QUANTITATIVE HIGH-RESOLUTION ELECTRON MICROSCOPY (qHRTEM) OF NANOSTRUCTURED SEMICONDUCTORS

W. Neumann, H. Kirmse, I. Häusler

Institute of Physics, Humboldt University of Berlin,
12489 Berlin, Newton Street 15, Germany

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 [1]. For various semiconductor systems of low dimensions including multilayers, islands and quantum dots the potential applicability of transmission electron microscopy (TEM) was demonstrated [2].

In order to analyse the structure and composition of nanostructured materials on an atomic scale, high-resolution TEM (HRTEM) has to be applied. Structure images give no direct quantitative information on the strain in the specimen or on the lateral variation of composition due the complexity of the electron scattering and the imaging processes. Various quantitative methods have been developed to extract the desired information on the atomic structure, the local strain and the chemical composition from HRTEM micrographs (for an overview, see e.g., [3]). The methods of quantitative HRTEM (qHRTEM) for strain analysis can be divided into peak finding procedures and the geometric phase method [4]. The use of aberration-corrected TEM, where delocalisation phenomena can be minimized when the spherical aberration is adjusted close to zero ensuring the imaging of interfaces without broadening, is advantageous for strain analysis.

The potential of qHRTEM will be discussed in detail for various semiconductor nanostructures. The possibilities and limitations of the procedures applied will be outlined.

References:

[1] Bimberg, D., Grundmann, M., Ledentsev, N. N. Quantum dot heterostructures. (1998) Chichester, Wiley- Interscience.

[2] Neumann, W., Kirmse, H., Häusler, I. Otto, R., Hähnert, I. J. of Alloys and Compounds 382, (2004) 2.

[3] Kret, S., Ruterana, P., Rosenauer, A., Gerthsen, D. phys. stat. sol. (b) 227, (2001) 247.

[4] Hÿtch, M. J., Snoeck, E., Kilaas, R. (1998) Ultramicroscopy 74 (3), 131..

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