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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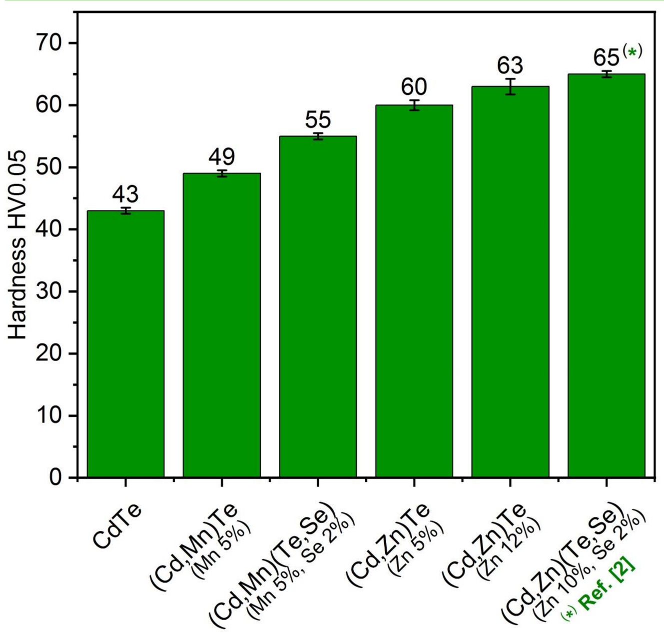
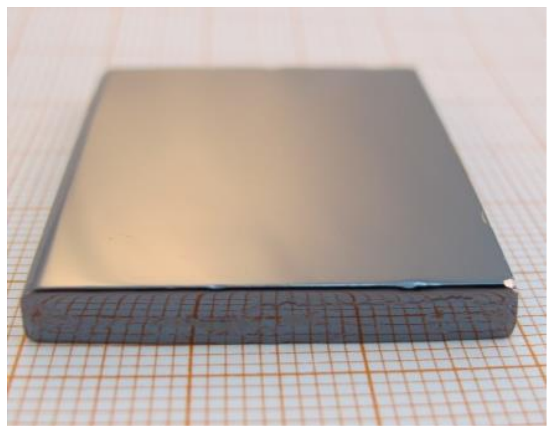
Introduction

- CdTe-based crystals are investigated for use in room-temperature X-ray and gamma-ray detectors.
- In this application, high resistivity crystals with high mobility-lifetime product are neccessary. To fulfill above requirements, we need single crystals with minimized number of defects.
- The harder compound, the lower density of defects [1]. We add manganese and selenium to CdTe to increase the hardness of the material and obtain better crystal properties. We check whether this approach gives satisfactory results.
- We study $Cd_{0.95}Mn_{0.05}Te$ and $Cd_{0.95}Mn_{0.05}Te_{0.98}Se_{0.02}$ crystals grown using the low-pressure Bridgman method. The crystals are 2 or 3 inches in diameter.

Motivation

There are less harmful **subgrains** in harder materials [1].



