Charge Transport Properties of CdMnTe Radiation Detectors

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Semiconductor gamma and X-ray detectors are finding increase use in medicine, industry, astronomy and national security. Conventional semiconductors consist mainly of germanium and silicon. Their use has however become marginalised in an increasing number of applications due to their physical limitations such as low detection efficiency and the need for bulky cryogenics. Detectors based on wide-bandgap high-Z compound semiconductors are logical choices to fulfill this technology need. A very recent and promising candidate is cadmium manganese telluride (CdMnTe). While previously used as Faraday rotors, solar cells and optical isolators, its application as a radiation detector was only first investigated in 1999 [1]. Its distinct advantages of good compositional homogeneity and a highly tunable band gap compared to CdZnTe and CdTe, which have been leading room temperature detector candidates for over three decades, have encouraged CdMnTe detector developments in recent years. Through a fruitful collaboration between Australian Nuclear Science and Technology Organisation and Brookhaven National Laboratory (USA) the performance of CdMnTe detectors are being investigated [2] and the detector properties are being improved.

Uniform charge carrier transport is critical to the spectroscopic performance of CdMnTe detectors. Ion beam induced charge (IBIC) measurements, utilising beams from the ANTARES accelerator at ANSTO, have revealed the charge transport of these devices down to micron scale resolution. These measurements have quantified how major impurities such as tellurium inclusions present within the detector bulk, affect the charge collection of these devices. These measurements have also shown that the role of tellurium inclusions in degrading charge collection is reduced with increasing values of bias voltage. Combining transient current and charge measurements the electric field distribution inside these detectors has been investigated for the first time. Spectroscopy measurements have demonstrated that the average charge collection efficiency of these detectors approaches 100 % at high biases.

Knowledge gained from these measurements has already led to the growth of CdMnTe crystals with improved stoichiometry by our collaborator. Continued improvements in crystal quality and detector fabrication will be required for realisation in medical and national security applications.

[1] A. Burger et al., "Crystal growth, fabrication and evaluation of cadmium manganese telluride gamma ray detectors", *J. Cryst. Growth*, **198/199,** 872-876 (1999).

[2] R. Rafiei et al., "Investigation of the charge collection efficiency of CdMnTe radiation detectors", *IEEE Trans. Nucl. Sci.,* (2012) accepted.