Solapur University, Solapur

Ph.D. Course work Syllabus in Physics

(w.e.f. June 2014-15)

Paper No. II: Recent Trends in Physics

1. **X – ray Diffraction Spectroscopy:** Review of basic crystal systems, powder diffraction method, instrumentation of X – ray diffractometer, sources of X – rays, detectors of X – rays, acquisition of raw data, data processing and refinement. θ – θ and θ - 2θ Spectrometers, Method of determination of lattice parameters for cubic, tetragonal, hexagonal crystal systems, use of JCPDs data cards. Basic concept of calculation of intensity of XRD data Low angle XRD and texture analysis, Qualitative and Quantitative analysis tools and software.

2. **SEM, FESEM and TEM:** Basic Instrumentation, Principle of Image formation, backscattered and Secondary electrons and images, basic concept of EDS and WDS, Principle of FESEM and advantages over SEM, TEM and HRTEM, SAED and Concept of electron diffraction, Sample preparation of for SEM, TEM.

3. **IR Spectroscopy and Applications:** Diatomic Molecule as SHO, Absorption IR, IR Sensitive and insensitive modes of vibration, Application of IR to Organic molecules, For IR applications for $NiFe_2O_4$ and $BaTiO_3$, FTIR instrumentation and advantages.

4. **UV – VIS Spectroscopy:** Basic concept of absorption of light, typical UV spectra for organic molecules, types of transitions, effect of conjugation, Determination of optical bandgap using absorption spectroscopy.

5. **Atomic Force Microscope (AFM)** , contact – mode, tapping mode and lateral – force AFM, electrostatic force microscope, magnetic force microscope, AFM based nano – lithography, surface force and adhesion measurements, as well as molecular recognition.

6. **XPS and UPS:** basic principle, instrumentation configuration, data interpretation and analysis, chemical shift, quantification, and depth – profiling. basic principle, instrumentation configuration, data interpretation and analysis, valence – band analysis and work function measurement.

Reference Books:

1. X – ray Diffraction – B. D. Cullity
2. Research Article by Waldran.
3. Research paper by Last
4. Elements of Organic Spectroscopy by Y. R. Sharma
5. Characterization of Materials Vol. 1 By Elton N. Kaufman.
6. Spectroscopy of Organic Compounds - By P. S. Kalsi - Publisher - New Age
7. Analytical Instrumentation - By R. S. Khandpur

Paper No. III: Advanced Development in Physics
(E_1): Solar Cells and Super Capacitor

1. **Basics of Solar Cells:**

   Solar radiations and solar spectrum, basic semiconductor concepts of N and P type semiconductors, P-N Junction hetero and homojunctions, photovoltaic effect, Current –voltage characteristics and solar cell characterisation. Spectral response, internal photon conversion efficiency

2 **Types of Solar Cells:**

Classification of solar cells, solid state solar cells, Silicon solar cells, GaAs based solar cells, CdS/Cu_2S solar cells, $CuInSe_2$ based solar cells, Metal-semiconductor solar cells, photoelectrochemical and photo electrolysis cells, Dye sensitised solar cells

3 **Fabrication of Solar Cells:**

Thin film deposition methods, Junction fabrication methods, Single junction

and multi junction solar cells, Recent developments in solar cells, Applications of solar cells.

4 **Supercapacitors**

Differences between capacitors, Super capacitors and batteries, Regaon Plots, Types of super capacitors: Electrochemical double layer and pseudocapacitors, Hybrid super capacitors, advantages and disadvantages of electrochemical double layer, Psudocapacitors and hybrid supercapacitors.

5 **Fabrication of Supercapacitors:** different methods for preparation of cathodic and anodic electrode materials, Fabrication of super capacitors with examples, Supercapacitor characterisation,

6 **Performance of Supercapacitors:** carbon material based super capacitors,

Metal oxide and polymer based super capacitors, Stability studies, Applications of supercapacitors.

Reference Books

1. Electrochemical Supercapacitors, B E Conway, Kluwer Academic/

   Plenum publishers, NY 1999.

2. Metal oxide thin film based supercapacitors C.D. Lokhande, D.P. Dubal, Oh-Shim Joo Current Applied Physics 11 (2011) 255e270
3. B.E. Conway, Electrochemical Supercapacitors: Scientific, Fundamentals, and Technological Applications. Kluwer, (New York), 1999.
4. J.R. Miller, A.F. Burke, Electrochem. Soc. Interface (Spring 2008)
5. A. Burke, J. Power Sources 91 (2000) 37.
6. R. Kotz, M. Carlen, Electrochim. Acta 45 (2000) 2483.
7. A.K. Shukla, Resonance 6 (2001) 72.

Paper No. III : Advanced Development in Physics

E_2: Ferroelectric and Ferrimagnetic Materials

1. Electric Polarization And Relaxation

Fundamental Concepts, Motion of Electrical Charge Carriers, Electromechanical Effects, Electrostatic Induction, Electric Polarization and Relaxation in Static Fields, Mechanism of Polarization, Classification of Dielectric Materials, Nonferroelectric Materials, Ferroelectric Materials, Internal Field, Electric Polarization and Relaxation in time varying fields, Complex Permittivity, Crammers equation, Debye Equation, Effect of dc conductivity, Cole- Cole plots, Relaxation phenomenon.

