NORTH MAHARASHTRA UNIVERSITY, JALGAON

SYLLABUS FOR M.Sc.SOLID STATE PHYSICS & CRYSTAL GROWTH FOR M.SC. PHY. STUDENTS FROM JUNE 1992.

** SOLID STATE PHYSICS- I **

1. Formation of Crystals:-

Crystal Growth:-

Velocity of growth. Theories of growth. Mechanism of growth. Twining

Growth twins, Deformation twins. Transformation twins. Gr Growth in the Solid State

Recrystallization. Martensite transformation (6)

2. Transformation in Crystals:-

Elements of thermodynamics.

Introduction. Free-Energy calculation. Equilibrium transformations.

Introduction. Ist & IInd order transformations. Order-disposer transitions.

Transformations in complex structures. Equilibrium diagrams.

The phase rule. Solid solutions. Complex diagrams. Kinetics of transformations.

Transformation rates. Homogeneous nucleation. Heterogenous nucleation. Precipitation from solid solutions. (6)

3. Mechanical properties of Crystals:-

Classification of properties.

Properties of engineering importance. Anisotrophy in crystals. Preferred orientation in polycrystalline aggregates.

Elastic deformation.

Single crystals. Polycrystalline aggregates. (8)

Plastic deformation.

Slip in angle crystals. Mechanics of deformation Fracture.

4. Imperfections in atomic packings:-

Types of imperfections.

Discovery of imperfections. Classification of imperfections. Points defects. (8)

Schottky defects. Frankel defects. Disordered crystals.

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Line defects.

Large-Angle boundaries. Small-Angle boundaries. Stacking faults.

5. Shear strength of Single Crystals:-

Slip.

Dislocations.

Burgers Vectors. Stress fields of Dislocations. Low Angle Grain boundaries. Dislocation Densities. Dislocation Multiplication and slip. (7)

Dislocations and crystal Growth:-

Whiskers.

6. X-Ray, Electron and Neutron Diffraction in Crystals:-

Emission of X-Rays. Absorption of X-Rays. The Geometry of diffraction. The Intensity of the Diffracted beam. X-ray diffraction methods. The uses of X-ray diffraction Techniques. Electron Diffract[illegible], Neutron Diffraction, Zeolities. (5).

REFERENCE BOOKS

1. Introduction to Solids.	L.V.Azaroff.
2. Solid State Physics.	A.J.Dekker.
3. Introduction to Solid State Phys.	C.Kittle.
4. The Physics of Engineering Solids.	T.S.Hutchison & D.C.Baird.
5. Dislocation	Hull.
6. X-ray diffraction procedures	(Accde.Press).

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SOLID STATE PHYSICS PAPER- II

1. Properties of Semiconductors:-

Band Theory:-

Energy bands. Intrinsic semiconductors. Extrinic semiconductors conductivity.

Electrons and holes. The temperature dependence of conductivity.

Mobility of charge carriers. Lifetime of minority carriers and Hall effect. (10)

Optical Properties:-

Absorption spectrum. Photoconductivity. Photovoltaic effect.

Junction Properties.

Metal:- metal junctions. Metal-semiconductor junctions. MIS structure, p-n junctions, Transistors.

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2. Structure of Semiconductor:-

The elements:

Dimond structure.Graphite structure.Complex structures.Intermetallic compannds.

General properties. III-V compounds,II-VI compounds,Silicon Carbide.

Sulfides.

Wurtzite and halite types. Binary sulfides. Complex sulfides Oxides. Binary oxides. Complex oxides. (10)

3. Luminescence:-

Excitation and emission,Decay mechanisms, Thallium-activited alkali halides. The sulfide phosphors.

Types of luminescence. (5)

4. Ferrimagnetism:-

Introduction,the structure of ferrites,the saturation magnetization. Elements of Neel's theory (3)

5. Principle of Laser & Master Action:-

The Nature of spontaneous and Stimulated Emission. The Maser cavity.Pumping in the optical Maser. The Two-Level,Three Level and Four Level Optical Maser. The Ruby Optical Maser.The Semiconductor Optical Maser. The Solid State Detector,Ruby laser,Application laser in medicine and crystallography. (6).

Mossbeaur Effect:-

Instrumentation,Relativity & Mossbeaur effect,Atomic motion & Chemical application. Introduction Recoilles resonance-absorption.

6. Radiation Damage in Solids:-

Damage by neutron radiation,Irradiation by heavy charged particles Irradiation by fast electrons. Irradiation by Gamma rays. (3)

7. Photoconductivity:-

Historical survey,photoconducting materials,Electronic transitions in photoconductors,Absorption & excitation,Trapping and capture , Recombination,Life time, Photosensitivity,capture cross-section, simple model of a photoconductor,Excitions;Absorption,Excitions across the gap Trapping and it's effects.

REFERENCE BOOKS :-

1. Introduction to Solids — L.V.Azaroff.
2. Solid State Physics. — A.J.Dekker.
3. Introduction to Solid State Phys. — C.Kittel.
4. The Physics of Engineering Solids — T.S.Hutchison & D.C.Baird.
5. Solid State Physics — R.L.Singhal.
6. Fundamentals of Solid State Physics — Saxena,Gupta.
7. Dislocation — Hull & Read
8. Mossbeaur effect — G.K.Wertheim.

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9.	Crystal Growth & Characterization	R.Ueda J.B.Mullin.
10.	Semiconductor Physics.	Shieger.
11.	Essentials for Solar Cell	N.P.Singh (New Delhi)
12.	Semiconductors Physics	T.S.Moss.
13.	Introduction to Mossbear effect	V.G.Bhide.
14.	Semiconductor Physics	S.M.Zea.

