Investigation of the internal electric field uniformity in (Cd,Mn)Te, (Cd,Mg)Te and (Cd,Mn)(Te,Se) crystals by using the Pockels effect

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Crystals based on CdTe with addition of manganese Mn, magnesium Mg or selenium Se are currently investigated as new materials in fabricating room temperature X and gamma radiation detectors. Such devices work in energy range from 30 up to 800 keV. These detectors are needed for various applications, for example: in national security or in imaging implements for medicine [1]. The interest in CdTe-based materials is due to their large absorption cross-section for considered radiation owing to high atomic number and proper bandgap [2]. Crystals for nuclear radiation detectors have to fulfill special requirements, such as: those should be large-volume single crystal (more than 2 cm^3) with high resistivity $\rho \sim 10^{10}\ \Omega$, low concentration of tellurium precipitations $\leqslant 5 \cdot 10^3\ cm^{-3}$ and with uniform distribution of internal electric field. All these demands ensure good carrier transport without any charge traps.

Internal field measurement in nuclear radiation detectors has always been a difficult task. Hopefully, in considered range of chemical composition, all above mentioned materials crystallize in zinc blende structure (they do not have inversion symmetry), so they have strong linear electro-optical coefficient [3], which allows to make use of the Pockels effect. The Pockels image of sample with uniform distribution of internal electric field should be of the constant brightness. When dark and bright areas (areas with different refractive indexes) in one sample can be distinguished, that means there is a non-uniform distribution of internal electric field and relying on such sample, the nuclear detector cannot be built (fig.1).

In this work it has been shown qualitative (Pockels imaging using infrared microscopy – fig. 1) as well as quantitative (E-field profiling at single points) results of investigations into three compounds. (Cd,Mg)Te crystals show strong non-uniformity owing to tendency in twins forming during crystallization. In (Cd,Mn)(Te,Se) it is very difficult to obtain high resistivity samples, and as a result to use high voltage which is necessary during experiment. In those which had high resistance, there were numerous tellurium and cadmium inclusions. In the Pockels effect measurements the only signal comes from spherical tellurium inclusions which are formed in a line. There is no signal from separated star-like cadmium inclusions. The most uniform internal electric field has been obtained in (Cd,Mn)Te crystals which have limited amount of defects and this material could be promising in nuclear detector fabricating.

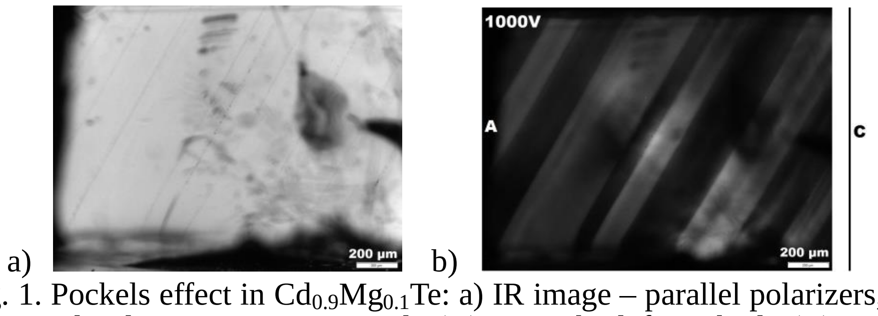

Fig. 1. Pockels effect in $Cd_{0.9}Mg_{0.1}Te$: a) IR image – parallel polarizers, 0V; b) Pockels image – crossed polarizers, 1000V. Anode (A) is on the left, cathode (C) is out of view right. The non-uniform distribution of internal electric field can be visible.

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