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Optimization of the Peak-to-Background Ratio and the Low Energy Response of Silicon Drift Detectors for High Resolution X-ray Spectroscopy

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Silicon Drift Detectors (SDDs) with integrated JFET transistor are fabricated at Max-Plank-Institute in Munich in cooperation with PNSensor and are now widely used as high-resolution X-ray sensors in many industrial and scientific applications.

Besides their excellent energy resolution (down to 124 eV) at moderate operation temperature (around -20°C - easily reached with one stage Peltier cooler), SDD detectors offer also high peak-to-background ratio values and light element detection capability up to boron (B) fluorescence line.

One particular SDD type which is of special interest in the microbeam analysis is the SDD droplet (SD^3) detector - see Fig 1. By moving the integrated transistor aside, the detector capacitance is further reduced and the energy resolution is improved. Typical energy resolution of 128 eV at -20°C at 1 µs shaping time are achieved with this detector type (see Fig. 2a). When operated in pulse reset mode, the excellent energy resolution remains almost unchanged up to input count rates higher than 100 kcps (Fig 2b). By covering the outer margin of the detector with a proper collimator, values of the peak-to-background ratio of about 10.000 are obtained.

Besides the standard detector area of 5 and 10 mm^2, larger area SD^3 detectors have also been fabricated. They are of particular interest for application requiring a reduced throughput time, but maintaining the very good energy resolution. SD^3 detectors with active areas of 20 or 30 mm^2 are now available and their performances regarding the resolution and peak-to-background ratio will be presented.

For applications requiring a very close arrangement of the detector to the probe (e.g. EDS spectroscopy in SEM machines), a four channel SD^3 detector with a total active area of 60 mm^2 (see Fig 3a) has been fabricated and successfully tested. The special detector design with the integrated hole allows the exciting beam (electrons or X-rays) to penetrate the detector while traveling to the probe and therefore to minimize the distance between detector and probe to a few mm (Fig 3b).

Since the quality of the detector entrance window has a large impact on the peak-to-background ration and on the light element detection capability of our detectors, a great effort is put into the optimization of the detector entrance window. Measurements with different entrance window types will be shown. A balance between light element detection capability and radiation hardness of the detector has to be found.

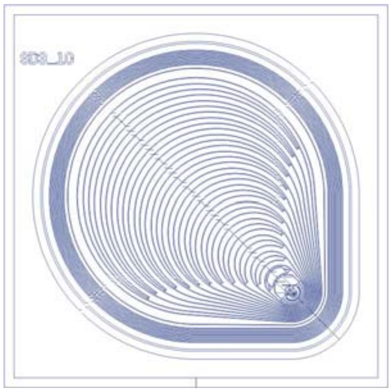
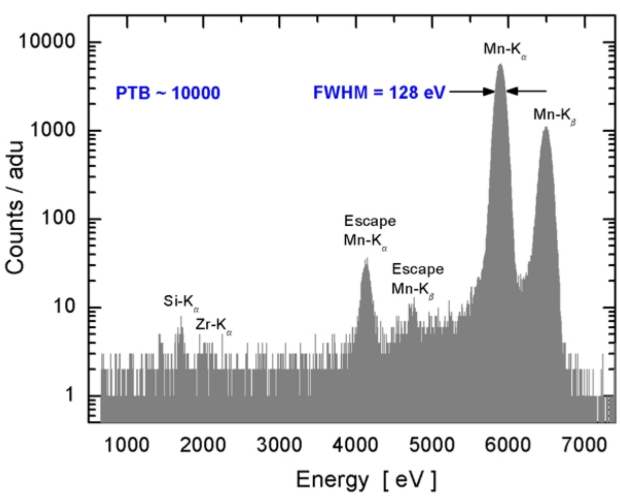
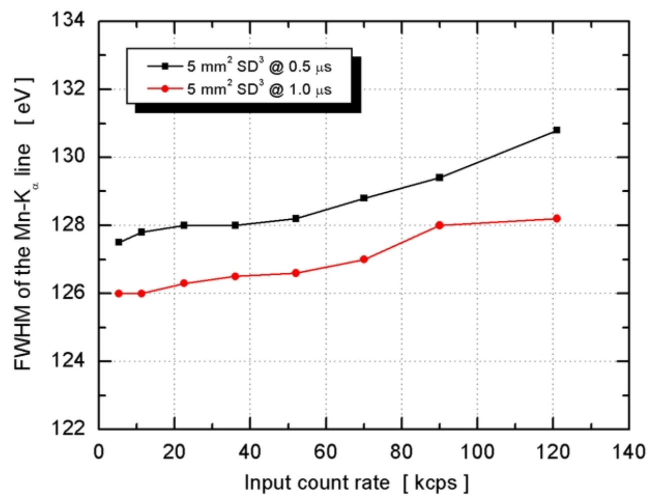


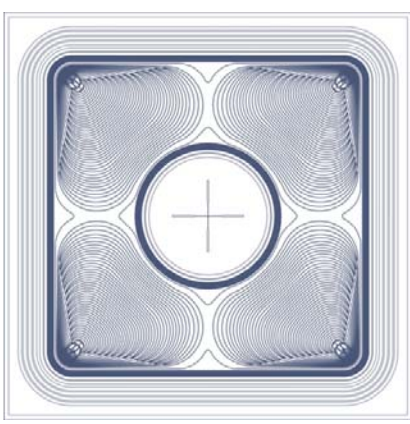
Fig. 1 Layout of the Silicon Drift Detector Droplet (SD^3) with active areas of 5, 10, 20 and 30 mm^2

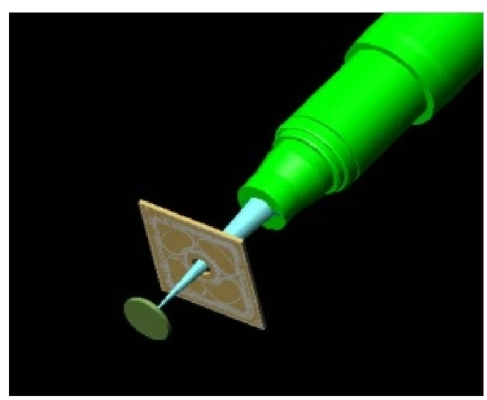




(a) (b)

Fig. 2 a) Spectrum of ^{55}Fe source measured with a 10 mm^2 SD^3 detector at -20°C. b) Energy resolution of the Mn-K_α line versus input count rate for a 5 mm^2 SD3 detector at -20°C





(a) (b)

Fig. 3 a) Layout of a 4-channel SD3 detector with integrated hole and total area of 60 mm^2; b) Arrangement of the detector very close to the probe.

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