Thin Film Analysis by X-ray Scattering, Part II, Laborations, 4.0 credits

Tunnfilmsanalys med röntgenspridning, del II, laborationer, 4.0 hp

Third-cycle education course

6FIFM37

Department of Physics, Chemistry and Biology

Valid from: Second half-year 2024

Approved by **Approved**

Registration number

Entry requirements

Solid state physics, part I, or similar.

Specific information

Doctoral studies (also open to senior scientists, etc. depending on availability)

Learning outcomes

This course is intended for PhD students who are working, or will work, with X-ray diffraction in their studies and future careers. The course aims to provide an introduction and thorough understanding of X-rays, the interaction with matter, and various X-ray scattering methods, in particular for thin film characterization. This means that after the course the students should:

- understand the production and properties of X-rays and their interaction with electrons, atoms and crystals
- be able to explain the principles of X-ray diffraction, including factors that influence the diffracted X-ray intensities, and its use in crystal structure determination
- understand the concept of reciprocal space, and be able to explain diffraction in real and reciprocal space, i.e. Bragg's law and the Laue condition
- know about the most common optical configurations of the diffractometer, and be able to setup the instrument for a specific type of measurement
- have an in-depth knowledge of the X-ray scattering methods for phase analysis, line profile analysis, grazing incidence X-ray diffraction, X-ray reflectivity and diffuse scattering, texture measurements, residual stress measurements, high resolution XRD and reciprocal space mapping

Contents

The course consists of lectures and laborations separated into two parts. In part I the theory behind X-rays and the X-ray scattering methods are treated in seminars/lectures. In part II most of the scattering methods are demonstrated in laborations. These start with a short repetition of the theory, including setup, handling, and operation of the diffractometers. The laborations also provide training in safe and appropriate use of the instrument. Part I needs to be completed before part II.

Part I – Seminars (5 hp)

1. Principles of X-ray diffraction I – introduction to X-rays and the interaction with matter
2. Principles of X-ray diffraction II – reciprocal space and optical configurations of the diffractometer
3. Identification of chemical phases – qualitative and quantitative phase analysis
4. Line profile analysis - peak fitting and line profile analysis with the emphasis on size broadening and inhomogeneous strain broadening, including the validity of the Scherrer equation, and Williamson-Hall plots
5. Grazing incidence diffraction techniques, including grazing incidence X-ray diffraction (GIXRD) and grazing incidence diffraction (GID)
6. X-ray reflectivity and diffuse scattering of thin films and multilayers
7. Texture and preferred orientation, including texture factors, pole figures, inverse pole figures, and the orientation distribution function, ODF
8. Residual stress analysis using X-ray diffraction
9. High resolution X-ray diffraction and reciprocal space mapping

Part II – Laborations (4 hp)

1. Phase Analysis (+Line Profile Analysis)
2. Grazing Incidence Diffraction + X-ray Reflectivity
3. Texture + Residual Stress Analysis
4. High Resolution X-ray Diffraction

Educational methods

The course contains lectures and laborations

Examination

Student credits: 5+4 hp
Part I: The course is examined by a combination of continuous examination in connection with the seminars and a written final exam.
Requirements:
80% correct answers on each of the 8 pre-seminar test (20 min)
Each passed pre-seminar test eliminates one question on the final exam
80% correct answers on the final exam (8 questions in 4 hours) – only 2 attempts are allowed
Part II: 80% attendance on laborations

Grading

Two-grade scale

Course literature

Mario Birkholz, Thin Film Analysis by X-ray Scattering, Wiley 2006
Lecture notes, articles, etc. will be distributed during the course

General information

The course is planned and carried out according to what is stated in this syllabus. Course evaluation, analysis and suggestions for improvement should be fed back to the course responsible.