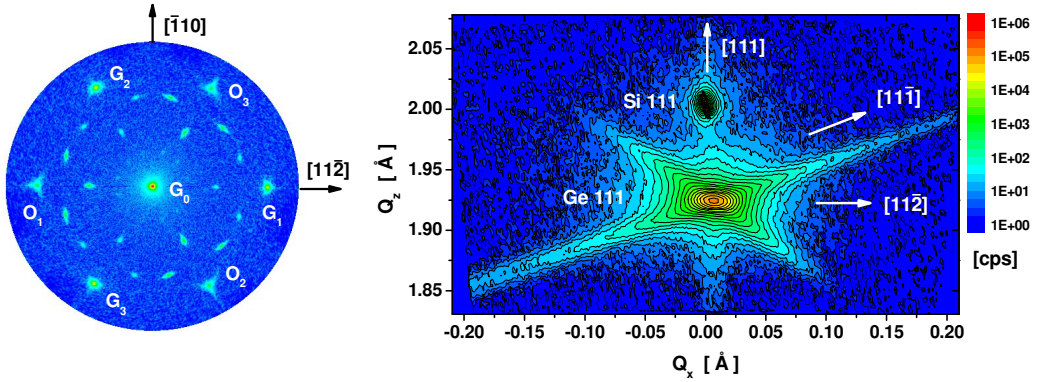
Laboratory-based Characterization of Heteroepitaxial Structures: Advanced Experiments not needing Synchrotron Radiation

P. Zaumseil, IHP, Im Technologiepark 25, D-15236 Frankfurt (Oder), Germany

The aim of this contribution is to demonstrate that also laboratory-based equipment is able to realize a complex X-ray characterization of heteroepitaxial structures. This is on one side essential for a fast continuous monitoring of deposition processes and on the other side for a best possible pre-characterization of selected samples, which may than be studied in more detail at a synchrotron.

Our subjects of interest are epitaxially grown semiconductor – insulator – semiconductor (SIS) structures. Thin metal oxide (Pr_2O_3, Y_2O_3) layers act as buffer between a Si(111) substrate and the top layer of epi-Ge or epi-Si. Such structures may be used for new applications in microelectronics or in the case of Ge as a possible template for A_3B_5 material integration. The following parameters may be determined by X-ray techniques: thickness, roughness, and density of all layers; oxide phase; orientation and strain of layer material relative to the substrate; structural perfection.



X-ray reflectivity (XRR) is our routinely used technique to determine the first three parameters. Specular ω-2Θ diffraction scans (XRD) give first information about the off-plane orientation and strain of all layers. Pole figure (PF) measurements (see left figure for a Ge/Pr_2O_3/Si(111) structure, Ge 111 reflection) in combination with XRD scans or reciprocal space mapping (RSM) in selected spots (see right figure, measured in the G_0 spot of the same sample) reveal the in-plane orientation of the epi-layers. In this example, the positions of the Ge-related G spots confirm the same in-plane orientation as the Si substrate, while the oxide layer (O spots) is 180° rotated around the 111 substrate normal. The other spots in the PF are related to structural defects (mainly micro twins) that can be investigated in more details by RSM. A full strain analysis of all epi-layers is done by grazing incidence diffraction and an analysis of different tilted diffractions.