SOL GEL PROCESSING IN SOLID STATE MATERIALS

UNIT 1

PHYSICOCHEMICAL ASPECTS OF DISPERSED SYSTEM:

Properties of dispersed of systems, classification of disperse system of dispersity, state of aggregation, types of disperse systems, molecular- kinetic properties of disperse systems,concepts of Brownian motion, osmosis, sedimentation of suspensation, measure of dispersion.

UNIT 2

VFEATURE OF COLLOIDAL SOLUTION

Colloidal state, scattering and absorption of light by colloidal systems and colloidal systems,, importance of colloidal systems and colloidal processes in nature and Engineering , stability and coagulation of colloidal systems , Synthesis and swalling processing in coagulate structural system

UNIT 3;

CHEMICAL ASPECT OF SOL GEL PROCESS:

Various parameters involved in sol gel process, composition, Gel formation, precursors, Drying , aging and processing ,Role of organics, incorporation of organics, preparation, Properties and uses of Aerogel.

UNIT4:

PRECURSORS FOR SOL GEL DRYING:

Metal alkoxides and their synthesis, physical and chemical properties of metal alkoxides, Degree of oligomerization, voltality, viscosity, Reaction with alcohols, molecular association between alkoxides, stabilization against hydrolysis, non alkoxides precursors, carboxyl ate and Acetylatonates.

UNIT-5

HYDROLYSIS AND CONDESAION OF SILICATES AND STRUCTURAL ASPECTS

Hydrolysis and condensation: effect of catalyst, steric and inductive effects, effect of water contest, solvent effects, mechanisms, transterfication, Reesterification, effects of reverse reaction, sol gel kinematics , structural evolution .

References:

1 Colloidal Chemistry: By S.Voyutsky MIR publishers 1975
2 A course in colloid Chemistry : By D.A. Fridrikkhsberg, MIR publishers Moscow 1986
3 Advance in polymer chemistry: ByV.V.Korshank, ,MIR publishers Moscow 1986.

M. Phil (PHYSICS) Paper III

Deposition of films and their applications

Unit I. Deposition of films using Physical methods (15)

i) **Thermal evaporation:-** Vacuum systems, Evaporation methods- Resistive heating , Laser evaporation, electron beam bombardment heating.

ii) **Cathodic Sputtering:-** Sputtering process , Glow discharge, Sputtering Variants, low pressure sputtering, Reactive sputtering, Magnetron sputtering, RF Sputtering

Unit II. Deposition of films using Chemical methods (15)

i) **Chemical vapour deposition:** Deposition mechanism, Laser CVD, Photothermal CVD, Plasma enhanced CVD, MOCVD.

ii) **Solution deposition**: - Ionic and solubility products, deposition parameters and process, Chemical deposition, SILAR, Spray pyrolysis and Spin coating.

iii) **Electrodeposition**: - Faradays laws, mechanisms and deposition parameter, binary and ternary alloy deposition.

iv) **Epitaxial growth of films**:-Influence of substrate and deposition condition, Theories of epitaxy.

Unit III (Solar energy devices) (15)

i) Solid state junction solar cells:- principle of solar cells, Fabrication of CdS/ Cu_2S and CdS / $CuInSe_2$ solar cells, performance testing, stability and efficiency consideration. Organic solar cells

ii) Photoelectrochemical Solar Cells:-Basic principle, fabrication of CdSe/Polysulphide/Pt cell, band diagram, Stability of PEC cells.

iii) Dye sensitized solar cells (DSSC):- Working principle, Fabrication of DSSCs based on TiO_2 and ZnO, stability and performance of dyes.

iv) Solar selective Surface:-Method of obtaining selective surface, Application of selective surface in photo thermal conversion.

Unit IV (Other devices) (15)

i) **Microelectronics:-** MOS transistors, different steps in C MOS technology, thick film hybrid micro circuits.

ii) **Super capacitor:** - Materials for super capacitors, Types of super capacitors, thin film based super capacitors on carbon, polymers, metal oxides.

iii) **Thin film gas sensor:**:- Basic parameters and mechanism of gas sensing, electrical resistivity and heterojunction based sensors.

Reference books

1) Thin film phenomena- K. L. Chopra, Mc Graw Hill, N.Y (1969)
2) Preparation of thin films- Joy George, Marcel & Dekker (1992)
3) Physics of thin film –L. Eckertova. Plenum press, N.Y (1986)
4) The theory and practice of microelectronics-S. K. Gandhi, John. Wiley & sons, N.Y (1968)
5) Gas sensors, V Demarne and R Sanjincs, Dordrecht, (1992)
(6) Electrochemical Supercapacitors, B E Conway. Kluwar- plenum, NY 1999.

