MS26 O5

Composition analysis of nanostructured materials by TEM – possibilities and limitations

W. Neumann, I.Häusler, H. Kirmse, *Humboldt University of Berlin, Institute of Physics, Chair of Crystallography, Newtonstrasse 15, D-12489 Berlin, Germany*.
E-mail: wolfgang.neumann@physik.hu-berlin.de

Keywords: transmission electron microscopy, nanostructures, semiconductors

The structure, composition, size and shape of nanostructured materials are essential parameters in determining their physical properties. In order to analyse structure and chemical composition on an atomic scale high-resolution transmission electron microscopy (HRTEM) has to be applied. The potential applicability of TEM has been demonstrated for various nanostructured systems, particularly semiconductor materials like multilayers, islands and quantum dots [1], [2].

The chemical composition of ternary material systems can be determined by a combined analysis of dark-field imaging and quantitative HRTEM (qHRTEM) [3]. This method is restricted to material systems where on the one hand chemically sensitive reflections occur and on the other hand the material surrounding the nanostructure consists of the same atomic species. The procedure developed also takes into consideration that the strained state of the system can lead to a change of space group. The local strain is determined by means of qHRTEM procedures like DALI (Digital Analysis of Lattice Images) [4]. For analysing the chemically sensitive dark-field images the intensity calculated as a function of chemical composition must be normalized by a known concentration value. This value can be gained from the displacement field $\vec{u}_z$ determined from the HRTEM images. The derivation of the displacement field $\frac{\partial \vec{u}_z}{\partial z}$ is the zz-component of the strain tensor ε_{zz}. From this tensor the concentration can be calculated. The procedure also takes into account a thickness fluctuation of the wedge-shaped TEM specimen.

The method will be demonstrated for the following systems:

(i) $In_xGa_{1-x}As$ quantum dots (QDs) grown by metalorganic chemical vapour deposition (MOCVD) on GaAs substrates,
(ii) $GaSb_xAs_{1-x}$ QDs grown by MOCVD on GaAs.

The possibilities and limitations of the method described will be outlined.

[1] Neumann, W., Kirmse, H. Häusler, I., Otto, R. J. of Microscopy, 2006, 223, 200.
[2] Otto, R., Kirmse, H., Häusler, I., Neumann, W., Rosenauer, A., Bimberg, D., Müller-Kirsch, L., Appl. Phys. Lett., 2004, 85, 21, 4908.
[3] Häusler, I., PhD thesis, Institute of Physics, Humboldt University of Berlin 2007.
[4] Rosenauer, A., Kaiser, S., Reisinger, T., Zweck, J., Gebhardt, W., Gerthsen, D., Optik 1996, 102, 63.