MM 17: Topical Session: TEM-Symposium - HR Imaging & Analytic I

Time: Tuesday 10:15–11:30 Location: H4

Topical Talk MM 17.1 Tue 10:15 H4

Quantification of sample properties by low-energy scanning transmission electron microscopy — Erich Müller, Holger Blank, Marina Pfaff, Tobias Volkenandt, and •Dagmar Gerthsen — Laboratorium für Elektronenmikroskopie, Karlsruher Institut für Technologie (KIT), Karlsruhe, Germany

Scanning transmission electron microscopy (STEM) at low energies ($<$ 30 keV) is a promising technique for microstructure analysis and quantification of sample properties. Low-energy STEM images can be taken in a standard scanning electron microscope which is equipped with a STEM detector. Using thin samples a high lateral resolution in the order of 1 nm can be achieved which is sufficient for many materials science and biological applications. Modelling of the STEM image intensity at low electron energies can be performed by Monte-Carlo simulations, which is considerably less complex than STEM image simulations at high electron energies. Quantification of the sample information (local sample thickness and composition) can be performed by comparison of simulated and experimental STEM intensities.

High-angle annular dark-field STEM is particularly interesting because the chemical sensitivity of this particular imaging mode increases with decreasing electron energy. The high chemical sensitivity can be exploited for the study of samples which provide low contrast as, e.g., polymers and biological objects. We will show applications of low-energy STEM in materials science and biology with a particular focus on quantification of the sample thickness and sample composition in compound semiconductors.

MM 17.2 Tue 10:45 H4

Quantitative HAADF-studies on GaP/Si heterostructures — •Andreas Beyer, Nikolai Knaub, Benedikt Haas, Katharina Gries, Katharina Werner, and Kerstin Volz — Structure and Technology Research Laboratory, Philipps-Universität, Marburg, Germany

The growth of III/V-materials on Si enables a variety of new optoelectronic devices. We investigate GaP grown on Si as a model system. The growth of a polar material on nonpolar substrate holds several challenges as the interface is not necessarily charge neutral and antiphase domains (APDs) can form at monoatomic steps of the Si-surface.

High resolution high angle annular darkfield (HAADF) measurements were carried out in a JEOL JEM 2200FS,equipped with a corrector for spherical aberration of the condenser lens system. For quantification of the data HAADF-intensities were simulated using an absorptive potential approach.

The simulated and experimental HAADF-images show that the intensity ratio of Si and GaP is not constant but a function of local TEM sample thickness and microscope parameters. This can be exploited to determine the thickness via high resolution HAADF images of the interface. The determined thickness values are compared to the ones derived by electron energy loss spectroscopy. For a known sample thickness the influence of element intermixing at the interface as well as the local atomic structure of present APDs on the HAADF-intensity is investigated and quantified.

MM 17.3 Tue 11:00 H4

Investigating the potential of determining the 3D structure of nanoparticles from through focus series of HRTEM images — Alexander Surrey[1,2], Darius Pohl[1,2], Ludwig Schultz[1,2], and •Bernd Rellinghaus[1] — [1]IFW Dresden, Helmholtzstr. 20, D-01069 Dresden, Germany. — [2]TU Dresden, Institut für Festkörperphysik, D-01062 Dresden, Germany

The acquisition of through focus series of HRTEM images allows for a determination of the complex electronic exit wave function (EWF) which is a result of modifications of the incoming electron wave through multiple scattering processes within the sample. On the other hand, using the channeling theory in combination with the vacuum propagator to control the defocus in principle allows for a quantitative reconstruction of the full 3D structure of the specimen from the amplitudes and phases of the EWF through Argand plots. In order to explore the applicabitity of this approach we have calculated the EWF for a 4 nm Au octahedron supported by 5 nm of amorphous carbon by means of a multi-slice algorithm and subsequently back-analysed the likewise obtained EWF with the above mentioned approach to reconstruct the 3D structure of the model particle. We find that such a reconstruction should indeed be possible under ideal microscopy conditions. However, taking into account realistic limitations of the imigang process even for the case of state-of-the-art aberration-corrected microscopy leads to a collapse of the channeling circle thereby impeding an unambiguous reconstruction of the structure. These theoretical findings are confirmed by the results of likewise conducted experiments.

MM 17.4 Tue 11:15 H4

Novel III/V-Alloys Investigated Using Transmission Electron Microscopy — •Tatjana Wegele, Rafael Fritz, Vivien Vossebürger, Kakhaber Jandieri, and Kerstin Volz — Faculty of Physics and Material Science Centre, Philipps-University Marburg, D-35032 Marburg

Three- and four-compound III/V semiconductor layers are a must-have for efficient solar cells. We use boron atoms and/or arsenic atoms as substituents in GaP or GaAs host materials. The incorporation of these atoms allows to grow metastable materials lattice matched on a substrate with a band gap tuned nearly to a desired value. The amount of the incorporated substituents as well as the crystal quality and therefore the efficiency of the semiconductor devices depend on well-optimized growth conditions.

We investigated GaP-based (BGa)(AsP) and (BGa)P as well as GaAs-based alloys using transmission electron microscopy combining the following techniques: Dark-Field Imaging, High-Resolution Imaging, High-Angle Annular Dark-Field Imaging and Energy Dispersive X-ray Spectroscopy. The latter two are used in scanning TEM mode.

We were able to determine the chemical composition of the investigated layers and also to directly test the quality of the interfaces. The maximum possible concentration of incorporated substituent atoms, that do not produce any defects in the layers, was determined. Moreover the homogeneity or inhomogeneity of the substituents distribution in the three- and four-compound layers, respectively, were visualized and quantitatively studied.