHD Eland, Butterworth & Co.

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

Semester: **M.Tech. II Sem.** Branch: **E & TC.**
Subject: **Electronics & Photonics** Code: 547214 (28)
Total Theory Periods: **40** Total Tutorial Periods: **12**
Total Marks in end Semester Exam.: **100**
Minimum number of class tests to be conducted: **02**

Unit 1 Low Dimensional Semiconductors: Two dimensional semiconductor nanostructures, Square quantum well of finite depths, Parabolic and triangular quantum wells, Quantum wires and dots, Strained layers, Effect of strained layers, MOSFET structures, Heterojunctions, Superlattices.

Unit II Transport Phenomenon in Nanostructures: Parallel transport, Perpendicular transport, Quantum transport, Effect of magnetic field on a crystal, Low-dimensional systems in magnetic fields, Density of states of a 2D system in a magnetic field, The Aharonov–Bohm effect, The Shubnikov–de Haas effect, The Quantum Hall effect

Unit III Electronic Devices: MODFETs, Heterojunction bipolar transistor, Resonant tunneling effect and transistors, Single electron transistors,

Unit IV Optoelectronic Devices: Heterostructure semiconductor lasers, Quantum well semiconductor lasers, Vertical cavity surface emitting lasers (VCSELs), Strained quantum well lasers, Quantum dot lasers, Quantum well and superlattice photodetectors, Quantum well modulators, OLEDs, OPDs

Unit V Electronic Circuits & Applications: Fin-Fet circuits and applications, Hybrid Nano/CMOS circuits and applications, Nanowire arrays, Nanoscale ASIC, Carbon Nanotubes application, Graphene transistors and circuits, Resonant tunneling diodes application.

Text Books:

1. Nanotechnology in Microelectronics & Optoelectronics, J.M Martine Duart, R.J Martin Palma, F. Agullo Rueda, Elsevier

2. Nanoelectronic Circuit Design, N.K Jha, D Chen, Springer

Reference Books

1. Handbook of Nanophysics- Nanoelectronics & Nanophotonics, K.D Sattler, CRC Press

2. Organic Electronics-Sensors & Biotechnology- R. Shinar & J. Shinar, McGraw-Hill

3. Nanoelectronics, K. Iniewski, McGraw-Hill

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

Semester: **M.Tech. II Sem.** Branch: **E & TC.**
Subject: **Carbon Nanotubes & its Functionalization (Elect-II)** Code: 547231 (28)
Total Theory Periods: **40** Total Tutorial Periods: **12**
Total Marks in end Semester Exam.: **100**
Minimum number of class tests to be conducted: **02**

UNIT I Structure of carbon nanotubes
Preparation of Carbon Nano-Tubes (CNT): CVD, arc discharge and other methods of preparation
Properties: Electrical, Optical, Mechanical and Vibrational properties.

UNIT II Applications of carbon nanotubes: Field emission, Fuel Cells, Display devices Functionalization of CNTs**:** Fictionalization of Carbon Nanotubes, Reactivity of Carbon Nanotubes; Covalent Functionalization -Oxidative Purification; Defect Functionalization

Unit III: Physics of Carbon Nanotubes: Basics of physical properties of carbon nanotubes, explaination of the strange behaviour of carbon nanotubes, electrical conductivity of carbon nanotubes, thermal conductivity of carbon nanotubes, elasticity of carbon naotubes.

Unit IV Transport phenomena: Ficks law, Hydrodynamic equations, Application to confined fluids at nanoscale.
Surface tension: Static and dynamic contact angle, Surface energies, Capillary flows.

Unit V Micro fluidics devices: Micro array chips , Pump, Mixers, Valves, Lithography, Etching, Photo polymerization, Multilayer soft lithography.