Revised syllabus (Physics) M. Phil. Paper II

"Frontiers in Physics"

Unit 1: Structural characterizations: Construction, Principle and working of XRD, SEM, TEM, AFM, XPS, TGA-DTA characterization techniques- Data analysis using above characterization techniques

Unit 2: Compositional Analysis: Atomic Absorption Spectrometry: EDAX, Augur electron spectroscopy- Working, actual determination, limitations, procedure, and experimental analysis

Unit 3: Optical Properties: UV–Vis–IR, Raman spectroscopy and photoluminescence: principle and working, reflection, absorption, transmission analysis, band gap determination, Identification of molecular groups for radicals in solids, zero phonon mode of vibration, electron-phonon and phonon-phonon interactions, scattering geometry in Raman spectroscopy.

Unit 4: Thin Film Applications: Solid state solar cells, Fuel cells, Photoelectrochemical solar cell, Super-capacitors, Sensors, Holography, Aerogels, Microwaves, smart windows, water purification, photodetectors by different methods

Reference books

1. Elements of X- ray diffraction By B. D. Cullity, (1956), Addison-Wesley Publishing company Inc., USA
2. X ray theory and experiments by Compton and Alison
3. Instrumental methods of analysis (V^{th} edition) by Willard, Merritt, Dean Settle
4. Photoelectrochemical solar cells by Suresh Chandra
5. Solar cells by Martin a Green
6. Thin film preparation by Joy George
7. Characterization techniques by Chatwal Anand
8. Modern Raman Spectroscopy: Practical Approach by Deon and Smith
9. Microscopy of materials - D.K. Bowen & C.R. Hall (the MacMillan press Ltd. (London) 1975

Department of Physics
Shivaji University, Kolhapur
M. Phil. / Pre Ph.D. Physics
Paper-III
Fuel Cell Technology

Unit-I Introduction:

Fuel cell definition, historical developments, working principle of fuel cell, components of fuel cell, EMF of the cell and general performance characteristics, Types of fuel cells, Advantages and disadvantages of fuel cells. Applications of Fuel Cells.

Unit-II : Alkaline Fuel Cells:

Principle and working of alkaline fuel cell; Thermodynamic Principles, Efficiency of fuel cell, Factors limiting fuel cell performance, Design calculations for a fuel cell.

Unit-III Solid Oxide Fuel Cells (SOFCs):

The ideal reversible SOFC, Thermodynamic principles, Components of SOFC: Electrolyte, anode, cathode, and interconnect, Classification of Solid Oxide fuel cells (SOFCs) based upon Electrolyte, Design, operating temperature and support. Cell operation and performance. Ohmic, Concentration and Activation polarization.

Unit-IV Electrolytes and Electrode Materials

Electrolyte: Ionic conductivity, Oxygen ion conducting materials, Proton conducting Oxides; Anode: Requirements of anode, Choice of Cermet anode, Anode behavior and anodes for direct oxidation of hydrocarbons.Cathode: Perovskite based materials, Physical and Physiochemical properties of perovskite materials. Carbon nano tubes (CNTs).
Solid-sate synthesis, Combustion route, Material synthesis in thin-thick film form by spray pyrolysis, screen printing, Chemical vapor deposition.

References:

1. Fuel cell technology handbook, edited by Gregor Hoogers, CRC Press 2003

2. Handbook of Batteries and Fuel cell, David Linden, McGraw-Hill Book Company

3. High-temperature Solid Oxide Fuel Cells: Fundamentals, Design and Applications, S.C. Singhal, Elsevier Publications, 2003

4. Direct Energy Conversion Fourth Edition – Stanley W. Angrist , Carnegie Mellon University

Desirable

1. Non-stoichiometry, Diffusion and Electrical conductivity in binary metal oxides, P. Kofstad, Wiley-Interscience, New York, 1972.

