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Development and application of a simulation environment for the analysis of EDX signal processing algorithms

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Energy dispersive X-ray spectroscopy (EDX) is used for non-destructive material characterization in a wide range of industries and sciences. Signal processing for semiconductor X-ray detectors is usually performed in a FPGA-based digital spectrometer. Major challenges in the optimization of the signal processing are improvements in signal throughput, detection of low-energy signals, energy resolution, and efficiency at high energies and usage of low computing power. In order to extend the performance of digital spectrometers and improve material characterization, development and comparison of signal processing algorithms is needed. Experimental analysis of algorithms is often time-consuming and error-prone. A new approach is presented by the development of a simulation environment. Time-domain signals are modeled in a statistical Monte-Carlo-like approach, considering Fano-noise, X-ray timing, and rise-time variations. Detector noise and leakage current is added to the signal as well as distortion by analog frontend. Verification is performed by virtual signal processing with common algorithms and comparison of the results with a commercially available digital EDX-system. Good agreement in signal throughput and energy resolution is achieved at 5.9 keV. Furthermore, the simulation environment is used to analyze modern signal processing methods: dynamic detector reset, triggered by the signal processing unit improves the throughput at 30 keV up to 13% at low input counts rates (>20 kcps) for short energy-filter peaking-times (100 ns). The advantages are reduced for higher count rates, longer energy-filter peaking-times and lower energies. Pulse detection by proper filter combination leads to the better low-energy efficiency of a long pulse-detection-filter by maintaining good pileup-rejection of a long pulse-detection-filter.

Biography

Florian Rettenmeier has completed his BSc in the field of Physical Engineering and MSc with distinction in the field of Micro- and Nano-Technology at Munich University of Applied Science. Currently, he is a Research Associate and Doctoral candidate at the Bundeswehr University Munich in Neubiberg at the Institute for Microelectronics and Circuit Design. His field of research is the optimization of FPGA-based signal processing for energy dispersive X-ray spectroscopy.

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