Determination of composition and strain field of nanostructured semiconductor materials

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Nanostructured semiconductor materials, particularly quantum structures are an important class of materials because the dimensionality on the nanometer scale may drastically change the density of states and the optoelectronic properties. The properties of quantum structures essentially depend on the perfection of their structure, size, arrangement, morphology and chemical composition. For various semiconductor systems of low dimensions including multilayers, islands and quantum dots the potential applicability of transmission electron microscopy (TEM) was demonstrated [1].

Conventional TEM, high-resolution imaging (HRTEM) and digital image analysis were applied to determine strain and chemical composition of nanostructured semiconductor materials. The diffraction contrast method was applied to visualize the strain field in the surrounding of the quantum dots (QDs). For a reliable interpretation of the diffraction contrast features and also of the HRTEM images corresponding image simulations were carried out. Dark-field imaging allows a qualitative analysis of chemical composition using chemically sensitive reflections. Methods of quantitative HRTEM (qHRTEM) were used to measure the local strain and chemical composition on atomic scale. The possibilities and limitations of qHRTEM program packages DALI (Digital Analysis of Lattice Images) [2], CELFA (Composition Evaluation by Lattice Fringe Analysis) [3] and JCPM (Jülich Chemical Mapping Package) [4] will be demonstrated investigating the following systems:

(i) $GaSb_yAs_{1-y}$ QDs on $In_xGa_{1-x}As$ seed grown by metalorganic chemical vapour deposition (MOCVD) on GaAs substrates,

(ii) $Si_{1-x}Ge_x$ islands grown on (001) Si by liquid phase epitaxy (LPE)

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