2. Science and Technology of Ceramic Fuel Cells, 2nd Edition , Nguyen Minh, Elsevier Publications, 2007

NEW/REVISED SYLLABUS FOR

M. Phil. / Ph. D. Course Work

(Introduced from June, 2011 onwards)

(Paper-I) (Research Methodology and Computer Applications in Physical And Chemical Sciences)

Unit-I Computer Basics and Applications (15)

a) Introduction to : Computer and its generations, hardware, software-system software and application software, computer networks and internet,
b) Data and Program representation-digital data representation representing numerical data (binary), coding system for text based data(ASCII and EBCDIC) , Computer hardware: coding system for other types of data (graphics, audio and video data), inside the system unit -motherboard, power supply and drive bays, CPU, Memory Cooling components, expansion slots, expansion cards and express cards, ports and connectors
c) Operating systems, application software-word processing concept, spreadsheet concept, database concept, presentation graphic concepts, graphics and multimedia concepts

Unit-II Quantitative Techniques (15)

Classification of quantitative methods, General steps required for quantitative analysis, reliability of the data, classification of errors, accuracy, precision, statistical treatment of random errors, the standard deviation of complete results, error proportion in arithmetic calculations, Uncertainty and its use in representing significant digits of results, confidence limits, Estimation of detection limit.

Unit-III Research Methodology (15)

a) Meaning of research, objectives of research, motivation in research, types of research, research approaches, significance of research, research methods versus research and scientific methodology, importance of knowing how research is done, research progress, criteria of good research,
b) Research design: meaning of research design, features of good design, important concepts of relating research design, different basic designs
c) Method of data collection, types of data analysis; statistics in research, measure of central tendency, measure of dispersion; measure of asymmetry, measure of relationship, simple regression analysis, multiple correlation and regression, partial correlation

Unit-IV Literature Searching and Report Writing: (15)

a) Literature Searching: On-line searching, Database, SciFinder, Scopus, ScienceDirect, CA on CD, Searching research articles, Citation Index, Impact Factor, H-index etc,

b) Writing scientific report: Structure and components of research report, revision and refining' writing project proposal, Paper writing for International Journals, submitting to editors. Conference presentation, preparation of effective slides, pictures, graphs and citation styles.
c) Thesis writing: the preliminary pages and the introduction, the literature review, methodology, the data analysis chapters, the conclusions

Text Books:

1. Fundamentals of computers,Morley & Parkar, Cengage Learning Pvt. Ltd. New Delhi,
2. Research Methodology – Methods and Techniques, C. R. Kothari, Wiley Easter Ltd, New Delhi 1985.
3. Writing your thesis, Paul Oliver, Vistaar Publication, New Delhi
4. Fundamentals of analytical Chemistry by D. A. Skoog, D. M. West and F. J. Hooler.
5. Quality in the Analytical Chemistry Laboratory by R. D. Treble and D. G. Holcombe.

Reference Books:

1. Molecular dynamics simulations elementary methods by J. M. Haile.
2. The art of molecular dynamics simulations by D. C. Rapaport.
3. Introduction to computational chemistry by F. Jensen.
4. Molecular modeling principles and applications by A. R. Leach.
5. Computer Education by Prof. Lalini Varanasi, Prof. V. Sudhakar and Dr. T. Mrunalini, Neelkamal Publications PVT. LTD.
6. Basic Computing Principles by B. West, BPB Publications, New Delhi 1992
7. Essentials of computational chemistry by C. J. Cramer.
8. Practical Research Methods, Catherine Dawson, UBS Publishers Distribution, New Delhi 2002
9. Research Methodology – A Step by step Guide for Beginners 2nd edn. Kumar Ranjit, Pearson Education, Singapore, 2005
10. Introduction to Research and Research Methodology M. S. Sridhar
11. The Information Specialist's Guide to Searching & Researching on the Internate & the World Wide Web by Ernest Ackermann, Karen Hartman, Fitrzroy Dearborn Publishers, London.
12. Learning to Use the World Wide Web, Ernest Ackermann, BPB Publications.

M. Phil. (Theory) - Paper-III

Holography and its Applications

1. **History of Holography**
   Introductory concepts in holography, Hologram formation, Wave front reconstruction, Plane and Volume Hologram, Basic Holographic equations, In-line and Off-axis hologram

2. **Analysis of plane hologram**
   Off axis holography with non-diffuse subject light, Off-axis holography with diffuse signal, Hologram forming geometric, Effects of resolution and size of the recording medium, maximum efficiency of plane hologram.

3. **Holographic Interferometry**
   Real time Interferometry, Double exposure holographic Interferometry, Fringe localization and interpretation, Interferometry of vibrating surface, contour generation, applications and improvements.

4. **Recording Materials and Techniques for Holography**
   Classification of Holograms, Diffraction efficiency, Silver Halide photographic materials, holographic linear recording, phase hologram, other recording materials, Scientific and engineering application of Holography with special reference to non-destructive techniques.

