Overview of forthcoming Materials Science Laboratory

- **Introduction**
- **Course description**
- **Course objectives**
- **Lectures and Examinations**
- **Lab Experiments**
- **Grading scheme**

1. Introduction

- **Materials Scientist and Materials Engineer**

  Develop or synthesize new materials, whereas a materials engineer is called upon to create new products or systems using existing materials

- Engineers adapt materials and/or energy for society's needs.

Science

Discovering evidence and relationships for observable phenomena in nature and establishing theories that organize and make sense of it all.

Technology

Tools, Techniques, procedures for putting the findings of Science to use.

Physics laboratory LUMS

Science and Technology simultaneously

Types of Solid Materials

- **Metals**
- **Ceramics**
- **Polymers**
- **Composites**
- **Advanced materials**


Classification of Functional Materials
Aerospace
C-C composites, SiO_2, Amorphous silicon, Al-alloys, Superalloys, Zerodur™
Structural
Steels, Aluminum alloys, Concrete, Fiberglass, Plastics, Wood
Biomedical
Hydroxyapatite, Titanium alloys, Stainless steels, Shape-memory alloys, Plastics, *PZT*
Smart Materials
PZT, Ni-Ti shape-memory alloys, MR fluids, Polymer gels
Electronic Materials
Si, GaAs, Ge, $BaTiO_3$, *PZT*, $YBa_2Cu_3O_{7-x}$, Al, Cu, W, Conducting polymers
Optical Materials
SiO_2, GaAs, Glasses, Al_2O_3, *YAG*, *ITO*
Magnetic Materials
Fe, Fe-Si, NiZn and MnZn ferrites, Co-Pt-Ta-Cr, γ-Fe_2O_3
Energy Technology and Environmental
UO_2, Ni-Cd, ZrO_2, $LiCoO_2$, Amorphous Si:H

Important Properties of Materials

- **Mechanical properties**
- **Electrical properties**
- **Optical properties**
- **Thermal properties**
- **Magnetic properties**

2- Course description

- **Development of new materials in thin films, nanoparticles and bulk form with sol-gel spin-coating, sol-gel combustion and ceramic techniques.**

- **XRD-analysis, Temperature dependent electrical conductivity with four probe technique, dielectric constant, dielectric loss, tangent loss, a.c conductivity, Hall voltage and carriers concentration with Hall effect and compositional analysis with XRF are the key points of this course.**

3- Course Objectives

- **Understand solid state and chemical techniques for bulk and nanoparticles.**
- **Deposition of thin films with sputter coater and spin coater**
- **Crystal structure analysis**
- **Crystallite size analysis**
- **Lattice strain analysis**
- **Theory of four-probe technique for conductivity measurement**
- **Frequency dependent dielectric constant, tangent loss and dielectric loss with LCR-meter**
- **Mobility of charge carriers, charge density and sign of predominant charge carriers with Hall Effect**
- **Compositional analysis with XRF**

4- Lectures and Examinations

- **Chemical bonds in materials properties**
- **Structure of perfect crystals**
- **X-ray diffractometry (manual and computational)**
- **Defects in crystals (briefly)**
- **Phase Equilibria (Gibbs phase rules and phase diagrams)**
- **Synthesis of materials (Solid-State and Chemical route)**
- **Sputter coating of available metals**
- **Spin coating of oxide materials**
- **High temperature electrical resistivity and deduce Activation Energy from Arrhenius Plot.**
- **Dielectric properties of materials**
- **Magnetic properties of materials (Hall effect)**
- **Study of IR-spectra of materials**
- **Optical properties of materials (Band gap)**
- **XRF study of materials**

Lab Experiments

- **Preparation of ferrimagnetic, dilute magnetic oxides and ferroelectric materials with Sol-gel combustion and solid state route**
- **Phase confirmation, crystallite size and exact lattice parameters with X-ray diffractometry**
- **Pellet formation and calculate bulk-density and x-ray density to find porosity**
- **High temperature electrical conductivity with four-probe technique and deduce the activation energy from Arrhenius plot**
- **Temperature dependent dielectric constant, tangent loss, dielectric loss and a.c conductivity**
- **Study of FTIR-spectra of powder materials**
- **Deposition of metallic materials with sputter-coater and their analysis**
- **Deposition of oxide materials on different substrates with spin-coater and their analysis**

Grading Scheme

- **Homework = Nil**
- **Midterm = 35 %**
- **Final = 65 %**