INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-701** Course Title: **Laboratory**

2. Contact Hours: **L: 0** **T: 0** **P: 6**

3. Examination Duration (Hrs.): **Theory** 0 **Practical** 6

4. Relative Weightage**:** **CWS** 0 **PRS** 50 0 0 50

5. Credits**:** 3 6. Semester**: Autumn** 7. Subject Area**: PCC**

8. Pre-requisite**: Nil**

9. Objective: **To impart practical knowledge in Solid Sate Electronic Materials**

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Study of variation of resistivity with temperature of metal and highly resistive materials by Four Probe Technique.	14 x 6
2.	Mapping and analysis of the resistivity of large samples (thin films, superconductors) by Four probe Technique.	
3.	To study the temperature dependence of Hall coefficient of n- and p- type semiconductors.	
4.	(a) To measure the dielectric constant and Curie temperature of given ferroelectric samples. (b) To measure the coercive field (E_c), remanent polarization (P_r), Curie temperature (T_c) and spontaneous polarization (P_s) of Barium Titanate ($BaTiO_3$).	
5.	Thermoluminescence in alkali halides crystals. (a) To produce F centers in the crystal exposing to X-ray /UV source. (b) To determine activation energy of the F-centers by initial rise method.	
6.	Verification of Bragg's law and determination of wavelength/energy spectrum of X-rays.	
7.	Study of solar cell characteristics and to determine open circuit voltage 'V_{oc}' , short circuit current 'I_{sc}', Efficiency (η), fill factor, spectral characteristics and chopper characteristics.	
8.	To measure the magnetoresistance of semiconductor and analyze the plots of $\Delta R/R$ and log-log plot of $\Delta R/R$ Vs magnetic field.	
9.	To determine the coercivity, saturation magnetization and retentivity of ferromagnetic samples using magnetic hysteresis loop tracer	
10.	To study the temperature dependence of Laser diode characteristics	
11.	To determine transition temperature of given superconducting material and study Meissner effect.	
12.	To measure critical current density of given superconductor and study its field dependence.	

13	To determine the value of Lande's 'g' factor using ESR spectrometer.	
14	To study C-V characteristics of various solid state devices and materials (like p-n junctions and ferroelectric capacitors).	
	Total	**84**

11. Suggested Books:

S. No.	**Name of Authors/Book/Publisher**	**Year of Publication/Reprint**
1.	Melissinos, A.C. and Napolitano, J., "Experiments in Modern Physics", Academic Press.	2003
2.	Sze, S.M., "Semiconductor Devices Physics and Technology", John Wiley and Sons.	2002
3.	Nakra, B.C. and Chaudhary, K.K., "Instrumentation Measurements and Analysis", Tata McGraw Hill.	2002
4.	Sayer, M. and Mansingh, A., "Measurement, Instrumentation and Experiment Design in Physics and Engineering", Prentice Hall.	2000
5.	Runyan, W.R., "Semiconductor Measurements and Instrumentation", McGraw Hill	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-703** Course Title: **Semiconductor Materials and Devices**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 25 50 0

