Contract No:

This document was prepared in conjunction with work accomplished under Contract No. 89303321CEM000080 with the U.S. Department of Energy (DOE) Office of Environmental Management (EM).

SRNL-STI-2021-00244

Characterization of virtual Frisch grid detectors fabricated from as-grown CdZnTeSe ingots

Utpal N. Roy[1], Giuseppe S. Camarda[2], Yonggang Cui[2], Ge Yang[3] and Ralph B. James[1]

[1]Savannah River National Laboratory, Aiken, SC. USA.
[2]Brookhaven National Laboratory, Upton, NY. USA.
[3]North Carolina State University, Raleigh, NC. USA.

Over the past few years CdZnTeSe (CZTS) has emerged as an alternate material to replace CZT at a lower cost of production without compromising device performance. An ideal semiconductor material for room-temperature radiation detector applications should possess much less defects and higher compositional uniformity than CZT. A lower concentration of intrinsic defects and higher compositional uniformity in the resulting material ensure better spatial charge transport uniformity over large-volume detectors. This requirement of uniform spatial charge transport properties is a stringent one to enhance the yield of high-quality detectors, and CZT does not fully satisfy this requirement due to a random distribution of sub-grain boundary networks and Te inclusions in the crystals. The addition of selenium in the CZT matrix successfully avoids many of these issues and makes the resulting CZTS material promising as a potential replacement to CZT. The resulting quaternary material CZTS was found to be free from sub-grain boundary networks and also possess very few Te inclusions with better compositional uniformity along the length of the ingot, as compared to CZT grown by the Traveling Heater Method (THM). In this presentation we report detailed characterization of the performance of virtual Frisch grid detectors and their compositional uniformity for CZTS detectors fabricated from THM-grown ingots.

The salient advantages of CZTS over the most successful commercial CZT material are summarized in Figure 1. Fig. 1 indicates the material properties and their effects on the device performance as well as on the yield of high-quality detector for CZT and CZTS. As indicated in

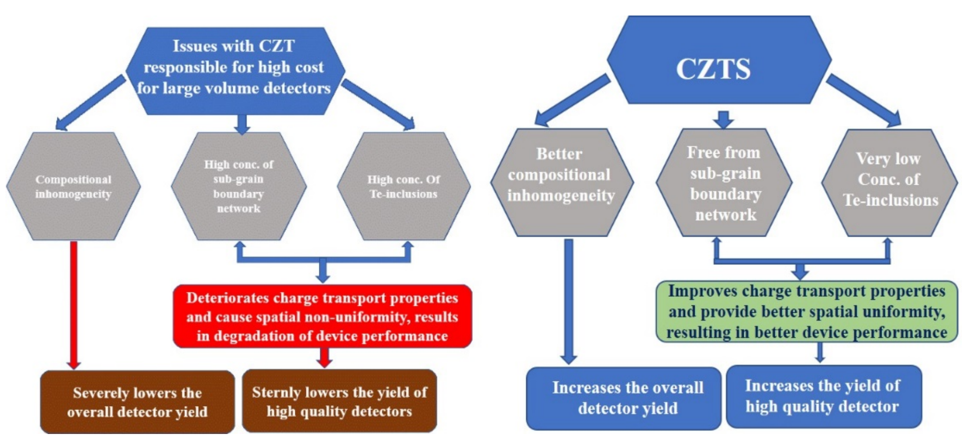

Figure 1. Advantages of CZTS over conventional CZT material.

Figure 1, the new quaternary material is free from sub-grain boundary networks and has highly reduced Te inclusions, eventually resulting in the increased yield of high-quality detectors. Figure 2 shows the pulse height spectrum of such high-quality virtual Frisch grid detector together with X-ray topographic image and infrared (IR) transmission image of the full detector. The distinct advantage of CZTS over CZT for medical imaging applications was also reported earlier by General Electric[1]. The overall future of CZTS looks very promising for commercial success.

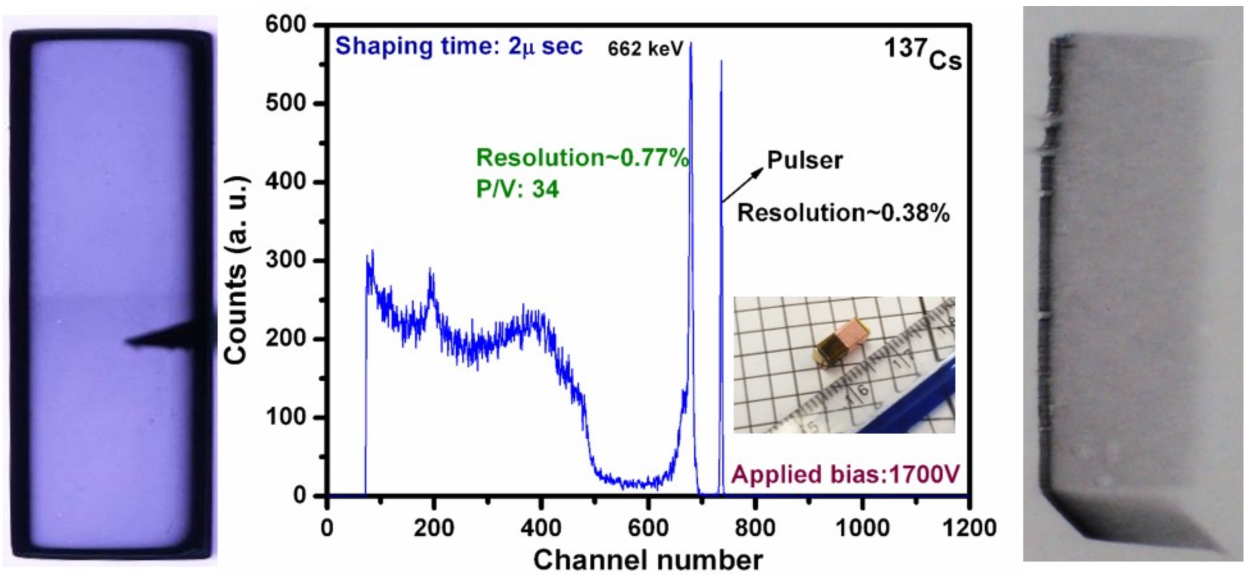

Figure 2. As measured pulse height spectrum for a ^{137}Cs source of a Frisch-grid detector fabricated from as-grown $Cd_{0.9}Zn_{0.1}Te_{0.98}Se_{0.02}$ THM ingot. Left: IR transmitted image of the whole detector and right: X-ray topographic image of the whole detector. The inset shows the image of the fabricated detector. Detector dimensions: 3.5x3.5x9.15 mm^3.

Reference:

1. Yakimov, A.; Smith, D.; Choi, J.; Araujo, S. Growth and characterization of detector-grade CdZnTeSe by horizontal Bridgman technique. *SPIE Proc.* **2019**, *11114*, 111141N.