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Polarization Studies of CdZnTe Detectors using Synchrotron X-ray Radiation

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***Abstract* – New results on the effects of small-scale defects on the charge-carrier transport in single-crystal CdZnTe (CZT) material were produced. We conducted detailed studies of the role of Te inclusions in CZT by employing a highly collimated synchrotron x-ray radiation source available at Brookhaven's National Synchrotron Light Source (NSLS). We were able to induce polarization effects by irradiating specific areas with the detector. These measurements allowed the first quantitative comparison between areas that are free of Te inclusions and those with a relatively high concentration of inclusions. The results of these polarization studies will be reported.**

SUMMARY

It has long been known that grain boundaries and twins degrade the performance of a device, and hence, a first step in material screening is to ensure that CZT crystals are free of these macroscopic defects. We use X-ray diffraction topography (XDT) measurements at the high-energy NSLS beamline and IR microscopy to identify the defects distribution and strains in the bulk of CZT crystals. However, the role of the Te inclusions remained somewhat obscure. A high-intensity X-ray beam collimated down to a 10-micrometer spot size, available at the NSLS, was employed to perform X-ray mapping to measure the correlation between microscopic defects (inclusions) and variations in the collected charges in long-drift-length CZT detectors. By using synchrotron radiation we demonstrated that single Te inclusions trap a significant amount of charge of an electron cloud. Te inclusions and their surrounding areas were measured, and the deleterious effects of Te inclusions on the energy spectrum were unambiguously observed [1-4].

The sizes, concentration, and shape of the Te inclusions is being measured with an unique automated IR imaging system developed at BNL to screen CdTe and CZT crystals. The morphology of the inclusions is a sensitive function of the temperature field in the growth process. Star-shaped Te inclusions, hexagonal-shaped, and irregularly shaped inclusions are shown in Figure 1.

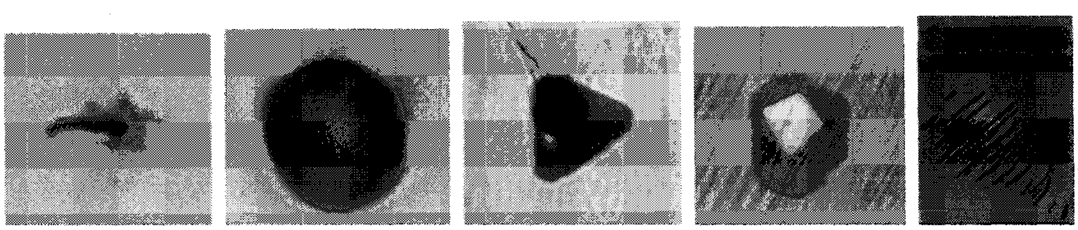

Figure 1. Some IR micrographs of Te inclusions in CZT

We measured some CZT samples from different vendors with our setup at X27B of NSLS, and we were able to induce polarization in certain regions of the detectors. The results of these polarization studies will be reported.

Another experiment is to measure the detector response while it is flooded with IR radiation to intentionally induce polarization. Polarization depends on material composition, bias applied, thickness of detector, time of exposure, and flux of the synchrotron radiation.

We also started investigating the field distribution in CZT detectors. Figure 2 shows a 1x1.5mm x-ray map of a pixellated detector that has one pixel biased and the others floating.

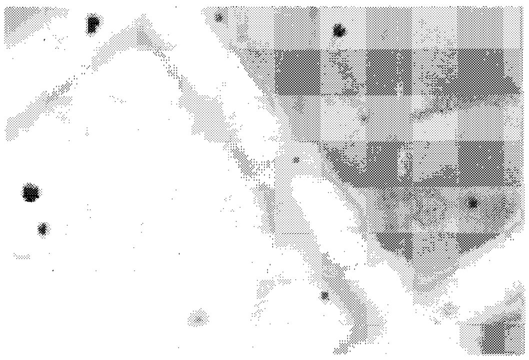

Figure 2. x-ray map of a pixellated detector

The goal of these studies is to understand the limitations of CZT material and provide feedback to the crystal grower who will work to find the most effective way to minimize deleterious material defects. Results of the infrared transmission, x-ray mapping and polarization experiments will be presented.

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