A study of electric field in CdTe radiation detectors using Pockels effect method

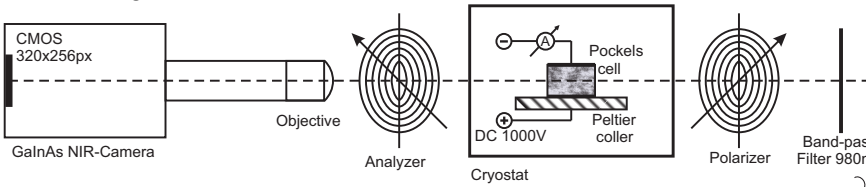
Device CdTe is a II-IV high atomic-mass semiconductor with gap 1.5 eV used for X-ray detection in the range 10-200keV. A classical capacitor configuration of the device exploits semi-insulting property of the material at room temperature. An incident high energy photon generates an electron-hole cloud which is separated in an electric field and subsequently collected by respective electrodes. The amount of charge is proportional to the photon energy. Repetition of a single event gives a histogram depicting radiation spectrum of the source (Fig. 3).

Method CdTe has a high linear electro-optical coefficient thus the detector represents a phase retarder between a pair of the orthogonal linear polarization modes. External electric field powers the detector for function as well as it induces Pockels effect itself. Infrared testing light propagating through the optical cell is analyzed by crossed-polarizers technique and then projected to a camera (Fig. 1). Dispersion of the electric field defines magnitude of the Pockels effect, ergo the constrast of camera image. As a consequence the spatial distribution of the electric charge within the electrodes could be registred straightforwardly (Fig. 2).

Goal Unintentional deep level traps in low concentration are localized in the vicinity of the midgap causing reduction of the charge collection efficiency. Photo-generated charge is accumulated on those traps screening off the external driving electric force. Such an undesirable effect is called the detector polarization and creates a dead layer blocking the detector from the standard operation. A work function of the electrode metal affects band bending at the metal-semiconductor interface which could facilitate collection of the charge and change the occupation of deep traps. The study was aimed to investigate behavior of the system under high laser photon flux simulating real X-ray radiation.

Outcome It was observed that additional illumination with sub/above bandgap excitation laser could serve either to probe energies of deep levels or even to restore constant electric field throughout the detector by dissolving accumulated charge on deep traps. The idea of resetting the detector could be realized with periodical flashing by laser diodes with the appropriate photon energy.

Figure 1: A CdTe detector in an experimental set-up for electric field investigation.



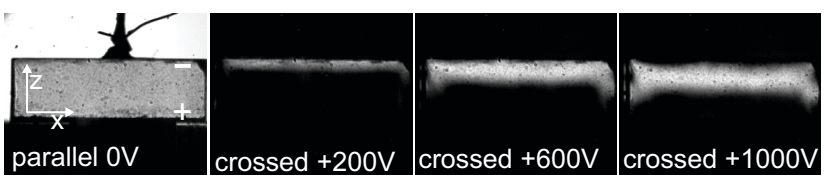


Figure 2: Camera photographs of a Au/CdTe/Au cell. Bright strip below the blocking Au cathode indicates positive space charge region (polarization). Presence of charge gives rise to the electric field that induces stronger Pockels effect. Oppositely, the dark region means null E-field. The effect of polarization is amplified with bias voltage.

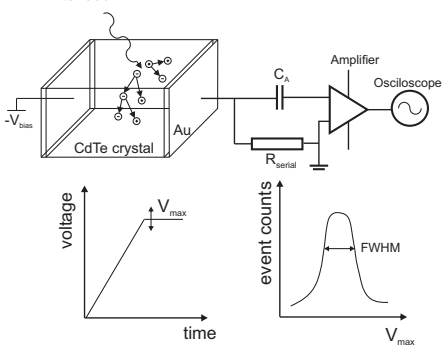


Figure 3: CdTe detector in operation.

References

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