Text Books:
1. Synthesis Functionalization and Surface Treatment of Nanoparticles by Marie Isabelle Baraton, American Scientific Publisher

2. Physical Properties of Carbon Nanotube by R Satio, Imperial College Press

3. Applied Physics Of Carbon Nanotubes : Fundamentals Of Theory, Optics And Transport Devices by S. Subramony & S.V. Rotkins, Springer

Reference:

1. Nanotubes and Nanowires by CNR Rao and A Govindaraj, RCS Publishing

2. Carbon Nanotubes: Multifunctional Materials – Ed. Prakash R. Somani and M. Umeno, Applied Science Innovations Pvt. Ltd., India

3. Physical Chemistry of Surfaces by Arthur W, Adamson and Alice P. Gast (John Wiley and Sons)

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

Semester: **M.Tech. II Sem.** Branch: **E & TC.**
Subject: **Laser Technology (Elect-II)** Code: **547232 (28)**
Total Theory Periods: **40** Total Tut Periods: **12**
Total Marks in end Semester Exam.: **100**
Minimum number of class tests to be conducted: **02**

Unit 1 Introduction to Lasers: Definition, Properties of lasers, Laser spectrum and wavelengths, Application of Maxwell's equations to dielectrics- laser gain medium, Dispersion equations, Coherence, Particle nature of light.

Unit II Radiative Properties of Matter: Molecular energy levels and spectra, Energy levels in liquids and solids- Dielectrics and Semiconductors, Radiating bodies, Cavity radiators, Absorption and stimulated emission.

Unit III Laser Amplifiers: Absorption and gain, Population inversion, Saturation intensity, Development and growth of laser beams, Exponential growth factors, Threshold requirements, Operation above threshold, Laser amplifiers.

Unit IV Laser Resonators: Longitudinal and Transverse cavity modes, Mode Properties, Stable curved mirror cavities, Gaussian beams, Unstable resonators, Q-Switching, Gain –Switching, Mode-Locking, Pulse shortening techniques, Ring lasers, Multi-mirror cavities, Cavities for gas lasers.

Unit V Laser Systems: Laser systems in low density gain media- Helium-Neon lasers, Argon-Ion lasers, Copper-vapor lasers, Carbon dioxide lasers, Excimer Lasers, X-ray plasma lasers, Free electron lasers. Laser systems in high density gain media- Organic Dye Lasers, Solid state Lasers, Ruby Lasers, Neodymium lasers, Alexandrite lasers, Fiber lasers, Semiconductor lasers.

Text Books:

1. Laser Fundamentals, W.T Silfvast, Cambridge University Press, 2004
2. Photonics and Lasers- An Introduction, R.S Quimby, Wiley Interscience, 2006

Reference Books

1. Handbook of Lasers- M.J Weber, CRC Press, 2001
2. Principles of Lasers and Optics, W.S.C Chang, Cambridge University Press, 2005
3. Lasers, A.E Siegman, University Science Books, 1986

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

Semester: **M.Tech. II Sem.** Branch: **E & TC.**
Subject: **Nanosensors : Principle Design and Applications(Elect-II)** Code: **547233 (28)**
Total Theory Periods: **40** Total Tut Periods: **12**
Total Marks in end Semester Exam.: **100**
Minimum number of class tests to be conducted: **02**

Unit I : Basics of Nanosensors:
Nanosensors based on different nanomaterials, Fabrication of nanosensors, Large-scale integration of nanosensor arrays, Common recognition elements, Surface chemistry and functionalization, Signal transduction, Practical applications .Properties of nanomaterials for designing powerful sensing and biosensing devices. Nanosensors based on metal nanoparticles, semiconductor nanowires and nanocrystals, and carbon nanotubes.

Unit II :**Types of Nanosensors**: Temperature Sensors, Smoke Sensors, Sensors for aerospace and defense, Accelerometer, Pressure Sensor, Night Vision System, Nano tweezers, Nano-cutting tools, Integration of sensor with actuators and electronic circuitry Biosensors.

Unit III: Inorganic Nanotechnology Enabled Sensors
Gas Sensing with nanostructured thin film, Adsorption on surfaces, Conductometric transducers suitable for Gas Sensing, Gas reaction on the surface, Effect of gas sensitive structures and thin films, Effects of deposition parameters and substrates, Metal Oxides Modification by additives, Surface modification, Filtering, Post deposition treatments.

