New Silicon Drift Detector Technology Enables High-speed Energy Dispersive X-ray Spectrometry

A NIST researcher has made significant progress in high speed energy dispersive x-ray spectrometry with the development of the silicon drift detector (SDD) technology. This detector now provides a 1 MHz output count rate with resolution better than 140 eV.

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The silicon drift detector (SDD) continues to make extraordinary advances in energy dispersive x-ray spectrometry (EDS) performance compared to the conventional Si(Li) detector. For all but one major performance criterion (the inevitably decreased efficiency of the 0.3 mm thick SDD for high energy photons above 12 keV compared to the 3 mm thick Si(Li))), the SDD equals or betters the Si(Li), despite operating at -30 ^{o}C with Peltier cooling and passive radiative exhaust compared to -190 ^{o}C for the Si(Li) with liquid nitrogen cooling.

The SDD has superior resolution performance for the same active detector area (e.g., measured at MnKα, 127 eV vs. 129 eV for a 10 mm^2 detector; 134 eV vs. 140 eV for 50 mm^2).

Most importantly, the SDD achieves a given resolution with a much shorter peaking time, which translates into a higher maximum in the curve of output count rate (OCR) vs. input count rate (ICR).

In our previous work with the SDD, a maximum OCR of 14 kHz was achieved with the "best resolution" (134 eV) peaking time of 8 microseconds, which can be compared to the Si(Li) OCR of 1.8 kHz with a 50 µs peaking time for the same resolution. An unexpected advance in SDD technology has now resulted in a "best resolution" peaking time of 400 ns (for a 10 mm^2 SDD with on-chip first stage amplifier), which gives a maximum OCR above 250 kHz with a resolution of 131 eV. By ganging four of these detectors and multiplexing the signal stream, a combined OCR of 1 MHz can be achieved while retaining resolution below 140 eV for the combined signals of four detectors. This extraordinary OCR performance permits useful x-ray spectrum imaging (e.g., 100 x 100 pixel scan; 1 ms pixel dwell) in only 10 seconds per field of view, while achieving detection sensitivity to all major constituents (concentration greater than 0.1 mass fraction) as well as some minor constituents.

Such high speed image data acquisition opens up new applications in microstructural characterization and particle analysis. For example, an x-ray spectrum image can be recorded for each particle, enabling the analyst to make explicit corrections for particle geometry effects that compromise quantification procedures when single point spectra are used. Inhomogeneous particles can be directly recognized in the x-ray spectrum image, information that is inevitably lost when particle overscan spectrum acquisition is used.