Spectroscopy in STEM/TEM

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Next generation of SDD detectors for ultra-fast, high-resolution EDS in microanalysis

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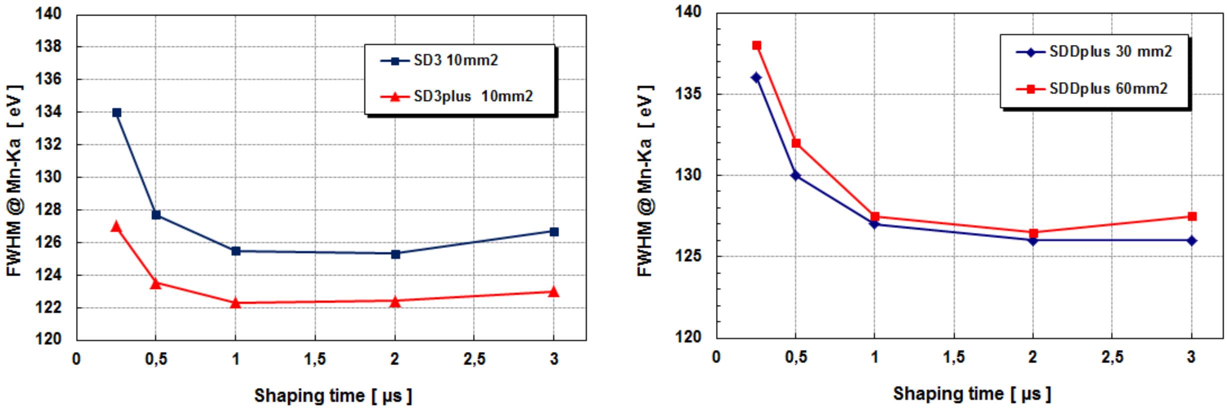
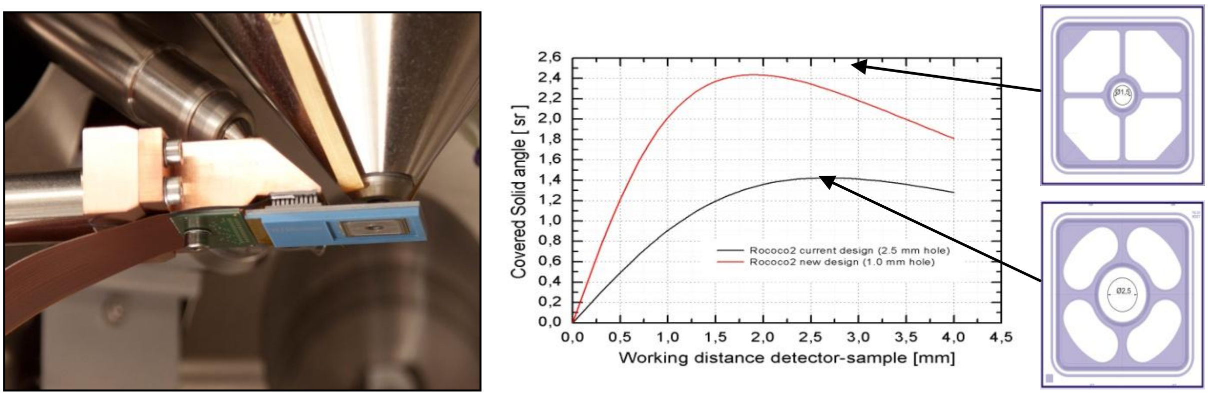
The Silicon Drift Detector (SDD) has become nowadays the standard detector choice for Energy Dispersive X-ray Spectroscopy (EDS) in SEM or TEMs. Recent advances in electron microscopy instrumentation with respect to electron beam brightness and spot size have continuously pushed for higher energy resolution and faster X-ray detectors. SDDs manufactured by PNDetector and PNSensor in Munich with their unique feature of monolithically integrating the first amplifying transistor onto the sensor have established themselves as state-of-the-art detectors for X-ray microanalysis and are distributed worldwide. High-accuracy, ultra-fast elemental analysis requires detectors with extremely low input capacitance, insuring optimum detector operation at very short shaping times. In the recent years a significant development work has been done in this direction at PNDetector by remodeling the geometry of the anode and of the integrated FET with the goal of further reducing all the parasitic capacitances related to the detector anode. This led to a new generation of SDDs – the so-called SDD^{plus} series. The low capacitance anode/ FET can be adopted for all SDD types and sizes (from 5 mm^2 up to 100 mm^2 or multichannel devices). Whereas energy resolution values of down to 126 eV are achieved with the round-shape SDD^{plus} devices (see Fig 1b), when applied to the droplet-shaped SD3 devices, the low capacitance FET drives the energy resolution below 122 eV at shaping times as short as 1 µs (see Fig 1a). With the detector operated at 0.25 µs shaping time (maximum input count rate of 800 kcps) the energy resolution is still below 127eV. Further measurements with SDD^{plus} devices of various sizes will follow. When analyzing thin samples or biological probes with a low photon yield, the measurement time is directly related to the detector collection angle. A very special detector configuration designed for maximum collection angle in SEM or STEM is the annular SDD configuration Rococo2. The detector consists of four kidney-shaped cells with a total active area of 60mm2 arranged around a central hole, therefore allowing the positioning of the detector underneath the pole-shoe in the microscope with the primary electron beam travelling through the detector hole (see Fig 2a). Fig. 2b shows the solid angle coverage of the Rococo2 detector configuration for two different geometries. Representative measurements with a Rococo2 detector system in an SEM will be presented. For applications where boosting the x-ray photon intensity is of primary interest, but no compromises in terms of energy resolution are accepted, multi-channel SDD devices become the first choice. A 7-channel SDD with a total area of 70 mm^2, mounted in a very compact package and capable of dealing with huge count rates up to 7 Mcps will be introduced. Selected measurements with this multi-channel SDD device will be shown.



