

Geometrically Weighted Frisch Grid Semiconductor Radiation Detectors for Remote and Portable Gamma Ray Spectroscopy

D.S. McGregor – Principal Investigator

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SBIR grant in co-operation with Radiation Safety Engineering. The project involves the investigation of commercial grade CdZnTe materials for the development of trapezoid detector arrays. A variety of materials are being studied. The second phase goal, if awarded, is to develop, construct, and demonstrate an operating hand-held probe utilizing a pseudo-coaxial array of CdZnTe trapezoid detectors.

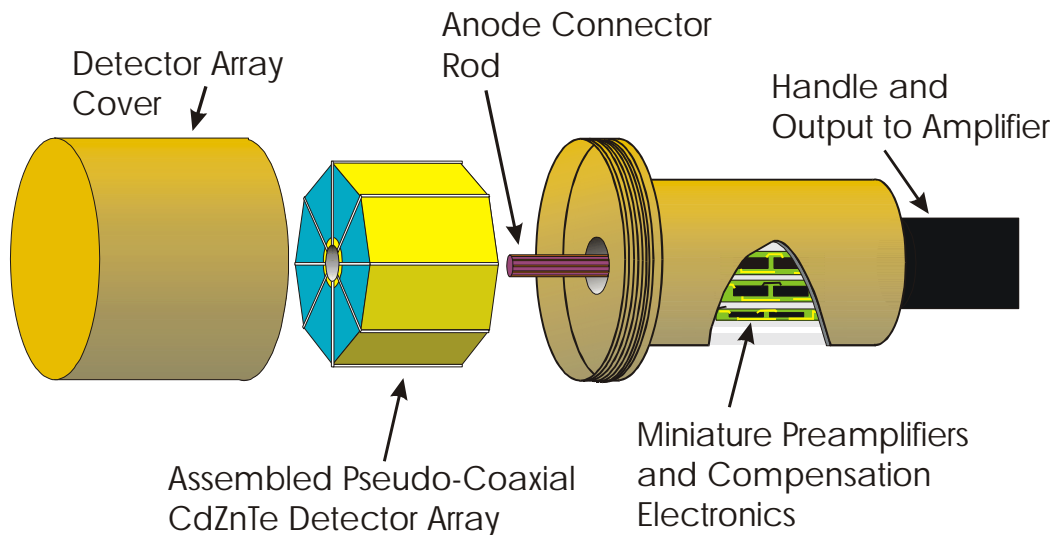


Figure 1: Depiction of the proposed probe. A pseudo-coaxial assembly of trapezoid detectors is arranged around a central conductive connector rod. Miniaturized preamplifiers are connected to each detector and adjusted to compensate for slight differences in gain. The device is configured as an easily handled wand that can be connected to commercial NIM electronics.

Geometrically weighted CdZnTe detectors are being fabricated from a variety of commercially available materials to determine the feasibility of constructing a pseudo-coaxial array of devices for a hand-held probe (as shown in Figure 1). Materials of differing grades acquired from different sources are being studied.

The materials are etched and inspected with an infrared microscope before processing begins. The bulk crystals are mapped for defects and sliced selectively to remove the regions with large cracks and defects. Sample blocks sliced from the inspected ingots are shaped and etched. Electrical contacts are put on the trapezoids, which afterwards are placed through a passivation step. Common grade CdZnTe trapezoid detectors have demonstrated energy resolutions of 3.5% FWHM (at 662 keV) or better for 1 cubic cm volume devices. Evidence indicates that improvements in material quality are necessary before reliable devices can be manufactured on a large scale.



Figure 2: Dr. McGregor carefully inspects a CdZnTe sample for crystal defects and imperfections with an infrared microscope. Cracks and major defects will cause the CdZnTe devices to perform poorly. The crystals are etched, inspected, and mapped before pieces are cut for device fabrication.

As of present, over 100 trapezoid detectors averaging 1 cubic cm in volume have been fabricated, of which about 20% have shown energy resolution of 3.8% FWHM or better at 662 keV. The best thus far has shown energy resolution of 2.68% FWHM for 662 keV gamma rays. Most of the poorly performing devices have large material defects within, as observed with an infrared microscope.

Precipitates and cracks in the bulk material reduce the amount of usable volume, and in some cases, by significant amounts. Still, CdZnTe spectrometers of higher resolution than typical scintillators are easy to

manufacture. It is expected that with improved quality of CdZnTe materials, many new device configurations can be realized that will serve as viable gamma ray spectrometers.

