Lecture course

Methods for Materials Diagnostics 2021-22

organized by Institute of Electrical Engineering SAS, Dúbravská cesta 9, 841 02 Bratislava.

Lecturers: E. Dobročka, A. Rosová, J. Šoltýs, M. Ťapajna

Lecture course is intended for PhD students in study programs related to material science, physical and electrical engineering, and solid-state physics. Due to current pandemic situation, the course will be limited to IEE PhD students and interested employees only. The course will be given in English.

The lectures will take place each Wednesday starting from 8:30 until 12:30 with following schedule (any possible changes will be announced in advance):

6.10.21 Dobročka	13.10.21 Dobročka	20.10.21 Dobročka	27.10.21 Dobročka	3.11.21 Dobročka	10.11.21 Dobročka
24.11.21 Šoltýs	1.12.21 Rosová	8.12.21 Rosová	15.12.21 Šoltýs	13.1.22 Ťapajna	20.1.22 Ťapajna

Room number: 101 (Common meeting room)

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Syllabus:

Structure of materials and X-ray diffraction analysis (E. Dobročka)

1. Introduction. Non-crystalline state. Hard-Sphere models, Random-Walk models, Fractal models.
2. Crystalline state. Symmetry, symmetry operations, space lattice, unit cell, primitive cell. Miller indices, crystallographic symbols. Crystallography in two dimensions. Crystallography in three dimensions. Crystal systems, Bravais lattices, point groups, space groups.
3. Symmetry and the properties of crystals. Neumann, Curie and Voigt principles. Examples of structures. Imperfections in crystals and their experimental observation. Point defects, dislocations, stacking faults.
4. Diffraction methods. Laue equations, reciprocal lattice, Ewald construction, Bragg equation. Diffraction indices, atomic form factor, structure factor, intensity of diffracted radiation.
5. Basic X-ray diffraction experiments, Debye-Scherrer method, Laue method, X-ray diffractometry. Bragg-Brentano set-up, double axis and triple axis diffractometry. Imaging methods, X-ray topography.

Scanning electron microscopy - SEM (J. Šoltýs)

6. Design and basic principle of electron microscopes (SEM), interaction of electron with sample surface. Types of SEM and its regimes, sample preparation, image adjustment and optimization. Additional options for SEM. Electron beam lithography.

Elemental analysis using characteristic X-rays in SEM – EDS a WDS (A. Rosová)

7. Characteristic X-ray emission, beam interaction volume, EDS and WDS – principles and comparison, measurement artefacts and errors, resolution and sensitivity, choice of optimized experiment parameters, qualitative and quantitative analysis, ZAF method, thin film analysis

Transmission electron microscopy - TEM (A. Rosová)

8. Why TEM – resolution, aberrations, advantages and limits. Elastic and inelastic electron interactions in thin foils, kinematical theory of electron diffraction, information from selected area electron diffraction patterns, creation of imaging contrasts, different imaging techniques, elemental analysis in TEM, Thin specimen preparation

Scanning probe microscopy - SPM (J. Šoltýs)

9. STM and AFM principle, basic modes, hardware, AFM probes, data processing. non-topographic modes, artefacts in AFM images. AFM surface modification and lithography.

Electrical characterization of semiconductor structures (M. Ťapajna)

10. Introduction to semiconductors. PN junction in the equilibrium, IV characteristic, secondary effects (generation-recombination, strong injection, breakdown). Analysis of CV characteristics, measurement of built-in potential, carrier concentration profiling in abrupt PN junctions. Determination of minority carrier lifetime.
11. Schottky contact, transport properties, IV characteristic, CV characteristic, carrier concentration profiling. Review of models describing Metal-Semiconductor contact (non-interacting, interacting, concept of charge neutrality level). Ohmic contacts characterisation.
12. MOS structure, depletion approximation, 'ideal' and real MOS structure, CV curve. Measurement of the metal work function and fixed oxide charge. Review of methods for evaluation of oxide/semiconductor interface states density.