5. Credits**:** 4 6. Semester**: Autumn** 7. Subject Area**: PCC**

8. Pre-requisite**: Nil**

9. Objective: To familiarize with semiconducting materials and devices

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Fundamentals of Semiconductors:** Energy bands, direct and indirect band gap semiconductors, concept of density of states and Fermi-level, carrier concentrations at equilibrium, Temperature dependence of carrier concentrations, conductivity and mobility, Effects of temperature and doping on mobility, excess carriers, recombination mechanisms, carrier lifetime, steady state carrier generation, concept of quasi-Fermi level, drift and diffusion of carriers, Einstein relation, Continuity equation, Solution of diffusion equation for steady state carrier injection, diffusion length, Haynes-Shockley experiment.	10
2.	**Junctions:** Homo p-n junctions at equilibrium, forward and reverse biased p-n junction, Carrier injection across p-n junction under forward bias; Derivation of ideal p-n diode current equation; reverse saturation current, Real p-n diode V-I characteristics, Reverse breakdown, capacitances in p-n diode; Hetero p-n junctions, metal-semiconductor contacts. **Bipolar Junction Transistors:** Minority carrier distributions and terminal currents, Ebers – Moll equations and charge-control analysis. Heterojunction Bipolar Transistors.	12
3.	**Field Effect Transistors:** Junction Field Effect Transistor (JFET): Structures of n and p-channel JFET, Pinch-off and saturation, Gate Control, Current Voltage characteristics; Metal-Semiconductor FET (MESFET): GaAs MESFET, High Electron Mobility Transistor (HEMT). Metal Oxide Semiconductor FETS (MOSFETs): Structure and working principle of Enhancement type and depletion type MOSFETs. Ideal MOS diode, inversion layer, threshold voltage, MOS C-V curve, Effects of work function difference and interface charge on threshold voltage, Output and transfer characteristics of enhancement MOSFET, Control of threshold voltage, charge-coupled devices (CCD).	12
4.	**Quantum Effect and Hot Electron Devices:** Tunnel diode, Resonant tunneling diode (RTD), Unipolar Resonant Tunneling Transistor, Hot electron heterojunction bipolar transistors (HEHBT), Transferred Electron Devices, Gunn diode and its applications.	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Streetman, B.G., Banerjee, S. K. **"**Solid State Electronic Devices", Sixth Edition, PHI Learning Private Limited.	2013
2.	Sze, S.M., **"**Semiconductor Devices: Physics and Technology**"**, Second Edition, John Wiley and Sons.	2002
3.	Tyagi, M.S., **"**Semiconductor Materials and Devices**"**, John Wiley and Sons.	2008
4.	Millman J, Halkias C. C., Satyabrata J, "Electronic Devices & Circuits", Tata McGraw Hill	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-705** Course Title: **Characterization of Materials**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**: CWS** 25 **PRS** 0 25 50 0

5. Credits**:** 4 6. Semester**: Autumn** 7. Subject Area**: PCC**

8. Pre-requisite**: Nil**

9. Objective: To introduce various methods of characterization of materials for their structural, electrical, magnetic and optical properties.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Crystal Structure Determination:** Brief description of crystal lattices; X-ray diffractometer; Determination of crystal structure using X-ray diffraction	12
2.	**Electron Microscopes:** Brief description of different microscopes like TEM, SEM, AFM; Modes of operation of microscopes, sample preparation, Interpretation of electron diffraction and determination of crystal structure; morphology of the crystals.	11
3.	**Thermal Analysis:** Thermogravimetric analysis, Differential thermal analysis and Differential scanning calorimetry and methodology; Determination of phase transitions using these methods.	5
4.	**Electrical and Magnetic Property:** Measurement of electrical conductivity in different materials- insulators, metals and semiconductors using four probe and Hall effect method. Vibrating Sample Magnetometer (VSM), Superconducting Quantum interference Devices (SQUID)	8
5.	**Optical Characterization:** Optical characterization of materials using photoluminescence and UV-visible spectroscopy.	3
6.	**Chemical Analysis:** Brief description to X-ray fluorescence, atomic absorption and electronic spin resonance spectroscopy.	3
	Total	42

11. Suggested Books.

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Culity, B. D., "Elements of X-ray Diffraction", Addison-Wesley.	2001
2.	Grundy, P. J. and Jones, G. A., "Electron Microscopy in the Study of Materials", Edward Arnold.	1976
3.	Egerton, R. F., "Physical Principles of Electron Microscopy", Springer.	2008
4.	Willard, H. H., Merritt, L. L. and Dean, J. A., "Instrumental Methods of Analysis", CBS publications.	1991
5.	Fultz, B. and Howe, J. M., "Transmission Electron Microscopy and Diffractometry of Materials", Springer.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-707** Course Title: **Computational Techniques and Programming**