References:

1. Optical Holography- Robert J. Coolier.
2. An Introduction to coherent optics and Holography- Strokes Robert Jones
3. Holography and Speckle Interferometry-Catherine Wykes
4. Speckle Interferometry- P. K. Rastogi

SYLLABUS FOR M.Phil. Paper III

THICK AND THIN FILM MICROSTRIP COMPONENT TECHNOLOGY

I. Thick films: Deposition process, printing machines, firing equipment, screens, properties of screen printed materials, conductors, resistors, thick films at high frequencies.

II. Thin film deposition technology: resistive heating, electron beam heating, laser evaporation, RF sputtering, electrodeposition, chemical vapor deposition.

III. Transmission lines for MIC, production methods for microstrip components, microstripline characteristics, losses in microstrip, mathematical techniques for the analysis of MIC.

Microstrip antennas: Types of antennas, antenna feeds, simple models, arrays

IV Microwave materials: microwave ferrite devices, Thermistors, ferroelectrics. Radome materials, Time domain reflectometer, Network analyser, VSWR measurement, microwave methods for characterization of materials.

References:

1.Handbook of thick film technology: P.J.Holmes, R.G.Loasby
2. Handbook of thick film technology: K.E.G.Pitt
3.Hand book of thin film technology: L.I. Maissel and R.Glang
4.Microwave electronics: L.f.Chen, C.K.Ong, V.K.Vardan et al
5.Hand book of microwave integrated circuits: R.K.Hoffmann
6. Microwave materials: V.R.K.Murthy, S.Sundaram, B.Vishwanathan
7. Microstrip antennas: I.J.Bahl, P.Bhartia
8.Microwaves and radars: A.K.Maini
9. Recent research papers on these topics

Department of Physics,
Shivaji University, Kolhapur
M.Phil / Pre. Ph.D Paper- III
Photocatalysis

Unit No. I Basic concepts of photochemical transformations (15)

Concept of light, Adsorption and Emission of light, Beer-Lambert law, selection rules for optical transitions, Electronic energy transfer and electron transfer, Redox reactions, Photoelectrochemical (PEC) solar cell, Efficiency of photochemical process- Homogeneous systems: Quantum yields, Chemical change, emission process, heterogeneous systems: photonic efficiencies.

Unit No. II Environmental photochemistry in heterogeneous media (15)

Solid-state and surface photochemistry, Metals, Semiconductors and Insulators, Interaction between surface and adsorbate, Heterogeneous reactions of environmental significance, Recombination kinetics, Charge transfer kinetics, Hole transfer through the intermediate formation of hydroxyl radicals, Haloaromatic and aliphatic compounds

Unit No. III Photochemistry of PAHS & PCBS in water (15)

Photochemistry at the interface, photochemistry in surfactant solutions, Titanium dioxide, Reactions of photogenerated hydroxial radicals in air and water, Direct photolysis of nitrate and nitrite, transformation reactions in the presence of organic compounds-transformation of organic compounds upon photolysis of nitrite and nitrate

Unit No. IV Introduction to photochemical advanced oxidation processes for water treatment (15)

Direct photolysis, senitization, photolysis of water in vacuum ultraviolet, UV/H_2O_2, UV/O_3, Photoinduced ozonation, Fenton reaction, Photo-Fenton and related reactions, SORAS technology, UV/periodate, UV/O_3/H_2O_2, Photoelectro-Fenton, Solar photocatalytic treatment of real waste water, Hydrophobocity- wettability on the surface, proposed mechanism for highly hydrophilic conversion, Photoelectrochemical detoxification reactor for degradation of organic molecules such as Oxalic acid.

References

1. O.Hutzinger, The Handbook of Environmental Chemistry, Available online at- SpringerLink.com, Vol. 2/M, 2005
2. Pierre Boule, Detlef W. Bahnemann, Peter K.J. Robertson, Environmental Photochemistry Part-II, Available online at- SpringerLink.com, Vol. 2/M, 2005
3. Environmental Impact Assessment of Recycled wastes on surface and ground waters, Engineering modeling and sustainability, Editor: T.A. Kassim, Vol. 5/F (3 Vols.), 2005
4. Photoelectrochemical Solar cells- Suresh Chandra

Solar cell: Fundamentals and Applied aspects

Unit I: Fundamentals of Solar cells **(15)**

Basic of Semiconductor Physics- the p-n junction, charge carriers in semiconductors , optical properties of semiconductors, Hetero- junctions, Solar energy fundamentals-nature of solar energy, conversion of solar energy, photochemical conversion of solar energy, photovoltaic conversion, photophysics of semiconductors and semiconductor particles, photocatalysis.

