Basic Information:

Course Title: **PHASE FORMATION AND CRYSTAL GROWTH – THEORY AND EXPERIMENT**

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Total Teaching Hours: 30 lecture hours

Annotation (up to 150 words)

The present lecture course provides an introduction to the physics of phase transitions and the kinetics of phenomena in crystal growth, as well as the structure and properties of surfaces, interfaces, and nanoscale systems.

The course is methodologically organized into two main directions. In the first direction, after introducing the principles of classical thermodynamics and statistical physics, the fundamental processes and phenomena in phase formation are examined theoretically. These include two-dimensional phase transitions, nucleation, mechanisms of crystal growth, thermodynamic and structural properties of interphase boundaries, and others.

In the second, experimental direction of the course, classical and modern methods and tools for the analysis of the structure and properties of materials are presented. Crystal growth mechanisms are demonstrated using reflection electron microscopy — growth by step propagation, growth by two-dimensional nucleation, normal growth, and spiral growth. Particular attention is given to energy-dispersive and wavelength-dispersive methods for elemental analysis.

Course content (brief description by topics or modules)

Topic / Module 1: Theoretical Foundations of Crystal Growth. Basics of classical thermodynamics and statistical physics, theoretical examination of the main processes and phenomena involved in the formation of a new phase, including two-dimensional phase transitions, nucleation, mechanisms of crystal growth, thermodynamic and structural properties of interfaces, growth of thin epitaxial films, the Si(111) surface, formation of atomic superlattices, quantum clusters, and computer modeling of processes and phenomena in physical systems of hard and soft condensed matter.

Topic / Module 2: **Experimental Foundations of Crystal Growth.** Methods and tools for the analysis of the structure and properties of materials are studied. Special attention is paid to the silicon surface, as well as to various industrial methods for the growth of silicon crystals. Crystal growth mechanisms are demonstrated using reflection electron microscopy – growth by step propagation, growth by two-dimensional nucleation, normal growth, and spiral growth. Particular emphasis is placed on energy-dispersive and wavelength-dispersive methods for elemental analysis, as well as on high-resolution SEM.

Teaching and assessment methods

Written test and/or open-ended questions.

Competencies acquired as a result of training

Acquisition of theoretical knowledge regarding the structure and properties of crystals, quasicrystals, amorphous substances, crystal surfaces, and interfaces.

Analysis of SEM imaging results.

Analysis of EDS (energy-dispersive X-ray spectroscopy) results.

Literature:

1. Handbook of Sample Preparation for Scanning Electron Microscopy and X-Ray Microanalysis, Patrick Echlin, Springer 2009, ISBN: 978-0-387-85730-5

2. Surface Diffusion - Metals, Metal Atoms, and Clusters, Gr. Antczak, G. Ehrlich, Cambridge University Press 2010, ISBN 978-0-521-89983-3

3. Modern Techniques of Surface Science, D. P. Woodruff, T. A. Delchar, Cambridge, 1994

4. Ivan Markov, Crystal Growth for Beginners: Fundamentals of Nucleation, Crystal Growth and Epitaxy, World Scientific, 2003