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In-Depth Sample Analysis with a Signal-Selective SEM Detection System

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Recent trends in analysing the image contrast obtained using sophisticated detection systems in scanning electron microscopes (SEM) show that it is valuable not only to capture the vast majority of signal electrons, but also to allow the selection of particular signal electrons according to the information they carry [1]. This complies with the need to enhance the subtler changes in contrast, in which case just high detection efficiency is no longer sufficient and energy- [2] and/or angular- [3] filtration of signal electrons becomes necessary.

Here we present initial results obtained on our new high-resolution SEM with an extended detection system. The two complementary BSE detectors (in-chamber and in-column) already enable built-in angular selection of BSEs. By adding the energy-filtering BSE detector [4] to the current array of detectors, imaging capabilities of the system are significantly enhanced. This detector incorporates a high-pass filtering grid which can be biased up to -3000 V. Surface-sensitive BSE imaging, as well as pure BSE imaging in the cathode lens (i. e. beam deceleration mode) is thus possible.

Figure 1 shows images of GaN nanowires with InGaN quantum wells acquired at 3 keV primary beam energy, and 200 pA probe current. Different types of contrast are clearly distinguishable. Topographic contrast dominates in the SE image (1a). The in-chamber BSE detector (1b) has a wide collection angle and enhanced sensitivity in the low-energy region, which results in a strong signal and a mixed material and topographic contrast due to low-angle BSEs (< 45°) from the sample surface (this behavior is well known, see [5]). The complementary in-column BSE (1c) provides enhanced material contrast, thanks to its narrow collection angle (> 70°) which encompasses only the high-angle (close to the optical axis) BSE trajectories. By biasing the grid of the energy-filtering BSE detector (1d) to -2900 V, only electrons that have undergone minimal energy losses can be detected (low-loss BSEs) and a high surface-sensitive contrast is achieved, allowing the observation of growth artifacts and impurities on the nanowires . This type of contrast was hitherto almost impossible to obtain and it could only be found in cathodeluminescence (1e) images.

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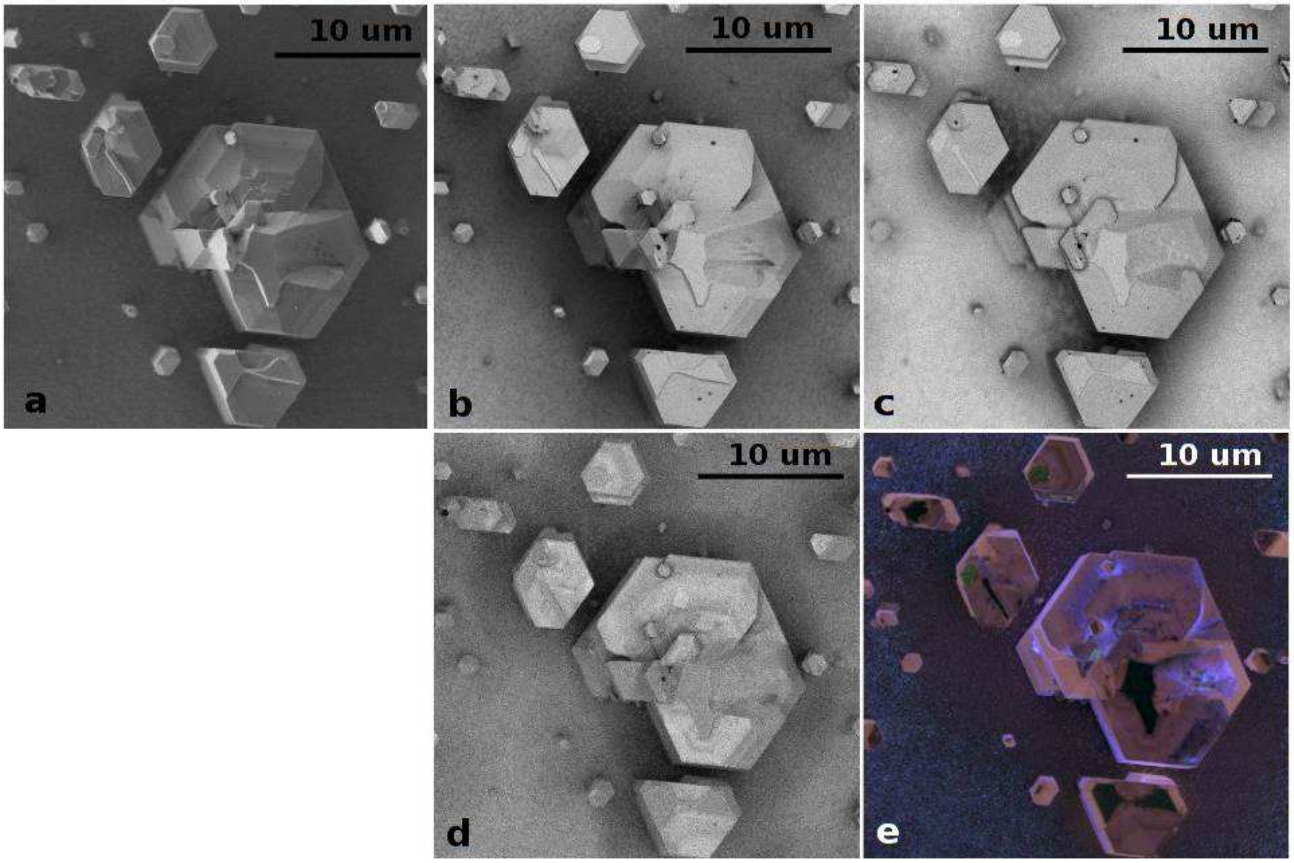

Figure 1. GaN nanowires with InGaN quantum wells imaged at 3 keV primary beam energy: a) in-chamber secondary electron signal, b) in-chamber BSE, c) in-column BSE, d) filtered BSE in the range 2900-3000 eV and e) cathodoluminescence in visible light spectrum. Different types of contrast can be observed (see the text for details). Sample courtesy of Max Planck Institute for the Science of Light, Erlangen.