Unit II: Silicon solar cells **(15)**

Device physics of silicon solar cells- Semiconductor device equations, The p-n junction model of Shockley, Real diode characteristics, Crystalline silicon solar cells- Silicon cell development, Substrate production, cell processing, cell cost, Opportunities for improvement, amorphous silicon solar cells, Amorphous silicon-based materials, Manufacturing costs, Environmental issues, Challenges for the future.

Chapter III: Dye sensitized solar cell **(15)**

Photoelectrochemical solar cell, semiconductor electrolyte interface, Basic principle and working of Graetzel Cell i.e., dye sensitized solar cells (DSSCs), Derivation of the Lifetime in DSSCs, theory of EIS, IMPS-IMVS for DSSCs, factors affecting on efficiency of DSSCs, present DSSCs research and developments, limitations of DSSCs.

Chapter IV: Polymer based and Quantum Dot Sensitized Solar Cells **(15)**

Introduction to conducting polymers, basic principle of HOMO & LUMO, bulk heterojunction polymer: solar cell Basic working principles, device architectures, single layer, Bilayer, Bulk heterojunction, diffuse bilayer heterojunction, tandem solar cell, efficiency relationship in organic bulk heterojunction solar cells. Quantisation effects in semiconductor nanostructures, optical spectroscopy of quantum wells, superlattices and quantum dots, Basic principle and working of quantum dot sensitized solar cells, effect of device architecture, theory of electron and light dynamic in QDSSCs, study of EIS, IMPS-IMVS in QDSSCs.

References:

1. Physics of solar cells from principles to new concepts: Peter Wurfel
2. Photoelectrochemical Solar Cells: Suresh Chandra
3. Solar energy conversion: A. E. Dixon and J. D. Leslie
4. Solar cells: Martin A. Green
5. Solid State electronic Devices: B.G. Streetman
6. Photoelectrochemical solar cell: Suresh Chandra
7. Dye sensitized solar cell: Michael Graetzel (Review Articles)
8. N. S. Sariciftci and A. J. Heeger in Handbook of Organic Conductive Molecules and Polymers Vol. 1, edited by H. S. Nalwa, John Wiley & Sons, 1997
9. Nanostructured and photoelectrochemical systems for solar photon conversion: Mary D. Archer & Arthur. J. Nozik
10. Quantum Dot Solar Cells. Semiconductor Nanocrystals as Light Harvesters: P. V. Kamat (Review Articles)
11. Clean electricity for photovoltaics: Mary D. Archer & Robert Hill
12. Solar cell technology and applications: A. R. Jha.

M.Phill/Pre Ph.D examination

Subject: Physics

Paper-III

Vacuum techniques and Thin films.

Unit. 1 High Vacuum technology

Vacuum pumps, mechanical pumps, diffusion pumps, cryogenic pumps, getter pumps, crysorption pumps, molecular pumps.

Unit2. Vacuum Measurements

Leak detection, pressure measurements, residual gas analysis.

Unit 3. Thin film deposition technology

Resistive heating, electron beam evaporation, sputtering, electrodeposition, chemical vapor deposition, plasma polymerization.

Unit4. Nature of the thin films

Condensation, nucleation, growth, structure in the thin films, epitaxial films.

Unit5. Film thickness & analytical techniques

Optical interference techniques, magnetic, electrical and mechanical methods, analysis of film composition. Chemical analysis, structural analysis, surface structure.

Unit 6. Mechanical and optical properties

Adhesion, stress, experimental techniques, optical constants of thin films, experimental methods, multilayer optical system.

Unit7. Applications of the thin films.

Antireflective, high reflecting, beam spliters, absorptive films, transperant conductive coatings, anticorrosive coatings, laser coatings, integrated optics, optical waveguides.

References:

1. Handbook of thin film technology	**L. I. Maisel & R. Glang**
2. Thin film phenomenon	**K. L. Chopra**
3. Vacuum technology	**Roth**
4. Optical properties of thin solid films	**O. S. Heavens**
5. Thin film technology & applications	**K. L. Chopra**
6. Physics of thin films	**Ludimila Eckertova**
7. Physical Properties of Polymers Handbook	**James E. Mark**
8. Conductive polymers by plasma techniques: A literature survey	**L. M. H. Groenewoud**

Date : 17/09/2011

To,

The Chairman,

BOS,

Shivaji University, Kolhapur.

Sub: Syllabus of the paper-III for M.Phill/Pre-Ph.D

Sir,

I am enclosing herewith the Pre-Ph.D syllabus of my paper- III (Vacuum techniques and thin films) for the academic year 2011-2012.

It is requested that this may please be approved.

Thanking you.

Yours Sincerely,

Dr. R. K. Puri

Forwarded through Head, Dept. of Physics.