An optimized Silicon Drift Detector design for high throughput measurements with unprecedented energy resolution

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Over the past ten years Silicon Drift Detectors (SDDs, figure 1) have established themselves as an indispensable tool for most energy dispersive x-ray (EDX) applications. While those detectors have an excellent energy resolution at intermediate throughput rates, increasingly faster measurements require this resolution also at higher count rates and thereby shorter signal shaping times. To achieve superior performance at high photon rates and short processing times, the total capacitance of the detector must be reduced to the lowest possible value. With the introduction of the SDD droplet (SD3) topology combined with a redesign of the detector readout structure including the anode and the integrated FET ($\mathrm{SDD^{plus}}$), the total input capacitance has already been reduced to ultra-low levels of 50 fF [1]. With these devices, one can reach energy resolution values down to 122 eV at 1 s shaping time (figure 2, left). At shorter shaping times, the performance of the SD3 is limited by the electrons spreading while drifting to the detector anode, and as a consequence, causing larger signal rise times, known as "ballistic deficit". This effect increases with detector size, and thus it also effectively limits the maximum size of an SD3 detector.

The recently developed GeniusLine SDD droplet ($\mathrm{SDD^{GL}}$) overcomes the ballistic deficit to a large extent by redesigning the drift ring structure. The new structure can be scaled and thereby enables larger detector areas with excellent energy resolution. In figure 3 the energy resolution versus the shaping time of an SD3, an $\mathrm{SDD^{GL}}$ and a round SDD detector are compared. The energy resolution of 127.5 eV at 125 ns shaping time of the 10 mm $\mathrm{SDD^{GL}}$ detector sets a new benchmark for SDDs at short shaping times. The 30 mm $\mathrm{SDD^{GL}}$ detector shows a compelling energy resolution of 124 eV at 1-2 s shaping time.

In addition to the high count rate operation the $\mathrm{SDD^{GL}}$ also shows an excellent light element performance. This is shown in figure 3 (left) where a light element spectrum of lithium, beryllium, boron and carbon was recorded. The light element peaks are separated nicely due to the very high energy resolution, e.g. 32 eV at Beryllium. Those lines can still be separated at very short shaping times and high input count rates (figure 3, right, 125 ns shaping time and 125 kcps input count rate). We will present further results of our next generation $\mathrm{SDD^{GL}}$ with further examples for high count rate applications and light element performance.

[1] A. Niculae et al., paper presented at M&M 2013 in Indianapolis.

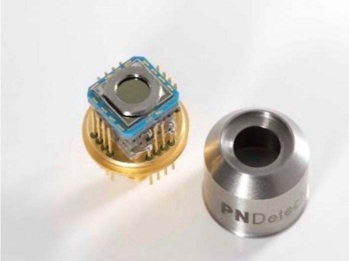

Figure 1: 30 sqmm SDD detector with cap aside

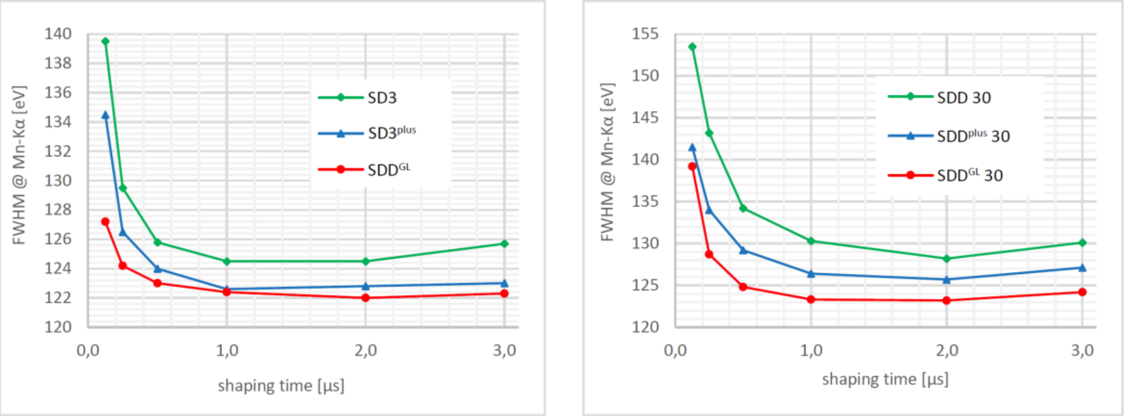

Figure 2: Energy resolution versus shaping time for a 10 sqmm SDDGL detector compared to a plus and standard SD3 detector (left). Energy resolution of a 30 sqmm SDDGL detector compared to other 30 sqmm round devices (right).

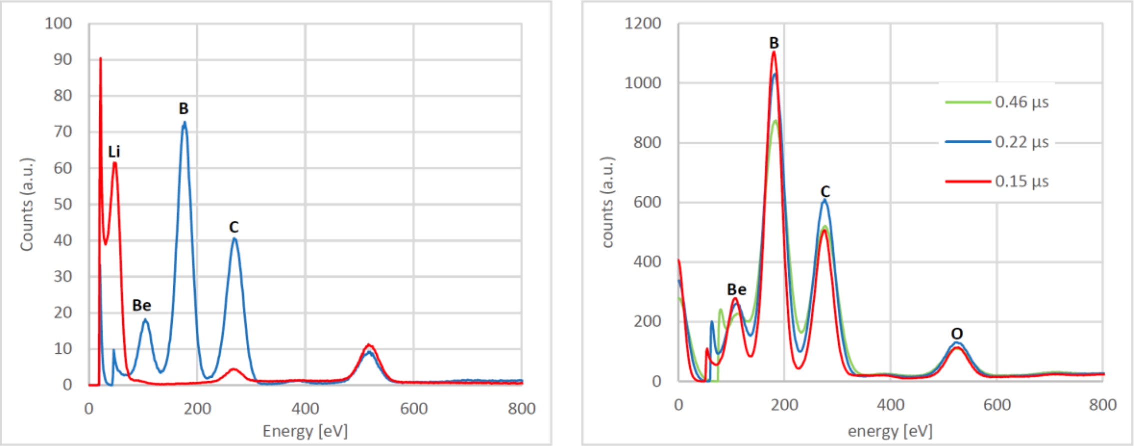

Figure 3: Spectra showing lithium, beryllium, boron and carbon at a count rate of 6 kcps (left). Spectra showing beryllium, boron and carbon at a count rate of 125 kcps.