2. Contact Hours: **L: 2** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 2

4. Relative Weightage**:** **CWS** 10 **PRS** 15 15 30 30

5. Credits**:** 3 6. Semester**: Autumn** 7. Subject Area**: PCC**

8. Pre-requisite**: Nil**

9. **Objective of Course:** To provide the knowledge of computation with suitable mathematical software and its applications to solve the problems of condensed matter physics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to mathematical software/language:** Concept of programming in FORTRAN/Matlab/Mathematica, input/output, interactive input, loading and saving data, loops, branches and control flow, matrix and array operations, eigenvalues and eigenvectors.	6
2.	**Sub programs:** Array of dimensional variables, subroutines, sub-programming, functions sub-programming, Advantages of modular programming, built-in functions, scripts, functions, sharing of variables between modules.	5
3.	**Graphics:** 2D plots, style options, axis control, overlay plots, subplot, histogram, 3D plots, mesh and surface plots, contour plots.	4
4.	**Numerical computation:** Computer programs for: solving linear system of simultaneous equations, nonlinear algebraic equation, roots of polynomials, curve fitting, polynomial curve fitting, least square curve fitting, interpolation, data analysis and statistics. Numerical integration, Quadrature, Monte-Carlo simulation, ordinary differential equation, first order and second order ODEs, partial differential equation methods (the finite difference method & the finite element method).	13
	Total	**28**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Pratap, R., "Getting started with MATLAB 7", Oxford University Press.	2006
2.	Gilat, A., "Matlab: An Introduction with Applications", Wiley.	2008
3.	Tao, P., "Computational Physics", Cambridge University Press.	2005
4.	David, P., "Computational Physics", John Wiley & Sons	1973
5.	Wolfram, S., "The Mathematica Book," 5th Ed., Wolfram Media	2003
6.	Gerald, C. F. and Wheatley, P. O., "Applied Numerical Analysis", 7th Ed, Addison Wesley	2003

S. No.	List of Experiments
1.	Eigen-value problem: 1-D square potential well
2.	Stochastic methods for multidimensional integrals
3.	Study of systems with chaotic dynamics
4.	Solving Kronig-Penny Model
5.	Study of doping profile in semiconductors
6.	Variation of dielectric constant for composite materials
7.	Calculation of modes of an optical waveguide
8.	Monte-Carlo simulations (Ising Model of magnetism)
9.	Molecular Dynamics Simulations

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-702** Course Title: **Nanomaterials and Technology**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 25 50 0

5. Credits**:** 4 6. Semester**: Spring** 7. Subject Area**: PEC**

8. Pre-requisite**: NIL**

9. **Objective of Course:** To impart knowledge of nanomaterials and technology

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Physics of Low-dimensional Materials:** An overview of quantum mechanical concepts related to low dimensional systems, classifications of quantum confined systems, electrons and holes in quantum wells, electronic wave functions, energy sub-bands and density of electronic states in quantum wells, quantum wires and quantum dots	10
2.	**Synthesis and Characterization of Nanomaterials:** various top down and bottom up approaches for synthesis of nanomaterials, overview of thin film technology for nanotechnology applications, physical vapour deposition and chemical vapour deposition techniques, synthesis of zero, one dimensional and two dimensional nano structures, characterization of nano materials using XRD, AFM, STM, FESEM and SQUID	12
3.	**Properties of Nano Materials:** Phenomena and properties at nanoscale, mechanical/frictional, optical, electrical and magnetic properties	08
4.	**Nanofabrication and Device Applications**: Miniaturization of electrical and electronic devices, Moore's law, nanofabrication using lithography techniques- electron beam lithography, X-ray lithography, soft nanolithography and dip pen nanolithography; electronic devices based on nanostructures, single electron transistor, future of silicon computer technology, heat dissipation and Rapid Single Flux Quantum (RSFQ) technology, quantum dot lasers, superconducting Josephson junctions, energy storage and fuel cells	12
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1.	Edelstein A. A. and Cammarata R .C., "Nanomaterials-Synthesis, Properties and Applications", Institute of Physics Publishing, London	**1998**
2.	Nalwa H.S., "Handbook of Nanostructured Materials and Nanotechnology", Vols. 1-5, Academic Press	**2000**
3.	Benedek G., Milani P. and Ralchenko V. G., "Nanostructured Carbon for advanced Applications", Kluwer Academic Publishers	**2001**
4.	Dresselhaus M.S., Dresselhaus G. and Eklund P., "Science of Fullerenes and Nanotubes", Academic Press	**1996**
5.	Wilson M, Kannangawa K, Smith G, Simmons M and Raguse B., "Nanotechnology: Basic Science and Emerging Technologies**",** Chapman and Hall	**2002**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-704** Course Title: **Quantum Heterostructures**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 25 50 0

5. Credits**:** 4 6. Semester**: Spring** 7. Subject Area**: PEC**

8. Pre-requisite**: NIL**

9. **Objective of Course:** To impart knowledge of size-quantization in nanosystems and semiconductor heterostructure quantum devices