2. Ferroelectrics, Piezoelectrics and Pyroelectrics.

Introductory Remarks, Ferroelectric Phenomena, General Features, Phenomenological Properties and Mechanisms $BaTiO_3$ - Type Ferroelectrics KH_2PO_4 - Type Ferroelectrics , Alloys of PbO, ZrO_2, and TiO_2(PZT alloys) - Type Ferroelectric Ceramics, PVDF [$(CH_2$ - $CF_2)a$] - Type Ferroelectric Polymers, Thermodynamic Theory, Ferroelectric Transition, Antiferroelectric Transition, Formation and Dynamics of Domains, Ferroelectric Materials.

3. **Applications of Ferroelectrics** - Autostabilization Nonlinear Dielectric Elements (TANDEL) High - Energy Electrical Pulse Generators, Memories, Piezoelectric Phenomena, Phenomenological Approach to Piezoelectric Effects, Piezoelectric Parameters and their Measurements, Piezoelectric Materials, Application of Piezoelectrics.

4. **Introduction to Magnetism**

Measurement of Field Strength, Hall Effect, Electronic Integrator or Fluxmeter, Magnetic Measurements in Closed Circuits, Demegnetizing Fields, Magnetic Shielding, Demagnetizing Factors, Magnetic Measurements in Open Circuits, Instruments for Measuring Magnetization, Vibrating - Sample Magnetometer.

5. Ferromagnetism & Ferrimagnetism

Introduction, Molecular Field Theory, Exchange Forces, Band Theory, Ferromagnetic Alloys, Theories of Ferromagnetism. Introduction, Structure of Cubic Ferrites, Saturation Magnetization, Molecular Field Theory, Above Tc, Below Tc, General Conclusions, Hexagonal Ferrites, Other Ferromagnetic Substances, y - $Fe2O_3$, Garnets, Alloys.

6. Magnetic Anisotropy

Introduction, Anisotropy in Cubic Crystals, Anisotropy in Hexagonal Crystals, Physical Origin of Crystal Anisotropy, Anisotropy Measurement, Torque Curves, Torque Magnetometers, Anisotropy Measurement (from Magnetization Curves), Fitted Magnetization Curve, Anisotropy Constants of Polycrystalline Materials

Reference Books:

1. Dielectric Phenomena in Solids: Kwan Chi Kao & F. R. de Boer
2. Introduction to Solid State Physics : C. Kittle
3. K. H. J. Buschow & F. R. de Boer: Physics of Magnetism and Magnetic Materials.

Paper No. III: Advanced Development in Physics

E_3: Solid State Gas Sensor Devices

1) Introduction

Classification of gas sensors (Semiconductor gas sensors, solid electrolyte & catalytic combustion gas sensors) gas sensing mechanism, physical model of gas adsorption, Method of sensor fabrication: pellet, thick-film, and Thin film), Thin film techniques physical methods: vacuum evaporation, sputtering and ablation. Chemical Methods: Chemical vapour deposition, electrochemical, and spray Pyrolysis. Solution combustion synthesis of oxide materials, role of fuels, salient features of solution combustion method

2) Electrical Based Gas Sensing

Electrical properties of metal oxide semiconductors surfaces: semiconductor statistics, surface states, surface space charge region. Conduction model of metal oxide semiconductor: polycrystalline materials with large grains, small grains, physical and chemical adsorption, surface reaction towards electrical properties, catalysts and promoters. Deposition techniques: Three dimensional, two dimensional, one dimensional nanostructures.

3) Solid / Gas Interfaces

Adsorption , physiosorption , chemisorptions , ionosorption , electrical behavior of defects , reduction , oxidation and dissociation of oxides , catalysis mechanism , need for activation of oxygen , sites for activation of oxygen , spillover mechanism.

4) Thick & Thin Film Gas Sensors:

Schottky barrier diode, sensors using films of metal oxide, thin film oxide sensors. Thick film technology, advantages of thick film sensors, screen printing technology (Screen preparation, mask, stencil, binders, glass frit, organic binder, curing of prints.

5) Applications of Solid –State Chemical Sensors:

Current use of commercial solid state gas sensor, Problems with semiconductor sensors, Electrochemical and FET base gas sensors.

Reference Books:

1. Solid state gas sensing – Elisabetta Co mini , Guido Fagila , G. Sberveglieri (Springer)
2. Chemical Sensing with Solid state devices – M.J. Madou , S R Morison (Academic Press Incorporation)
3. Physics , chemistry and Technology of solid state gas sensor devices- A Mandelis, C. Chritofides , Wiley
4. Handbook of modern sensors: Physics, Design and Applications – Fraden J. (Springer)

Ph.D. (Course Work) Nature of Question Paper Pattern

- Ph.D. कोर्सवर्कसाठी फक्त Long Answer व Short Answer असेच प्रश्न असतील.
- Ph.D. (Course work) प्रश्नपत्रिकेत कोणताही External Option व Objective प्रश्न असणार नाहीत.
- एकूण प्रश्न - ५ x गुण २० = १०० गुण
- प्रश्न क्रमांक १ ते ५
- (A) दिर्घोत्तरी प्रश्न (१० गुण)

  (B) Answer Any two out of three (प्रत्येकी ५ गुण)

  या प्रश्नपत्रिकेच्या स्वरुपामुळे Internal Option हा २५% राहतो.