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High Resolution Micro-calorimeter Arrays for micro-probe analysis

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Low temperature micro-calorimeters are powerful tools for energy-dispersive x-ray spectroscopy[1]. At soft x-ray energies, their resolution is approximately 30 times better than conventional SiLi instruments. This improved resolution makes micro-calorimeters ideal tools for the analysis of nanometer-scale particles and films increasingly to the semiconductor industry. Nanoelectronics must be interrogated with low energy microbeams in order to exclude the substrate from the interaction volume. Consequently, only low energy K, L, and M shell fluorescence can be measured resulting in peak overlaps that cannot be resolved with SiLi detectors but are easily distinguished by micro-calorimeters.

In recent work at NIST, we have conducted a detailed study of thermodynamic and other noise sources in our micro-calorimeters[2]. This study has resulted in an optimized detector design with an energy resolution of 2.4 eV FWHM at 5.9 keV. We are presently using this same design process to build micro-calorimeters optimized for energies of 1.5 keV and 100 keV. The 1.5 keV devices are intended for fast measurements of chemical shifts. The 100 keV devices are intended for precision g-ray and hard x-ray spectroscopy.

The active area of typical micro-calorimeters ranges from 250^2 microns^2 to 400^2 microns^2. In order to increase collection area and reduction acquisition times, we have fabricated close-packed arrays of up to 64 micro-calorimeters (shown in Figure 1). We are also developing a time domain squid multiplexer to reduce the wiring and room temperature electronics needed to read out these arrays. We have recently demonstrated the high-resolution multiplexed operation of four micro-calorimeters[3] (Figure 2), and will shortly implement a higher bandwidth multiplexer circuit able to measure 16. Follow-on systems with 100 pixels, active area of 100* 400^2 microns, and total count rate > 10 kHz are expected.

Finally, we continue to improve the stability and ease-of-use of our micro-calorimeter system. In particular, we are developing a compact, cryogen-free refrigerator to provide the 100 mK operating temperatures required by micro-calorimeters. This refrigerator will mount on commercially available scanning electron microscopes and eliminates the need for any cryogenic expertise on the part of the instrument user.

References
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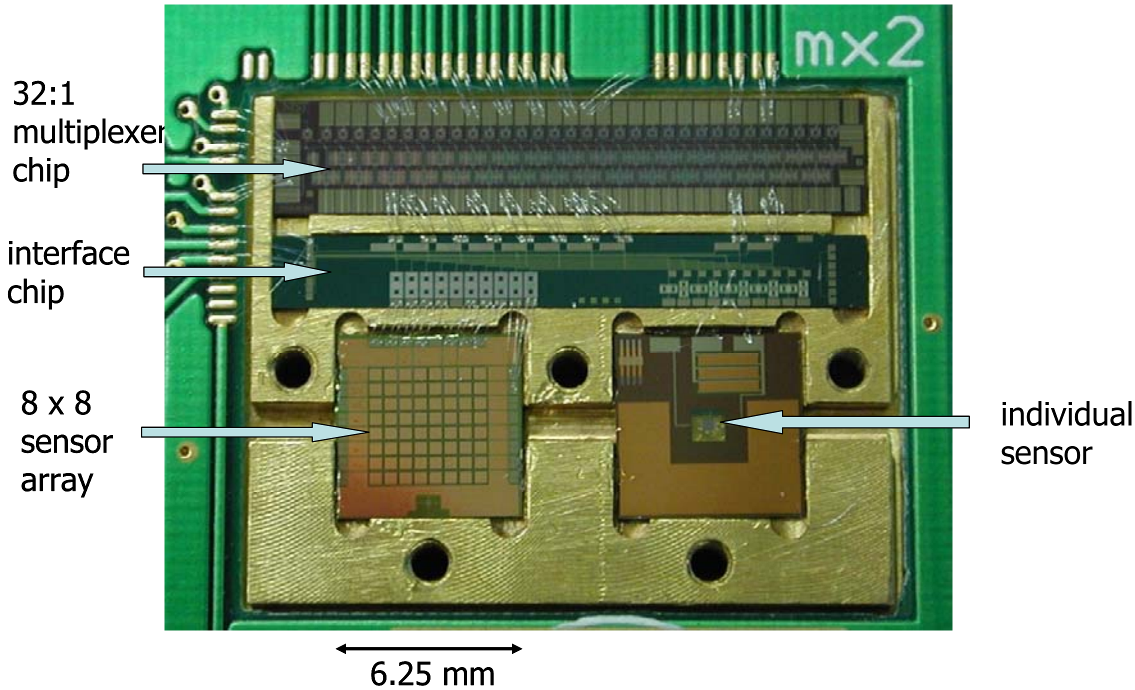

Figure 1 64 pixel array with multiplexer array and non-multiplexed pixel for comparison purposes.

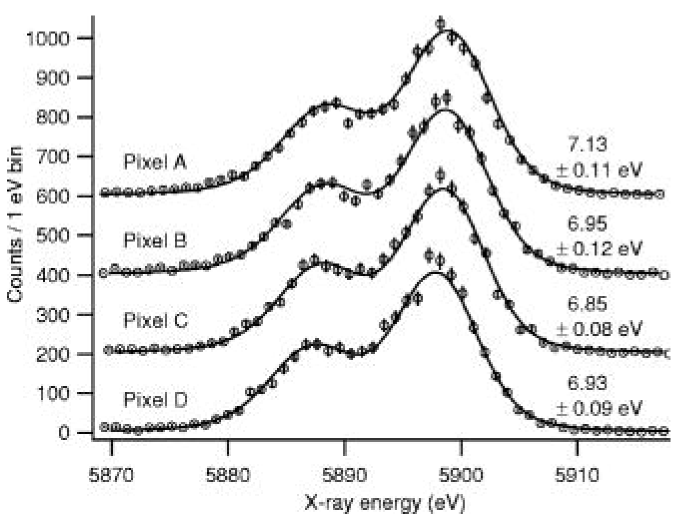

Figure 2 Fe55 Spectra from four multiplexed calorimeters.
Non-muliplexed resolution is 6.5 eV.

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