How fast backscattered electron detectors give new possibilities in state-of-the-art electron microscopy

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Today's Scanning Electron Microscopes are aiming for fast and accurate sample investigation combined with ease of use and optimized work flow. TV speed imaging at high resolution helps to search and identify sample regions as well as to acquire high quality pictures without the need for a search in reduced image resolution mode. However, not all types of detectors are able to support the capabilities offered by new SEMs. For compositional examination, Secondary Electron (SE) detectors are often used for coarse searching before switching to mostly slower Backscattered Electron (BSE) detectors. This consumes time and leads to superfluous electron exposure to the specimen. In this paper, we show the advantages of exclusively using BSE detection with a high speed segmented BSD module in the context of work flow, fast image acquisition and superior real time sample visualization.

Figure 1 shows the BSE detector module. To support the high speeds of the BSE-Chip, the diode and the preamplifier board form one unit placed in a flat high-grade housing. Next to high speed the BSE diodes are designed for maximum Geometric Collection Efficiencies (GCE) at standard working distances. For example a diode with 40 mm^2 sensitive area exhibits a maximum GCE of 50 % at a distance of 2 mm between the sample and diode. These high GCE values enable high contrast and SNR even at low beam currents. In addition, the design of the amplifier is geared to the diode, which enables rise times down to 20 ns, at an amplification factor of 10^5 V/A. Figure 2 shows a magnified part of an SEM picture taken at 20 ns pixel dwell time with no observable smearing. Full HD videos (1920x1080 pixel) can be captured at a frame rate of 24 Hz, highlighting the outstanding speed of the BSE detector module.

The advantage of fast BSE detection becomes obvious when comparing it to standard measuring procedures. The switching between SE and BSE detectors for coarse adjustment and image capturing can be omitted leading to significant improvement in work flow, results and time consumption. Furthermore, the acquisition system enables simultaneous procession of the four individual quadrants. Thus, e.g. compositional and topographic contrast as well as topographic surface reconstruction can be visualized at the same time. Figure 3 shows the live view of a structured Al layer on a Si wafer taken at a pixel rate of 50 Mhz (i.e. 20 ns pixel dwell time). The real time topographic surface reconstruction offers height information and helps to understand the sample properties, completing the overall view. In addition, shorter timescales ensure minimization of electron exposure of the specimen. This becomes especially important when analyzing electron sensitive materials as in life science applications such as serial block-face imaging. There, information has to be collected quickly and reliably with minimal exposure of the specimen to the electron beam. Fast BSE detectors can be used in a wide variety of applications without being limited by detector speed and offer simulations collection of multiple imaging modes.

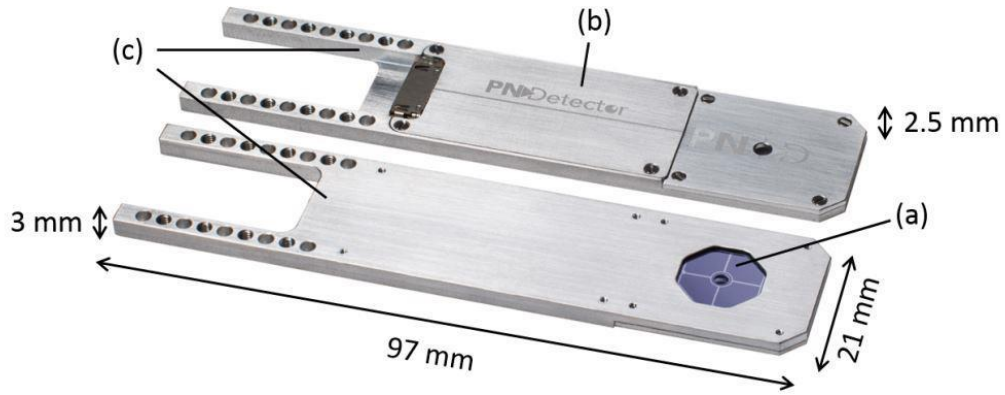

Figure 1: Front and backside view of the high speed BSE detector module: (a) 4 Quadrant BSE diode, (b) 4 channel preamplifier, directly connected to the diode, (c) ultra flat aluminum housing to fit below the pole piece.

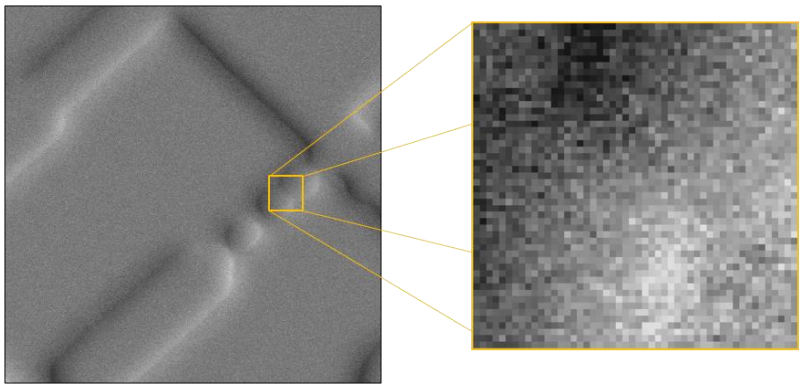

Figure 2: The left side shows an SEM picture taken at 20 ns pixel dwell time. The right side shows a magnified part of the left image with enhanced contrast. Smearing between single pixels is not observed.

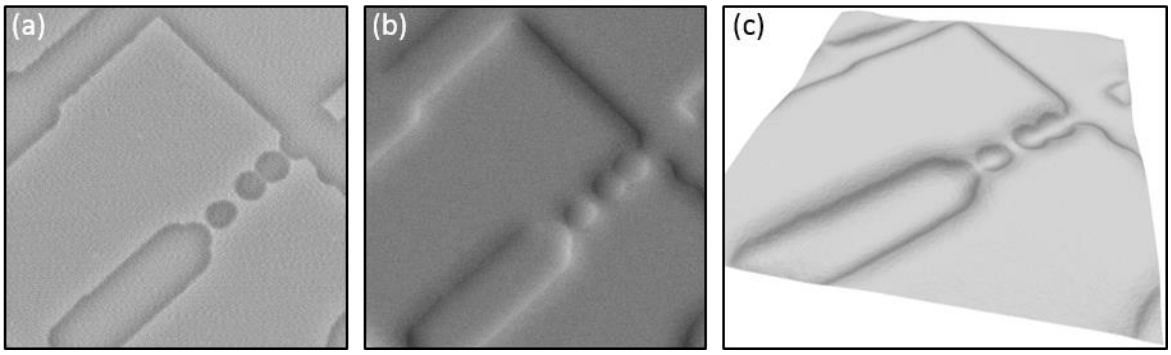

Figure 3: Live view of a structured Al layer on a Si wafer. Images obtained simultaneously at a scan speed of 20 ns pixel dwell time using an ultra fast scan and acquisition system with dedicated surface reconstruction software. (a) Compositional contrast. (b) Topographical contrast. (c) Real time topographic surface reconstruction with quantitative height information.