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Electrons in Quantum Confined Systems:** Density of states function in quantum wells, quantum wires, quantum dots and super lattices, coupling of quantum wells, Type-I and Type-II heterostructures	10
2.	**Electron Transport in nanostructures:** Parallel and perpendicular transport in quantum structures, linear electron transport, hot electron transport, real space transfer of hot electrons	08
3.	**Quantum Tunneling:** Single and double barrier cases, resonant tunneling, resonant tunnel diode characteristics and mechanisms, resonant tunnel transistors	08
4.	**Heterostructure Devices:** Super lattices and ballistic-injection devices, Block oscillations, Wannier-Stark energy ladder, single electron transfer and Coulomb blockade, velocity modulation interference transistors (vmt)	08
5.	**Quantum Optical Devices:** Quantum well lasers, multiple quantum well lasers, cascade lasers, optical modulators and quantum well photodetectors	08
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1.	Mitin V.V., Kochelap V. A. and Stroscio M. A., **"**Quantum Heterostructures: Microelectronics and Optoelectronic Devices", Cambridge University Press	**1999**
2.	Ferry D.K. and Goodnick S.M., **"**Transport in Nanostructures**",** Cambridge University Press	**1997**
3.	Shik A., **"**Quantum Wells: Physics and Electronics of Two-Dimensional Systems**",** World Scientific	**1998**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-706** Course Title: **Functional Materials and Devices**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**: CWS** 25 **PRS** 0 25 50 0

5. Credits**:** 4 6. Semester**: Spring** 7. Subject Area**: PEC**

8. Pre-requisite**: NIL**

9. **Objective of Course:** To impart knowledge of functional materials and devices

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Scope of functional ceramics, classification according to their different functions, electrical and electronic conduction in ceramics, defect chemistry, ionic conductivity, ceramic electrolytes and fast ion conductors, ceramic insulators; Ceramic Capacitors, piezoelectric, ferroelectric and electro optic ceramics - material systems, processing and fabrication	10
2.	Electroceramic thin film technology, materials and deposition methods, application of thin films in microelectronics and microsystems; Multilayer ceramic technology- processing of multi layer ceramics, sintering of multilayer structure, low temperature co-fired glass ceramics	10
3.	Smart functional role of the materials in devices which depends on their electrical, optical and thermal properties, smart transducers, optical fibers, optical coatings, liquid crystal displays, optical storage devices, ruby laser, solar cell, ceramic insulators, Peltier cooler	8
4.	Ceramic sensors and resistors- classification, operating principles of different sensors, preparation and applications; Positive and negative temperature coefficient ceramic thermistors, gas, humidity and pressure sensors, ZnO-varistors technology, varistor microstructure and fabrication, Varistor application	7
5.	Ceramic membranes- classifications, material requirements, preparation and applications, special glass and glass ceramics for defence applications	7
	Total	42

11. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1.	Buchanan R. C., "Ceramic Materials for Electronics", 3rd Ed, Marcel Dekker, NY	**2004**
2.	Moulson A. J. and Herbert J. M., "Electroceramics: Materials, Properties and Applications", Wiley; 2nd Ed.	**2003**
3.	Bachs H. and Krause D., "Low Thermal Expansion Glass Ceramics", Springer	**2005**
4.	Setter N., "Electroceramic based MEMS: Fabrication Technology and Applications", Springer	**2005**
5.	Nenov T. G., Yordanov S. P. and Nenov N., "Ceramic Sensors: Technology and Applications", CRC Press	**1996**
6.	Wang Z. L., Wang W. Z. L. and Kang Z. C., "Functional and Smart Material", Springer	**1998**
7.	Jaffe B., Cook W. R., Jaffe H. and Jaffe H. L. C., "Piezoelectric Ceramics", R.A.N Publishers	**1990**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-708** Course Title: **Solar Photovoltaic**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**: CWS** 25 **PRS** 0 25 50 0

