doi:10.1017/S1431927611007926
Microsc. Microanal. 17 (Suppl 2), 2011

Quantitative Analysis of Chemical Composition using HAADF-STEM in a JEOL 2200FS

R. Fritz*, A. Beyer*, W. Stolz*, K. Mueller**, M. Schowalter**, A. Rosenauer**, I. Häusler***, A. Mogliatenko***, H. Kirmse***, W. Neumann***, K. Volz*

* Philipps-University Marburg, Materials Science Center and Department of Physics, 35032 Marburg, Germany
** University of Bremen, Institute for Solid State Physics, Otto-Hahn-Allee 1, 28359 Bremen, Germany
*** Humboldt-University Berlin, Institute of Physics, Newtonstr. 15, 12489 Berlin, Germany

High angle annular dark field (HAADF) imaging in scanning transmission electron microscopy (STEM) allows for chemical sensitive imaging as the scattered intensity across the annular dark field (ADF) detector is proportional to the mean atomic number Z of the atomic column, which is illuminated by a focused electron beam. Quantification of HAADF image intensity requires quantitative agreement between the experimental image and a theoretical simulation taking into account parameters of sample and microscope, respectively. This however requires the knowledge of the incident electron beam intensity, to which the HAADF image has to be normalized, as described by Le Beau et al. [1].

The JEOL 2200 FS transmission electron microscope (TEM) can be equipped with two ADF detectors, one of which is located above the Omega-filter for in-column energy filtering, the second one below it. In the configuration used for this study, the upper ADF detector was coated with a YAP-scintillator (see figure 2), whereas the lower ADF detector was coated with a P-scintillator material (see figure 1), which resulted in a comparatively inhomogeneous angular gain profile.

We performed HAADF imaging of Ga(AsP)/GaP quantum wells using both detectors. To obtain the impinging beam intensity, the electron beam was scanned across either detector in imaging mode prior to recording the HAADF image in diffraction mode. In choosing the detector “brightness” and “contrast” settings, one has to pay special attention to neither saturate the detector with the impinging beam nor to cut-off the lower detection limit of the detector by choosing improper gain settings.

The estimation of the sample thickness, which is needed for quantitative analysis, is done by comparing the normalized image-intensity of material of known composition to simulated reference values. In this way, quantification of the chemical composition in various mixed III/V-semiconductor materials is possible [2].

The normalized image intensities were compared to simulated reference intensity values, obtained by simulating the electron beam propagation through the crystal in multislice approach using the STEMsim code [3]. Here the crystal potential has been calculated in frozen phonon approximation.

In this contribution we will discuss how the Jeol 2200FS microscope can be used for quantitative Z-contrast analysis and compare results obtained from the two different ADF detectors [4].

References
[1] LeBeau et al., *Ultramicroscopy 108* (2008) 1653.
[2] Rosenauer et al., *Ultramicroscopy 109* (2009) 1171.
[3] Rosenauer et al., *Microscopy of Semiconducting Materials* (2007) 169.
[4] This research was supported by the German Science foundation in the framework of the European Graduate College "electron-electron-interactions in solids" as well as by the Heisenberg program (KV). We are also grateful to Dr. M. Kawasaki (Jeol Inc. USA) for expert technical support.

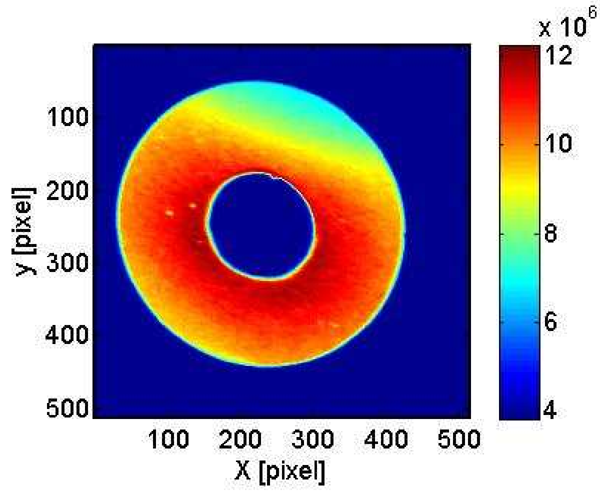

FIG. 1. Color-coded scan over the lower ADF detector area in imaging mode, showing the comparatively inhomogeneous angular gain profile.

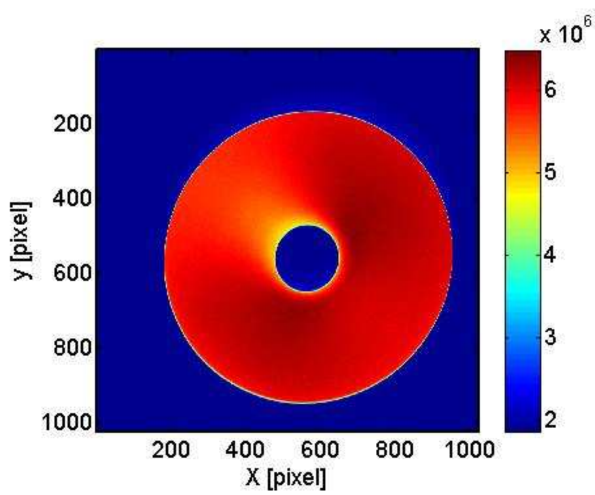

FIG. 2. Color-coded scan over the upper ADF detector area in imaging mode. Here one finds a much more homogeneous sensitivity of the scintillator material.