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Low Energy X-Ray Detection with a Silicon Multi-Cathode Detector for Microanalysis

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This paper presents several aspects of our design efforts toward the development of a large-area, high energy resolution analytical x-ray spectrometry system for x-ray microanalysis and x-ray spectrum imaging [1]. The spectrometer achieves excellent energy resolution and is capable of operating at very high counting rates (up to 600,000 cps throughput). The Vortex-EM™ spectrometer is based on a thermoelectrically-cooled silicon multi-cathode detector (SMCD), which is a type of “drift” detector [2-3]. The detector is specifically designed for optimal performance in the 0.2 - 40 keV range. Recent advancements in the detector design enhance the low energy x-ray performance. The spectrometer utilizes a non-cryogenic design, operating with thermoelectric cooling and passive heat transfer to the ambient without using any moving parts; a photograph of the spectrometer is shown in Figure 1.

With the current detector, which is ~ 50 mm^2 active area and ~ 0.35 mm thick, an energy resolution of 125 eV FWHM is achievable (at 5.9 keV, 6 μs amplifier peaking time), with a peak-to-background ratio of 2000:1 in an ^{55}Fe spectrum. These performance characteristics are superior to any non-cryogenic solid state detector of similar dimensions. The throughput rate is ~ 600 kcps for an input rate of 1.5 Mcps, at 0.25 μs peaking time. The detector shows virtually no change in energy resolution, nor shift in peak position as a function of count rate.

The Vortex-EM™ spectrometer was integrated into a JEOL 840 SEM at the National Institutes of Standard and Technology, and the spectral performance was evaluated in response to a variety of samples. Examples of spectra from boron, calcium carbonate, silicon dioxide and silicon nitride samples are shown in Figures 2 – 5, respectively. Additional low energy x-ray spectra and low energy performance parameters in electron microscopy applications will be presented.

[1] 1. S. Barkan, V. Saveliev, J. Iwanczyk, L. Feng, C. Tull, B. Patt, D. Newbury, J. Small, N. Zaluzec, “A New Improved Silicon Multi-Cathode Detector (SMCD) for Microanalysis and X-Ray Mapping Applications”, Microscopy Today, November 2004.
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[3] S. Barkan, J.S. Iwanczyk, B.E. Patt, L. Feng, C.R. Tull and G. Vilkelis, “Vortex™ – A new high performance silicon drift detector for XRD and XRF Applications”, Advances in X-Ray Analysis, 46 (2003) 332-337.

Fig. 1. Vortex-EM™ spectrometer and digital pulse processor; snout length is 300 mm.

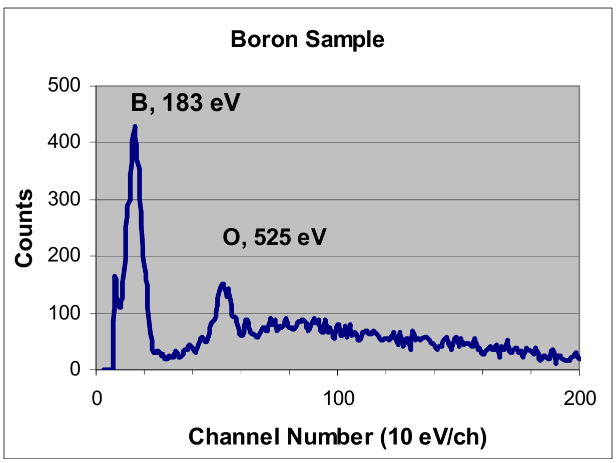

Fig. 2. Spectrum from a boron sample in the electron microscope.

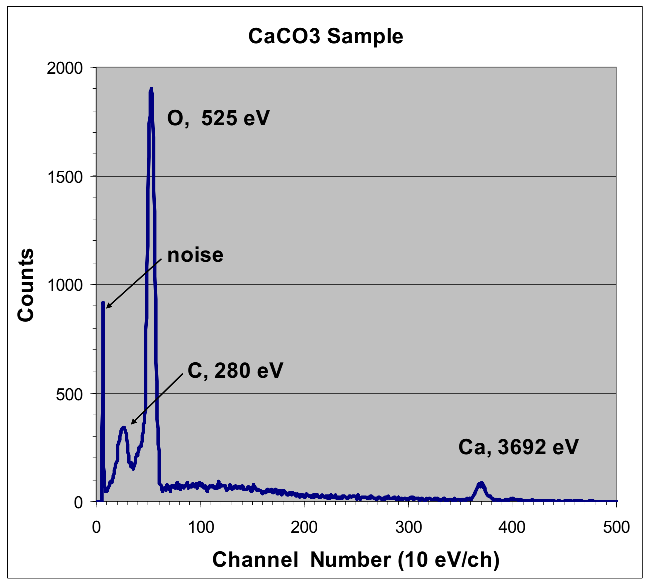

Fig. 3. Spectrum from a $CaCO_3$ sample in the electron microscope.

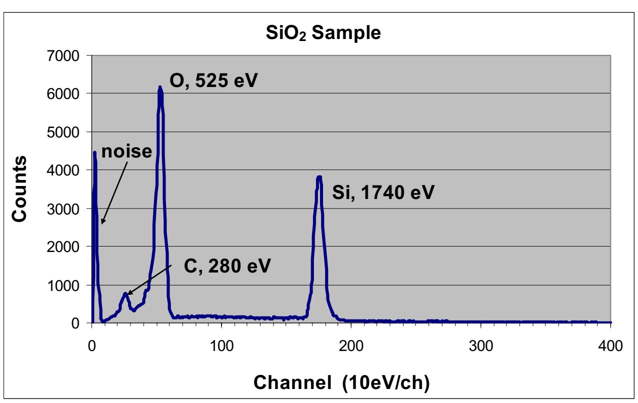

Fig. 4. Spectrum from a SiO_2 sample in the electron microscope.

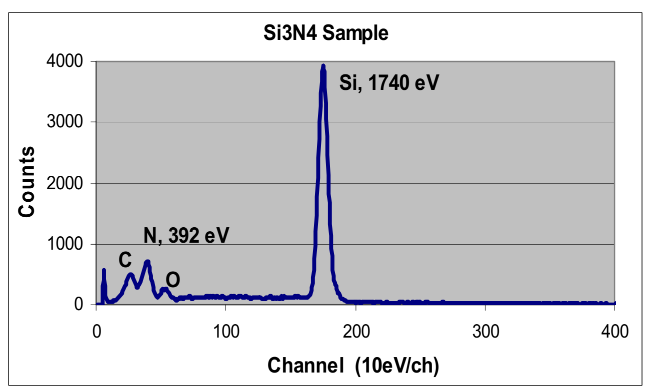

Fig. 5. Spectrum from a Si_3N_4 sample in the electron microscope.

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