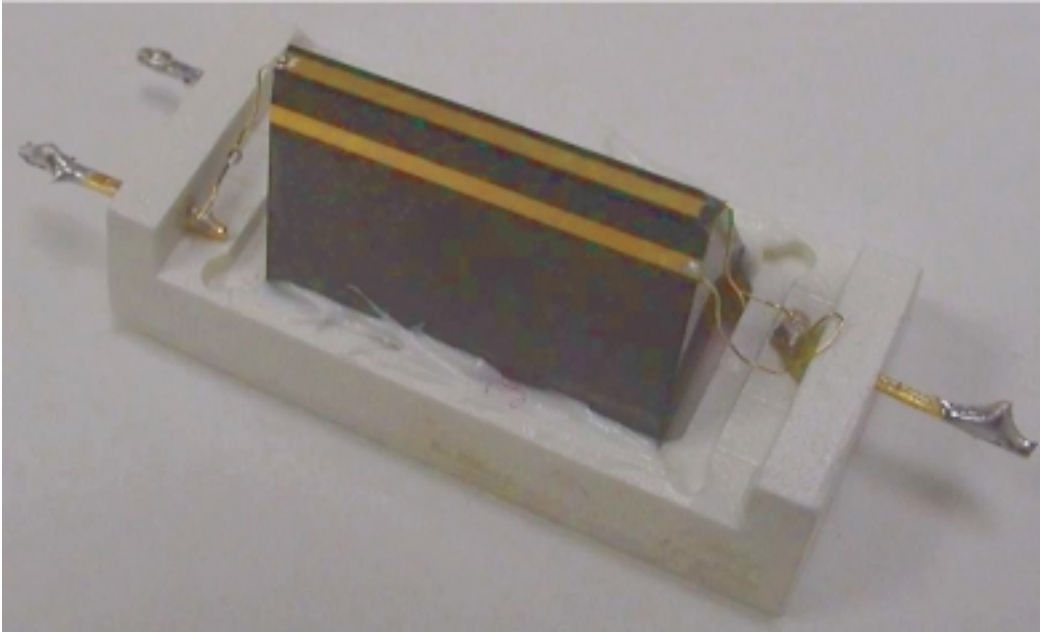


Figure 3: A 2 cm long geometrically weighted trapezoidal Frisch grid detector fabricated from commercial “discriminator grade” CdZnTe material.

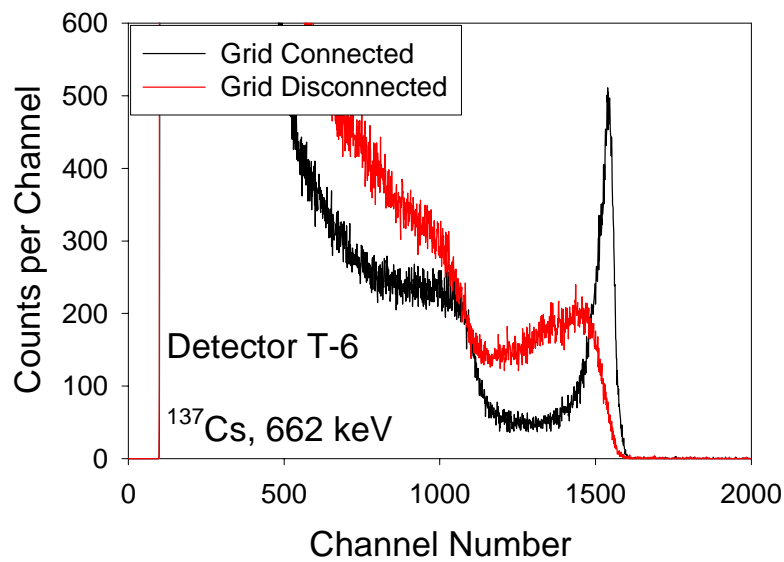


Figure 4: The effect of the geometrically weighted trapezoidal Frisch grid design on the detector performance. The discriminator grade material is transformed into an acceptable spectrometer.

Refereed Publications:

1. D.S. McGregor, N.J. Reddy, and D.K. Wehe, "Low Energy Gamma-Ray Characterization of a Trapezoid-Shaped Geometrically-Weighted Frisch Grid CdZnTe Gamma-Ray Spectrometer," Nucl. Instr. and Meth., Feb. (2000) in press.
2. D.S. McGregor, N.J. Reddy, and D.K. Wehe, "Design Considerations for Trapezoid-Shaped Geometrically-Weighted Frisch-Grid Semiconductor Radiation Detectors," Proc. SPIE, Vol. 4141 (2000) pp. 281-290.

Conference Presentations:

1. Douglas S. McGregor and Robert L. Metzger, "A Geometrically Weighted Frisch-Grid Semiconductor Radiation Detector for Gamma Ray Spectroscopy," Conference Record of the 12th Biennial RPSD Topical Meeting, Sante Fe, New Mexico, April 14-18, 2002.
2. D.S. McGregor, N.J. Reddy, and D.K. Wehe, "Design Considerations for Trapezoid-Shaped Geometrically-Weighted Frisch-Grid Semiconductor Radiation Detectors," SPIE-Hard X-Ray, Gamma-Ray, and Neutron Detector Physics II, San Diego, July 31- Aug. 2 (2000).