(a) (b)

Figure 1. High-accuracy, ultra-fast elemental analysis requires x-ray detectors with very good energy resolution at short signal processing times: (a) shows spectroscopic results measured with 10 mm^2 SD3^{plus}/SD3 detectors and (b) similar results measured with 30 and 60 mm^2 SDD^{plus} detectors



(a) (b)

Figure 2. a) Rocccoc2 detector mounted below the pole-shoe of an SEM; b) Solid angle coverage of the Rococo2 detector as a function of the distance to the sample.

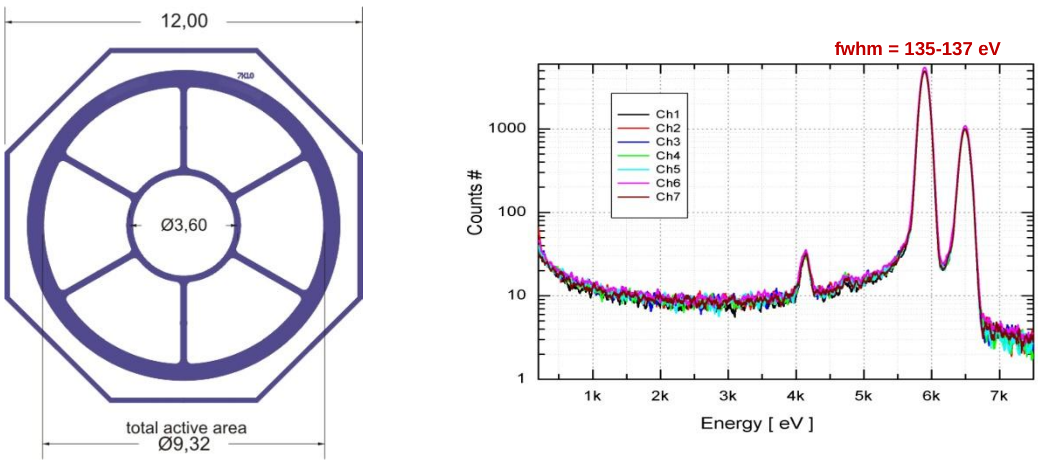


Figure 3. Layout and spectral performance of a 7-channel 7x10 mm^2 SDD capable of total input count rates of 7·10^6 cps. The Fe55 spectra were measured without detector collimator.