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Multi-Channel Detection of the Angular Distribution of Backscattered Electrons in the Scanning Low Energy Electron Microscope

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The final image contrast in the scanning electron microscope (SEM) is not only a product of the interaction of primary electrons with the target, but the collection efficiency of the detector with its energy and angular distributions, as well as any subsequent signal processing, also play a role. In order to arrive at a high signal-to-noise ratio, as many signal species should be caught as possible, though achieving a high contrast might require the selection of only a small part of the emission spectra. Multi-channel parallel detectors are promising in this respect.

It is well known that the angular distribution of backscattered electrons (BSE) provides a lot of information about the surface topography and crystallography, namely in dependence with the primary beam energy [1]. An example of anisotropy of the emission yields from a Si (111) surface is shown in FIG. 1.

We have designed a Multi-Channel Plate (MCP) based detector with an eight-channel collector to be implemented in the VEGA TS 5130MM SEM adapted to the Cathode Lens (CL) mode (FIG. 2 and 3). The assembly is finely mechanically adjustable in all three directions. The negatively biased specimen forms a cathode and the earthed detector grid serves as the CL anode. Primary beam electrons at a high energy E_P are decelerated to the final low landing energy E_L by means of the specimen potential U_{SP}, which is fluently controllable. The signal electrons, emitted at an energy E_e, are collimated by the same electrostatic field to the optical axis and accelerated towards the detector. It is well known that the SEM resolution in the CL mode is nearly constant throughout the whole energy range [2]. The low energy secondary electrons (SE) are more affected by the CL field than BSE so, in dependence with the immersion ratio $k = E_P/E_L$, SE escape detection through the collector opening while the BSE emission burst is spread over the eight-channel collector. Distribution of BSE in detection channels is sensitively controlled by k and hence quite high angular sensitivity at particular landing energies can be obtained. An example of the collection efficiency curves of such a detector, plotted as radial coordinates in the detection plane versus initial angles of signal trajectories, is shown in FIG. 4.

The new type of detection system described is expected to improve the grain contrast in polycrystals as well as imaging with low-loss electrons for examination of the real geometry of the sample surface [4]. [5]

References

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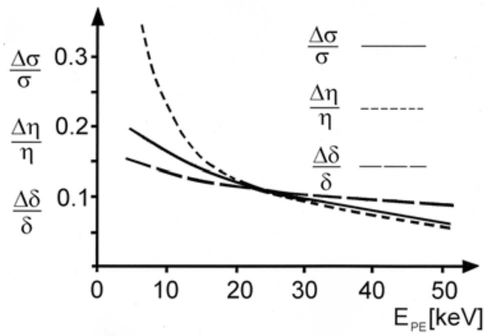

FIG. 1. Anisotropy of the SE (δ), BSE (η) and total (σ) yields from Si (111) versus the primary beam energy. Reprinted from [3].

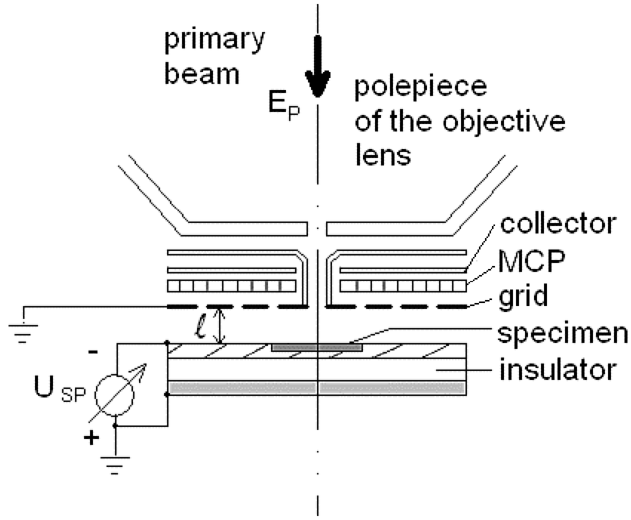

FIG. 2. Setup of the Cathode Lens mode and the multi-channel detector, inserted to below the SEM objective lens.

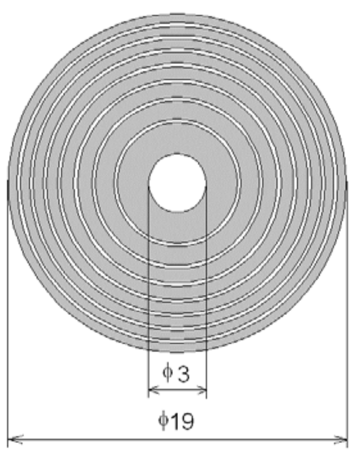

FIG. 3. Eight-channel collector of the detector shown in FIG.2.

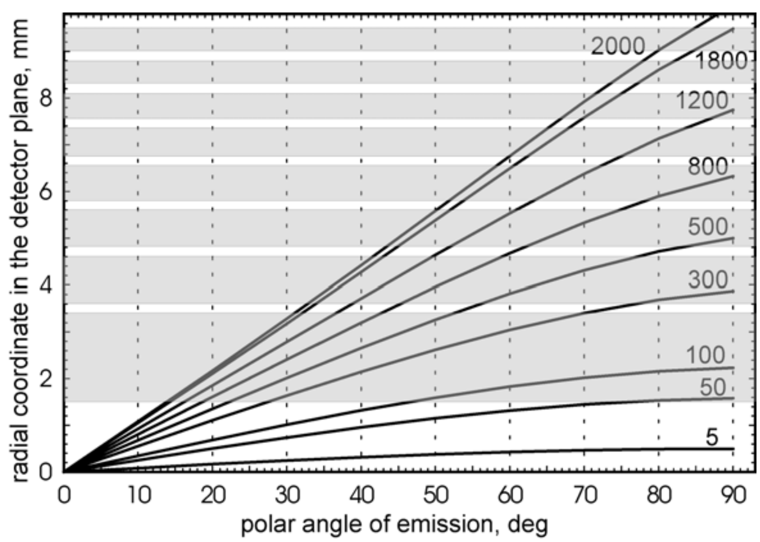

FIG. 4. Radial coordinate in the detector plane versus initial polar angle of the signal trajectory, primary energy E_P = 10 keV, landing energy E_L = 2 keV, l = 10 mm, curves labelled with the emission energies E_e. Detector segments shown as grey strips.

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