5. Credits**:** 4 6. Semester**: Spring** 7. Subject Area**: PEC**

8. Pre-requisite**: Nil**

9. Objective: To learn the fundamentals, design and application of solar photovoltaic systems for power generation on small and large scale electrification.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Review of Semiconductor Physics:** Electrons and holes in semiconductors, doping, electrical transport, Photo carrier generation and recombination; p-n and p-i-n Junctions; metal semiconductor contacts, band bending, Ohmic and rectifying contacts, Surface and interface states, homo and hetero-junctions; Depletion region, depletion capacitance, Carrier and current densities, Current voltage characteristics in dark and light	9
2.	**Device Physics of Solar Cells:** Photovoltaic effect - Principle of direct solar energy conversion into electricity in a solar cell. Semiconductor properties, energy levels, basic equations. Solar cell, p-n junction, structure**.** Solar radiation, conversion efficiency, p-n junction model, Effect of Parasitic resistance, irradiation and temperature on I-V characteristics. Numerical solar cell modeling	9
3.	**Principle of cell design:** Cell type, Optical design, surface and bulk recombination losess, design and fabrication of metal contacts, Crystalline Silicon and III-V Solar cells: Single, tandem and multi-junction solar cells, Thin Film Solar cells: Amorphous silicon, cadmium telluride and copper indium gallium diselenide based solar cells	9
4.	**Photovoltaic System Engineering:** Thermo-photovoltaic generation of electricity, Concentration and storage of electrical energy, photovoltaic modules, system and application	5
5.	**NANOMATERIALS FOR PHOTOVOLTAICS** Photochemical solar cells, PV panels with nanostructures. Phase compositions on nanoscale microstructures – role of nanostructures and materials – nanomaterials in solar photovoltaic technology- band gap engineering and optical engineering - tandem structures - quantum well and quantum dot solar cells - photo-thermal cells – organic solar cells. Performance and reliability of nanomaterials based solar cells.	10
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Jasprit Singh, "Semiconductor Devices, Basic Principles", Wiley	2001
2.	Jenny Nelson, "The Physics of Solar Cells", Imperial College Press	2003
3.	Stephen J. Fonash , "Solar Cell Device Physics", 2nd edition, Academic Press	2010
4.	A. Luque and S. Hegedus, "Handbook of Photovoltaic Science & Engineering", Wiley	2003
5.	Tsakalakos.L., "Nanotechnology for Photovoltaic's", CRC	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-710** Course Title: **Advanced Ceramics & Composites**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**: CWS** 25 **PRS** 0 25 50 0

5. Credits**:** 4 6. Semester**: Autumn** 7. Subject Area**: PEC**

8. Pre-requisite**: Nil**

9. Objective: The course is aimed to impart basic understanding about ceramics, fibres and composites with their properties, manufacturing routes and applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	INTRODUCTION: oxide and non-oxide ceramics, their chemical formulae, crystal and defect structures, non-stoichiometry and typical properties.	4
2.	POWDER PREPARATION: Physical methods (different techniques of grinding), chemical routes - co-precipitation, sol-gel, hydrothermal, combustion synthesis, high temperature reaction (solid state reaction).	5
3.	BASIC PRINCIPLES AND TECHNIQUES OF CONSOLIDATION AND SHAPING OF CERAMICS: powder pressing- uniaxial, biaxial and cold isostatic and hot isostatic, injection moulding, slip casting, tape-casting, calendaring, multilayering. Sintering: different mechanisms and development of microstructure (including microwave sintering) Preparation of single crystal, thick and thin film ceramics	5
4.	EXOTIC CERAMICS: functionally graded, smart/ Intelligent, bio-mimetic and nano-ceramics - basic principles, preparation and applications	6
5.	COMPOSITES: Introduction to composite materials – definition, characteristics, classification; Matrix Materials – polymers, metals and ceramics; Fabrication of thermosetting resin matrix composites, thermoplastic resin matrix composites, metal matrix composites, ceramic matrix composites, carbon – carbon composites, their preparation and properties (including nano-composites); Engineering applications: at room and high temperatures (including armour application)	8
6	Transparent ceramics, coatings and films: preparation and applications	3
7.	SPACE CERAMICS: Materials aspects of missile and satellite reentry, auxiliary space powder devices- rocket nozzle technology- the space environment and its effects. Quantitative analysis of texture, nature of grain boundaries, development of microstructure, grain growth, microstructure in glass ceramics, effect of particle size, pressure and sintering, dependence of mechanical and thermal properties on microstructure.	6
8.	CERAMIC FIBRES Introduction – difference between material in bulk form and fibre form, types of fibres, fibre flexibility, fibre manufacturing technology, glass fibres: manufacture & applications, carbon and graphite fibres, grades of carbon fibres.	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Michel W. Barsoum, M. W., "Fundamental of Ceramics", McGraw Hill International edition	1997
2.	Richerson, D.W., " Modern Ceramic Engineering", Mercel Dekker NY	1992
3.	Rahman, M. N., "Ceramic Processing and Sintering", Mercel Dekker	2003
4.	Somiya, S., "Handbook of Advanced Ceramics", Academic Press	2003
5.	Somiya, S., "Handbook of Advanced Ceramics, Parts 1 and 2, Academic Press	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-712** Course Title: **Optoelectronics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 25 50 0

