Liquid nitrogen free energy dispersive x-ray spectroscopy in TEM/STEM using silicon drift detectors

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Scanning Transmission electron microscopy (STEM) in combination with high angle annular dark field (HAADF) imaging and spectroscopy methods is a powerful tool to study element distributions in one to three dimensions on the nm-scale and below.

Electron energy loss spectroscopy (EELS) and energy dispersive x-ray spectroscopy ((X)EDS) are the most common methods used in STEM-mode for elemental mapping. EELS has the advantage of providing information on the bonding environment additionally to element identification and quantification. However, mostly not all elements in question have usable EELS edges in an energy range suitable for one EELS experiment or, the edges of interest do overlap. Thus, complementary, and if multiple elements are to be identified and quantified quickly, EDS is the method of choice.

EDS in TEM, up to now, required liquid nitrogen for cooling the Si(Li) detector. Since the introduction of Peltier cooled silicon drift detectors (SDD) [1] an alternative has become available. Bruker AXS has successfully adapted the SDD technology for the use in TEM and now a liquid nitrogen free EDS detector is available for TEM and STEM (Fig.1). It has an active area of 30 mm^2 and can be arranged to maximise the solid angle and thus the signal. XFlash SDDs have a good light element performance and high energy resolution. They are - unlike most Si(Li) - immune to overload conditions and so can be used in low magnification mode as well. Bruker's hybrid signal processing unit developed especially for SDD readout makes sure the superb collection capabilities of the detectors are properly exploited and guarantees extremely good count rate capabilities and very little dead time.

The successful performance of an SDD-EDS detector covering a solid angle of 0.12 sr on a conventional Jeol 2200 FS TEM/STEM will be demonstrated on various examples of nano-structures. One of them (Fig. 1) belongs to a TEM study of CdZnTe – nanorods [2]. Furthermore, the elemental profile an InGaAs/AlGaP quantum well structure was determined with nm-resolution (Fig.2). The Pt distribution in magnetic nanostructures was successfully investigated as well, which supported the explanation of the magnetic switching behaviour using micro-magnetic simulations [3].

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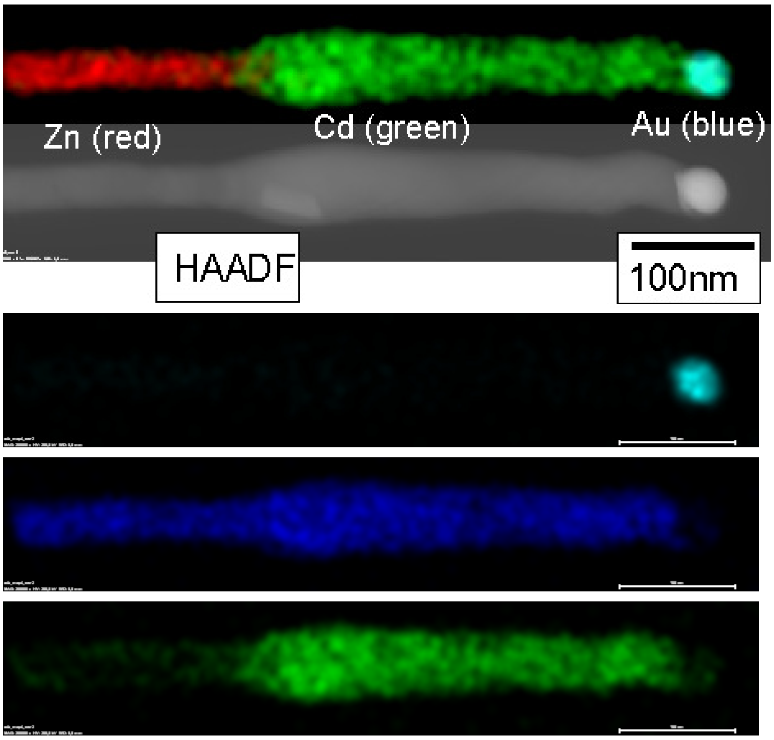

Figure 1. Zn-Cd-Te-nano-rod with Au-catalyst at the end, investigated by SDD-EDS:

HAADF,

Gold distribution,

Telluride distribution,

Cd distribution.

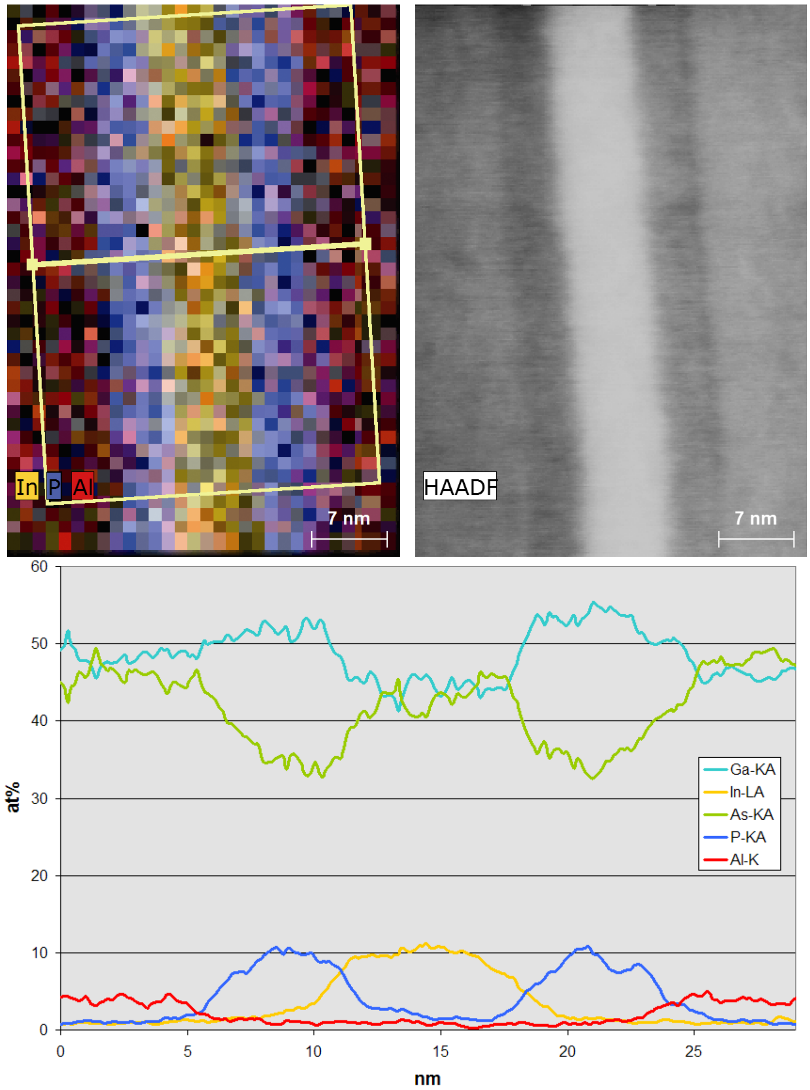

Figure 2. The element profile of a sample from research on laser diods: The Indium distribution resembles the bright features in the HAADF signal showing heavier elements. The element profile was generated using 8by8 binning and adding up all spectra perpendicular to the layers in the indicated area. Even the small kink on the right side of the light element P-profile is reproduced in EDS and HAADF.

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