Composition quantification of InGaAs quantum wells by transmission measurements in a scanning electron microscope

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Material-sensitive (Z-)contrast in scanning transmission electron microscopy (STEM) is more pronounced at low electron energies (<30keV) and can be used for quantitative composition analysis. Additionally, at low beam energies knock-on damage is reduced, enabling examination of radiation sensitive samples like semiconductor or biological materials. The presented method is based on high-angle annular dark-field (HAADF) images and the comparison of the measured intensities with Monte Carlo simulations. Electron transmission is measured with a common annular semiconductor detector in a state of art instrument. Parameters and alignment can be changed easily and no additional setup is needed. To verify the method, samples consisting of four $In_xGa_{1-x}As$ layers with well-known In-concentrations of x=10%, 20%, 30% and 40% are used. These layers, grown by molecular beam epitaxy (MBE) on a GaAs substrate are separated by thin layers of GaAs. The focused ion beam technique (FIB) is used to prepare wedge-shaped samples with defined geometries. Quantification of the electron transmission gives the possibility to determine the local thickness and wedge angle of the prepared samples. On the other hand the In-concentration can be determined by calculating intensity ratios among the layers containing In and the separating GaAs layers. Quantifications are performed with high lateral resolution and adequate signal-to-noise ratio.

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