Comparison of (Cd,Mn)Te and (Cd,Mn)(Te,Se) Compounds for Room Temperature X- and Gamma-Ray Detection: Optical Properties and Detector Response

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Semi-insulating CdTe-based compounds are being tested as materials for room temperature X- and gamma-ray detectors. More recently, selenium has been added to CdTe to increase the hardness of the compound as fewer harmful subgrains have been found in harder materials [1]. We have checked that compounds alloyed with Se are indeed harder. However, this application particularly requires good charge carrier transport, which is ensured by a low concentration of trapping defects.

In this work, two Bridgman-grown (Cd,Mn)Te-based materials were tested in order to compare their optical properties and the ability to detect X and gamma radiation. Our studies covered $Cd_{0.95}Mn_{0.05}Te$ and $Cd_{0.95}Mn_{0.05}Te_{0.98}Se_{0.02}$ crystals – as-grown samples as well as samples annealed in cadmium or selenium vapors. Low-temperature photoluminescence (PL) studies allowed us to discuss the presence of defect states. In both materials, two donor-acceptor pair transitions (DAP) exist. Shallow (s) and deep (d) DAP transitions are about 70 meV and 200 meV below the exciton lines, respectively. Bridgman-grown (Cd,Mn)Te has a high concentration of Cd vacancies, which are acceptors. Annealing in Cd vapors was carried out to reduce their concentration. This process eliminates or reduces the intensity of DAP^d line in (Cd,Mn)Te, whereas in (Cd,Mn)(Te,Se) even double annealing in Cd vapors does not influence the DAP^d line. In PL, the DAP^d line is observed in (Cd,Mn)(Te,Se) up to higher temperatures than in (Cd,Mn)Te. The possible interpretation of the differences between the two compounds might be the existence of a complex containing the Se vacancy in (Cd,Mn)(Te,Se). In principle, it should be a deep donor (analogy to Te vacancy) [2].

Then, the detector response of these two materials was compared. Pixelated detectors were created by the sputtering of metal layers. The room-temperature spectroscopic performance of the detectors was checked using a Co-57 point source. The (Cd,Mn)Te detector distinguishes 122 keV gamma-rays of Co-57 with an energy resolution of ~16%. On the other hand, the (Cd,Mn)(Te,Se) detector recognizes only X-rays of Co-57 at 7 keV with an energy resolution of ~45%, and a trace of gamma-rays at 14.4 keV. We associate the poor response of the (Cd,Mn)(Te,Se) detector with the presence of a deep trap involved in the luminescence of DAP^d. Therefore, (Cd,Mn)Te is a more promising material for use in X-ray and gamma-ray detectors.

Acknowledgements

The authors would like to gratefully acknowledge Janusz Gdański, Stanisław Jabłoński, Adam Marciniak, and Marek Zubrzycki for their technical support during experiments. This work was partially supported by the Polish National Centre for Research and Development through grant No. TECHMATSTRATEG1/346720/8/NCBR/2017.

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