Unit IV: Organic Nanotechnology Enabled Sensors
Proteins in nanotechnology enabled sensors, Structure of proteins, Analysis of proteins, Role of proteins in Nanotechnology, Using proteins as nanodevices, Antibodies in sensing applications, Antibody nanoparticle conjugates, Enzymes in sensing applications, Enzyme nanopraticle Hybrid based sensors, Motor proteins in sensing applications, Bioelectronic sensors based on DNA, DNA Sequencing with nanopores, Sensors based on molecules with dendritic architectures.

Unit V: Future Nanosensors
Nanometer and Picometer Displacement Sensors, Force Nanosensors, Thermal Nansensors, Heat-Flux Nanosensor, Micro-Thermocouple Sensor, Tunnelling Thermometer, Optical Nanosensors, Fiber-optic Nanosensors, Magnetic Nanosensors, Submicron Hall Probes, Micro-SQUID Sensors, Electronic Nose as a Sensor of Smell, Electronic Tounge as a Sensor of Taste, Advancement in Jaipur Foot by Various Sensors, Magnetic Stray Field Nanosensors, Magnetic Spin Sensors.

Text Book:

1. Sensors: Micro & Nanosensors, Sensor Market trends (Part 1&2) by H. Meixner.
2. Nanoelectronics and Nanosystems from Transistors to Molecular Quantum Devices by K. Goser, P. Glosekotter and J. Dienstuhl, Springer.
3. Nano Engineering in Science & Technology:An Introduction to the World of Nano Design by Michael Rieth.

Reference Books:

1. Handbook of Nanotechnology by Bharat Bhushan, Springer.
2. Nano Systems by K.E. Drexler , Wiley
3. Nanotechnology and Nanoelectronics : Materials, Devices and Measurement Techniques by W.R.Fahrner, Springer

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

Semester: **M.Tech. II Sem.** Branch: **E & TC.**
Subject: **Synthesis Nanomaterials Lab** Code: **547221 (28)**
Total Practical Periods: **40**
Total Marks in End Semester Examination: **75**

List of Experiments (students have to perform at least 10 experiments)

1. Synthesis of nanocrystalline films of II-VI compounds doped with rare earths by chemical deposition technique

2. Fabrication of nanocrystalline films for use as optical filter for solar cells.

3. Synthesis of Alkaline earth aluminates in nanocrystalline form by combustion synthesis.

4. Preparation of surface conducting glass plate by spray pyrolysis method

5. Preparation of surface conducting glass plate by chemical route

6. Working with high vacuum coating unit and deposition of various metals on different substrates.

7. Preparation of nanostructured Y_2O_3: Eu phosphors

8. Formation of Prussian blue nano thin film and study of its electro chromic properties.

9. Fabrication of micro fluidic nanofilter by polymerisation reaction

10. Synthesis of aqueous Ferro fluid (colloidal suspension of magnetic nanoparticles)

11. Preparation and characteristics of Cadmium Selenide quantum dot nanoparticles.

12. Fabrication of nano silver arrays by nanosphere lithography.

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

Semester: **M.Tech. II Sem.** Branch: **E & TC.**
Subject: **Characterisation of Nanomaterials-Lab** Code: **547222 (28)**
Total Practical Periods: **40**
Total Marks in End Semester Examination: **75**

1. Study of nanocrystalline films of II-VI compounds doped with rare earths for applications in light detectors, Solar cells, Lamp phosphors etc.

2. Absorption spectral studies of the prepared nanocrystalline films and determination of absorption coefficient.

3. Tauc's plots and determination of band gap from the absorption spectra

4.. Determination of particle size from the absorption spectral studies of nanocrystalline films.

5. Photoluminescence emission spectral studies of the prepared nanocrystalline films.

7. Study of luminescence characteristics of the prepared Alkaline earth aluminates.

8. Study of Hall effect in semiconductors and its application in nanotechnology.

9. Measurement of electrical conductivity of thin film of semiconductors by Four Probe Method and study of temperature variation of electrical conductivity.

10. Study and determination of optical and electrical properties. of surface conducting glass plate by spray pyrolysis method

11. Study and determination of i optical and electrical properties of surface conducting glass plate by chemical route

12. Study of luminescent properties of nanostructured Y_2O_3: Eu phosphors

13. Study of electro chromic properties Prussian blue nano thin film .

14. Study of aqueous Ferro fluid (colloidal suspension of magnetic nanoparticles) under external magnetic field.