5. Credits**:** 4 6. Semester**: Spring** 7. Subject Area**: PEC**

8. Pre-requisite**:** **Nil**

9. Objective: **To impart knowledge of photons and semiconductors physics of optoelectronic devices**

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Interaction of photons with atoms, spontaneous emission, stimulated emission and absorption, line broadening, the laser amplifier, theory of laser oscillation, characteristics of laser output, characteristics of common lasers	**6**
2.	Semiconductors- energy bands and charge carriers, binary, ternary and quaternary semiconductors, generation, recombination and injection processes, junctions, hetrojunctions, quantum wells, superlattices, interaction of photons with electrons and holes, band-to-band absorption and emission, rates of absorption and emission, refractive index	**8**
3.	Light emitting diodes, injection electroluminescence, LED characteristics, semiconductor laser amplifier, gain, pumping, hetrostructures, semicunductor injection lasers, amplification, feedback and oscillation, power, spectral distribution, mode selection, characteristics of typical semiconductor lasers, quantum well lasers	**8**
4.	Properties of semiconductor photodetectors, quantum efficiency, responsivity, response time, Photoconductors- photodiodes, p-n and p-i-n photodiode, hetrostructure photodiodes, array detectors, avalanche photodiodes, noise in photodetectors	**7**
5.	Principles of electron optics, Pockels and Kerr effects, electro-optic modulators and switches, scanners, directional couplers, spatial light modulators, electro-optics of anisotropic media and liquid crystals,	**6**

	photorefractive materials	
6.	Integrated optic planar waveguides, mechanism of light guidance, integrated optic components, directional coupler, optical fiber, step-index, graded-index, single-mode fibers, optical fiber components, fused fiber coupler, fiber Bragg gratings, long-period fiber gratings, sources for optical transmitters, detectors for optical receivers, fiber-optic systems	**7**
	Total	**42**

11. Suggested Books:

S. No.	**Authors/Name of Books/Publisher**	**Year of Publication**
1.	Saleh B. E. A. and Teich M. C., "Fundamentals of Photonics", John Wiley and Sons, Inc.	**1991**
2.	Ghatak A. and Thyagarajan K., "Optical Electronics", Cambridge University Press	**2003**
3.	Yariv A, "Quantum Electronics", 3 Ed., John Wiley and Sons	**1988**
4.	Streetman B.G. and Banerjee S., **"**Solid State Electronic Devices**"**, 6 Ed. Prentice Hall	**2006**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-714** Course Title: **Semiconductor Micro-Electronic Technology**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 25 50 0

5. Credits**:** 4 6. Semester**: Spring** 7. Subject Area**: PEC**

8. Pre-requisite**:** **Nil**

9. **Objective:** To impart knowledge of physics of semiconductor devices and their fabrication technologies.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Crystal Growth and Epitaxy:** Single crystal growth techniques of Silicon and GaAs, epitaxial growth techniques, structures and defects in epitaxial layers, thermal oxidation of silicon including the Deal-Grove model	10
2.	**Film Formation:** Vacuum science, vacuum technology and basic physics of a plasma, thermal oxidation of Si, deposition of SiO_2 film by CVD technique	7
3.	**Lithography:** Optical and nonoptical lithography, electron beam lithography, X-ray lithography, etching techniques- wet and dry etch processes including reactive ion and high density plasma etching	8
4.	**Impurity Doping:** Impurity diffusion in semiconductors, diffusion mechanisms, and rapid thermal processes, diffusion process, diffusion equation, diffusion profiles, evaluation of diffused layers, ion implantation-range of implanted ions, ion distribution, ion stopping, ion channeling, implant damage and annealing	9
5.	**Integrated devices:** Fabrication of active and passive components in an integrated circuit, bipolar, MOSFET and MESFET technologies	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1.	Sze S.M., "Semiconductor Devices: Physics and Technology", John Wiley and Sons	2002
2.	Streetman B.G. and Banerjee S., **"**Solid State Electronic Devices**"**, 6 Ed. Prentice Hall	2006
3.	Gandhi S.K., "VLSI Fabrication Principles", John Wiley and Sons	1994
4.	Nagchoudhuri D., **"**Microelectronic Devices**",** Pearson	2001
5.	Jaeger R. C., "Introduction to Microelectronic Fabrication", 2nd Ed., Prentice Hall	2001