

## **A New Improved Silicon Multi-Cathode Detector (SMCD) for Microanalysis and X-Ray Mapping Applications**

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A new class of silicon multi-cathode detectors (SMCD) has been developed for microanalysis and x-ray mapping applications [1,2]. The SMCD has a large active area ( $\sim 0.5 \text{ cm}^2$ ), high energy resolution, and high count rate capability. The detector utilizes novel structures that have produced very low dark current, high electric field, uniform charge collection, low noise and high sensitivity to low energy x-rays [3,4]. A custom-designed spectrometer package has been built with a long probe to fit a JEOL 840 scanning electron microscope (SEM). In bench-top measurements with an  $^{55}\text{Fe}$  radioisotope source, an energy resolution of 129 eV FWHM was repeatably measured with the  $0.5 \text{ cm}^2$  SMCD (at 5.9 keV, 6 - 12  $\mu\text{s}$  peaking time, cooled to  $-70 \text{ }^\circ\text{C}$ ).

The spectrometer package, shown in Figure 1, contains a  $0.5 \text{ cm}^2$  SMCD detector, cooled by using a small Peltier element. The spectrometer model shown in Figure 1 was designed specifically to use with a JEOL 840 scanning electron microscope (SEM) at the National Institute of Standards and Technology (NIST). The probe diameter is  $\frac{3}{4}$ " and its length is 12". An atmospheric thin window (ATW) from Moxtek (Orem, UT) is placed at the window edge and allows good transmission of very low energy x-rays while the detector is kept in a high vacuum condition. An electron trap is placed on the window to deflect electrons scattered from the sample.

The detector spectral response was evaluated using an  $^{55}\text{Fe}$  radioisotope source, as well as by fluorescing materials with an x-ray source. Figure 2 shows an  $^{55}\text{Fe}$  spectrum showing an energy resolution of 129 eV FWHM at 5.9 keV (collected at 12  $\mu\text{s}$  peaking time,  $-70 \text{ }^\circ\text{C}$ ). To evaluate the high count rate x-ray performance, which is very important for fast x-ray mapping, a Cu sample was fluoresced using a Rh-anode x-ray tube. Figure 3 shows the Cu spectra collected at: (a) 3000 cps input, with 206 eV FWHM at 8.04 keV (0.5  $\mu\text{s}$  peaking time), and (b) at  $> 1 \text{ Mcps}$  with an energy resolution of 214 eV FWHM and output count rate exceeding 350 kcps. The photopeak position and energy resolution are virtually independent of count rate.

The detector is scheduled to be assembled on a JEOL 840 SEM at NIST at the end of February 2004. We will measure the x-ray energy resolution and count rate performance under microanalysis conditions. In addition, we will evaluate the spectral response to very low energy x-rays, including C and B. The SEM results will be presented.



Figure 1. Photograph of the spectrometer designed for the JEOL 840 SEM. Probe length is 12”.

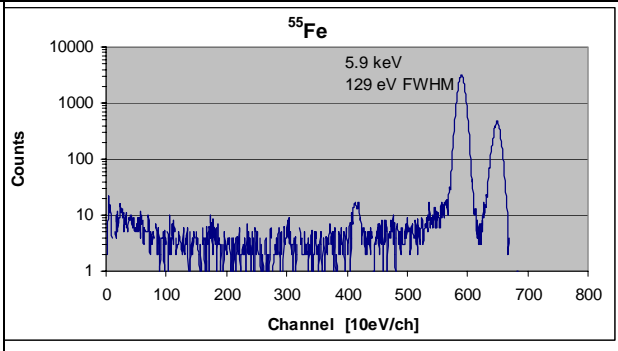
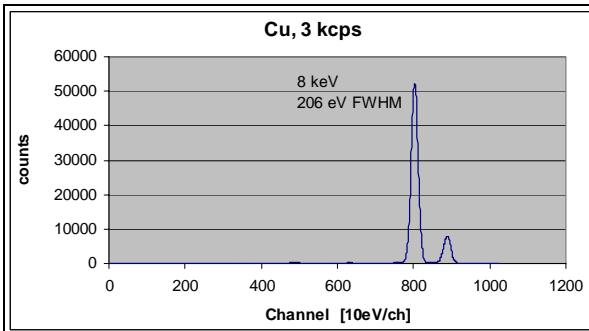
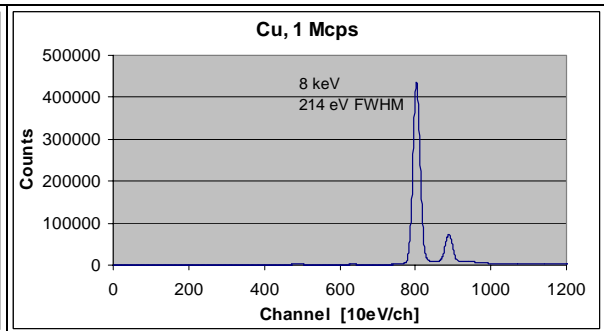


Figure 2. Spectral response of SMCD to  $^{55}\text{Fe}$ , showing an energy resolution of 129 eV FWHM (at 5.9 keV, 12  $\mu\text{s}$  peaking time, -70  $^{\circ}\text{C}$ ).



(a)



(b)

Figure 3. (a) Spectrum of Cu sample at low count rate (206 eV FWHM at 8 keV, 0.5  $\mu\text{s}$  peaking time and 6% dead time); (b) Cu spectrum at high count rate (>1 Mcps input, 350 kcps output, 214 eV FWHM at 8 keV, 0.5  $\mu\text{s}$  peaking time, 68% dead time).

## References:

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- [2] L. Feng, et al., “A New High Performance Silicon Multi-cathode Detector for XRD and XRF Applications”, *Hard X-ray and Gamma-ray Detector Physics V*, Proceedings of SPIE, International Society of Optical Engineering, Vol. 5198, (2004) 103-110.
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- [4] U.S Patent #6,455,858 B1 “Semiconductor Radiation Detector”, 2002.

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