

Advanced Lab Course

High-Resolution X-ray Diffraction

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Abstract

For the fabrication of modern semiconductor devices such as efficient light emitting diodes (LEDs), laser diodes, and high electron mobility transistors (HEMTs) - devices which already have found their way in our everyday lives as key components of smartphones and tablets - the growth of nearly defect-free epitaxial layers is crucial.

High-resolution X-ray diffraction (HRXRD) is a powerful experimental technique to study the structural quality of crystals. Deviations from the ideal crystal structure give rise to a broadening of X-ray diffraction peaks. Furthermore, a precise measurement of the lattice constants allows the investigation of strain and the determination of the composition of alloys. Besides, by means of HRXRD the epitaxial relationship between substrate and epitaxial film as well as its thickness can be determined.

In this laboratory exercise, we address the fundamentals of X-ray diffraction at solid-state crystals. Therefore, an overview of the basic concepts of how to describe a perfect crystal is given. Subsequently, irregularities and defects in real crystals are examined. Finally, the kinematic theory of X-ray diffraction and the characterization of real crystals by HRXRD is discussed. In the course of this laboratory work you will address the following assignments of tasks:

- examination of the mosaicity of different epitaxial films
- measurement of the layer thickness of an epitaxial film
- determination of the epitaxial relationship between substrate and epitaxial layer
- precise measurement of the lattice constants
- investigation of the composition of alloys

Keywords

space lattice, basis, primitive and conventional unit cell, Miller indices, Wurtzite lattice, lattice mismatch, Burgers vector, dislocations, grain boundary, mosaicity, kinematic theory of X-ray diffraction, reciprocal lattice, Bragg equation, Ewald sphere, structure factor

Experimental setup

Rigaku SmartLab high-resolution X-ray diffractometer, goniometer, X-ray tube, monochromator