Characterization of Compound Semiconductor Crystals: Role of Synchrotron X-ray Sources and Electron Microscopy

A. Hossain, A.E. Bolotnikov, G.S. Camarda, Y. Cui, R. Gul, U.N. Roy, G. Yang, R. B. James, Nonproliferation and National Security Department, Brookhaven National Laboratory, Upton, NY 11973

Compound semiconductors are under investigation to detect and image X- and gamma-ray radiation in nuclear non-proliferation and security, medical imaging and high-energy research applications. Among the different compound-semiconductor detectors available today, Cadmium Zinc Telluride (CdZnTe or CZT) is the leading material in the applications of radiation detection, solar cell and IR substrates. However, this material possesses various defects like dislocations, sub-grains, and precipitations that's can degrade the devices' overall performance, and hence, restrict their widespread deployment for field applications. The dimensions of these defects are in the range from the sub-micron- to the nano-scale, which cannot be readily identified with conventional techniques; instead more advanced tools like Synchrotron X-ray source and electron microscopy are needed. In this study, we characterized these structural defects in detector-grade CdZnTe crystals, employing a variety of advanced techniques, including high-resolution electron microscopy (TEM and STEM), along with SEM coupled with energy dispersive x-ray spectroscopy (EDS) to characterize the structural and other related defects in the material. The combination of these techniques allowed us to acquire comprehensive information on crystalline quality and elemental composition of the crystals. We will present our findings in terms of the defects' concentration, size, phase, etc. We also correlated the presence of these defects and their influence on the performance of fabricated devices.