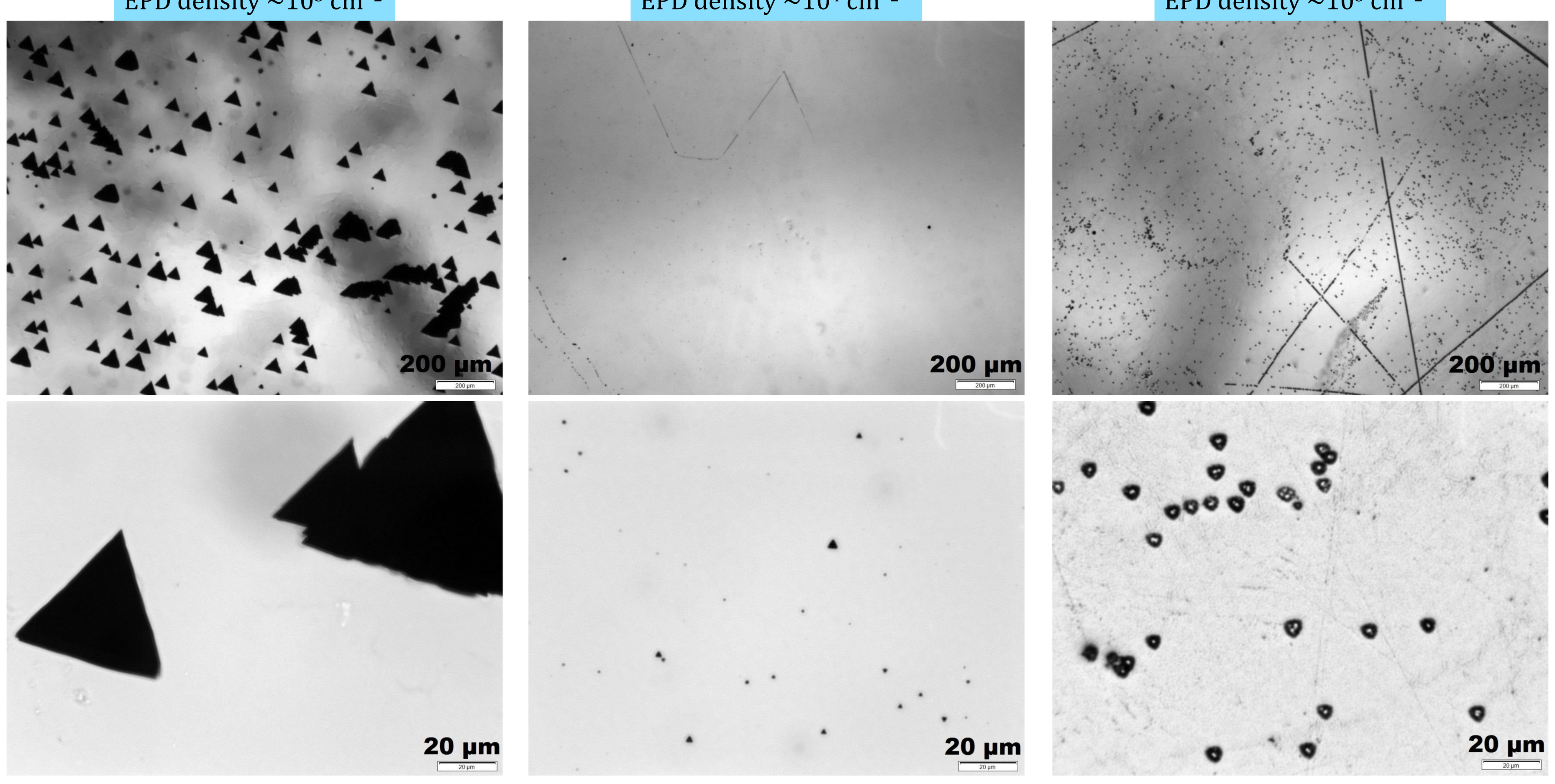


(Cd,Mn)Te single crystal samples.

Subgrains examination – etching samples with Inoue solution, which consists of $K_2Cr_2O_7$, $AgNO_3$, HNO_3, H_2O. Etch Pits form on the sample surface in the region of beginning of the dislocation.

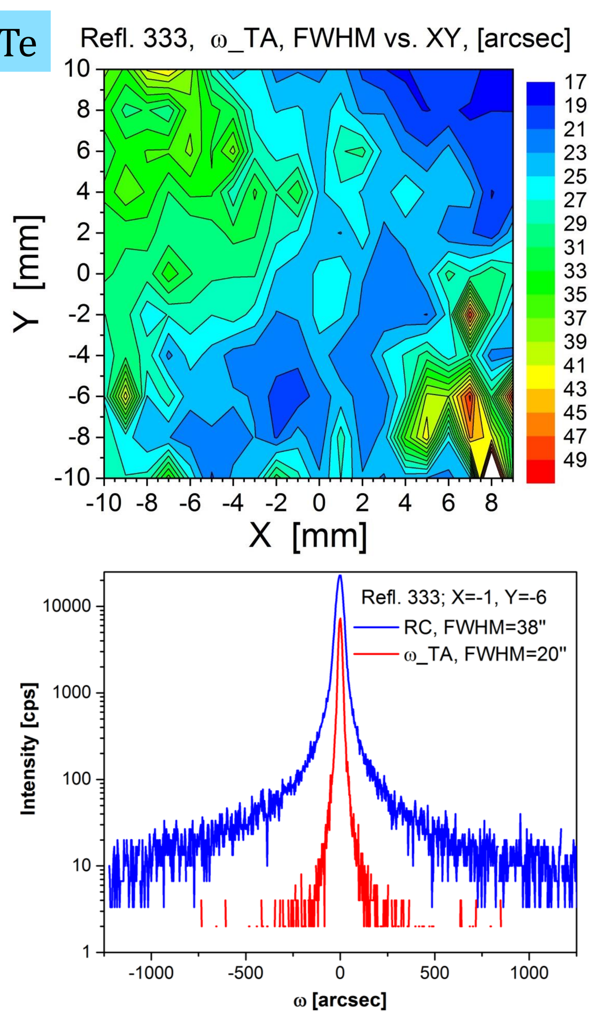
~**(111)** plane

CdTe	(Cd,Mn)Te	(Cd,Mn)(Te,Se)
Etching time: 90 s EPD density ~10^5 cm^{-2}	Etching time: 180 s EPD density ~10^4 cm^{-2}	Etching time: 90 s EPD density ~10^5 cm^{-2}