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SOLID STATE PHYSICS COURSE NO.1 EXPTS.

X-RAYS:- 1) Analys an X-ray power photograph for a substance having crystal lattice.
i) SC ii) BCC & iii) FCC & determine the (hkl) indices of reflections recorded. Hence determine lattice constant & Volume of unit cell.

MICROWAVE:- 1. Study of different microwate components:-Slotted section probe, tunable crystal detector, klystron tube, attenuators, frequency meters, directional couplers, circulators and horn antenna.

2. Determination of relationship between frequency f, wavelength in free space & wavelength in a wave guide by using a microwave bench.

3. Measurement of dielectric constant of various solids and liquids at room temperature by using a microwate bench.

CRYSTAL DEFFECTS:- 1. Study of defects in calcite crystals by chemical etching technique & density of dislocation by using an optical microscope.

2. To study ionic conductivity of solids at various temperatures (Alkali halides), using two probe method.

MAGNETIC RESONANCE:-1) Study of electron spin resonance in combined static and r.f. magnetic fields of a paramagenetic material.

NUCLEAR RADIATIONS:- 1. To determine "Plateau-range", Plateau slope" & "variation in counts with distance "for a given G.M.Counter.

2. To study absorption of beta rays in aluminium.

Measurement of range.

ALLOYS :- 1) To construct equilibrium phase diagram of a series of Lead-Antimony alloy system of varying composition & to measure the eutactic temp. by preparing Pb-Sb alloys.

2. To prepare a series of Nickel -Copper alloys and to measure the curie temp. of the alloys for different percentages of nickel content.

THERMO GRAVIMETRIC ANALYSIS (TGA):- 1. Thermo Gravimetric analysis.

(TGA) of $NiSo_4 \cdot 6H_2O$ crystals.

ADSORPTION PHENOMENON:- 1. To study adsorption in Zeolites.

(About 15 Expts. 3 hrs. each).

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** SOLID STATE PHYSICS **

COURSE II

MAGNETISM:

1. To study variation of capacitance & power factor with temperature in ferroelectric sample. (Barrium titanate)
2. To study variation of dc channel resistance of a field effect transistor (BFW 10) with external magnetic field.
3. To determine the paramagnetic molar susceptibility & hence magnetic moment & No. of unpaired electronics in pottassium ferricyanide $K_3Fe(CN)_6$ by Guoy method.
4. To study variation of susceptibility of a magnetic shat with temperature.
5. To study Faraday effect & to determine Vardet's constant of a magnetic material.

ELECTRICAL PROPERTIES:-

1. To determine electrical conductivity of a semiconducting material.
2. To determine energy gap of a semiconducting specimen.
3. To determine energy gap in the band structure of Indian Anti-monide from the given IR spectrum.
4. To study characteristics of NTC & PTC materials by varying their temp. and to determine temp. coefficient of resistance.

THIN FILMS:

1. To prepare cadmium sulphide photosensitive Thin Film by chemical bath deposition technique.
2. To determine step height on mica-cleavage by multiple beam interferometry.
3. To prepare thin films of semiconducting materials by flash evaporation technique & to measure resistivity by Two-Probe/Four Probe method.
4. To prepare thin films of photosensitive materials by solution growth technique and to study their photoconductivity.

HALL MEASUREMENT:- (FOR SEMICONDUCTORS)

1. To measure Hall-Co-efficient, the number of charge carriers per unit volume and the carrier mobility in p-type & n-type semiconducting samples & compare the results.

SUPERCONDUCTORS:-

1. To study theroetcial aspects & preparation of superconductors.

LOW TEMPERATURE:-

1. Effect of change in Temperature down to liquid nitrogen tempera-ture upon the break down potential of a voltage reference diode.

(15 Experiments:-3 Hours duration each).

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(Optional for M.Sc. Physics)

GROWTH OF CRYSTAL & THEIR CHARACTERIZATION:

1. Importance of growing single crystals & their uses. Thermodynamic principals & crystal growth equilibria. Theory of crystal growth, Revision, Nucleation from solution, melt and vapour.
2. Solution Growth:- Growth from water solution, Growth by Gel method, Growth by Flux, Hydrothermal Growth, Growth from Fluy, Growth by electro-deposition.
3. Growth from Melt:- Czcharalski Crystal pulling techniques. Bridgmann-Stockbarget technique, Zone Melting method, Detailed study, of growth & Silicon & germanium single crystals.
4. Vapour Growth:- The various methods of vapour growth. (Viz.CVD, Epitaxial Growth etc.) and growth kinetics.
5. Introduction to liquid crystals, their classification, properties, uses and limitations of each type.
6. Characterization of Crystals:

a) 6Identify classical gravimetric & volumetric analysis.
b) Major constituents.
c) Minor constituents.
d) Mapping (Electrical & dielectric properties)
e) X-ray power diffraction techniques.
f) Election Microspopic techniques (TEM, SEM)
g) Etching studies ¢Chemical Etching thermal & hydrothermal etching)
h) Characterization of Crystal surfaces by optical microscopy.

REFERENCE BOOKS:

1. Crystal Growth & Characterization. R.Ueda.J.B.Mulling
2. Crystal Growth Theory & Techniques Ed.C.H.L.Goodman.
3. Short Course on Solid State Phy.Vol. Vol.I Ed.F.C.Auluk
4. Art & Science of growing Crystals J.J.Gillman.
5. Fundamentals of Crystal Growth Dr.Franz A.Rosenberg.
6. Disłocations Hull & Read.

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