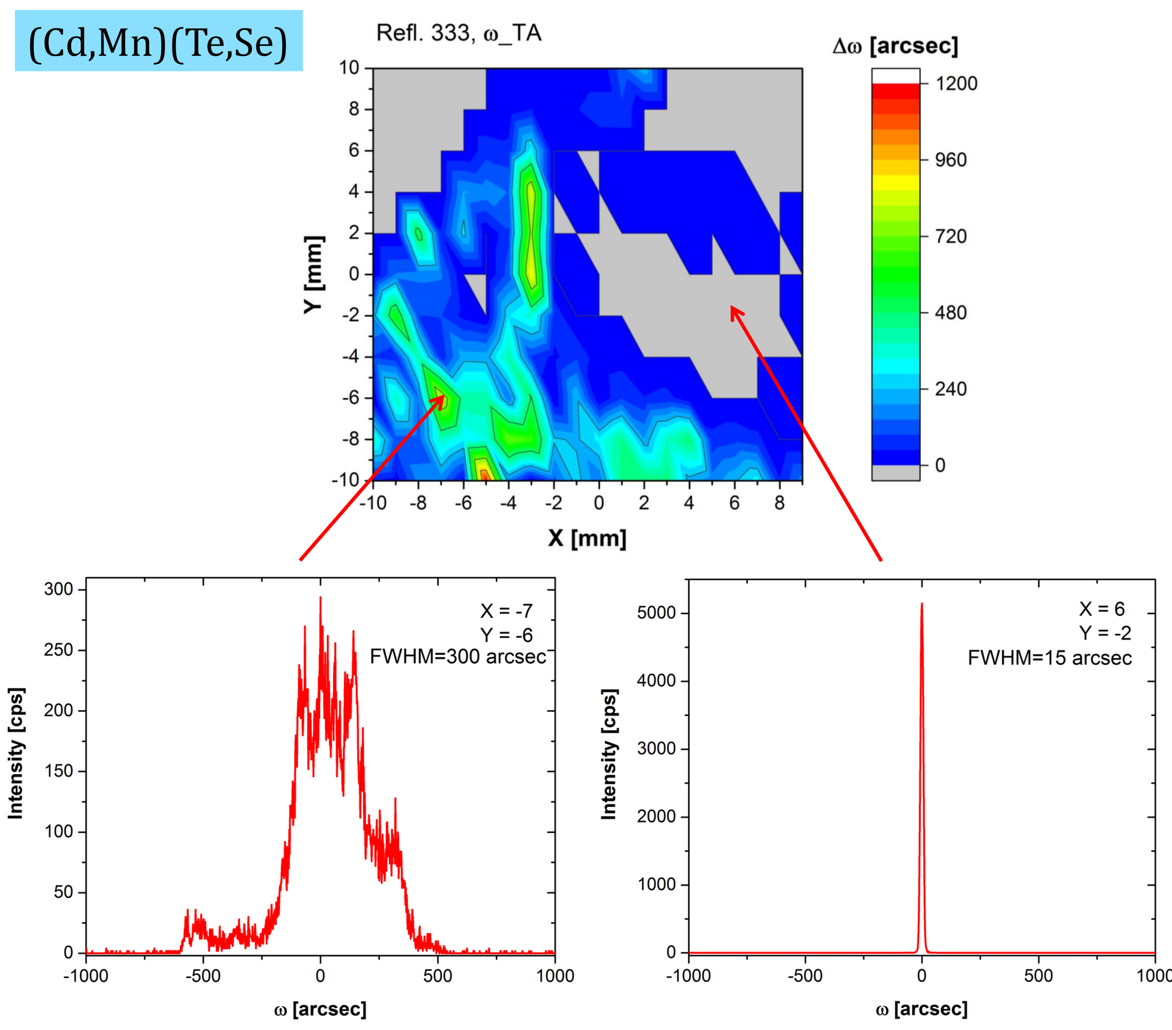


Crystal quality examination – Rocking-curve (RC) max. resolution: 21 arcsec. Triple axis geometry (TA) max. resolution: 9 arcsec.

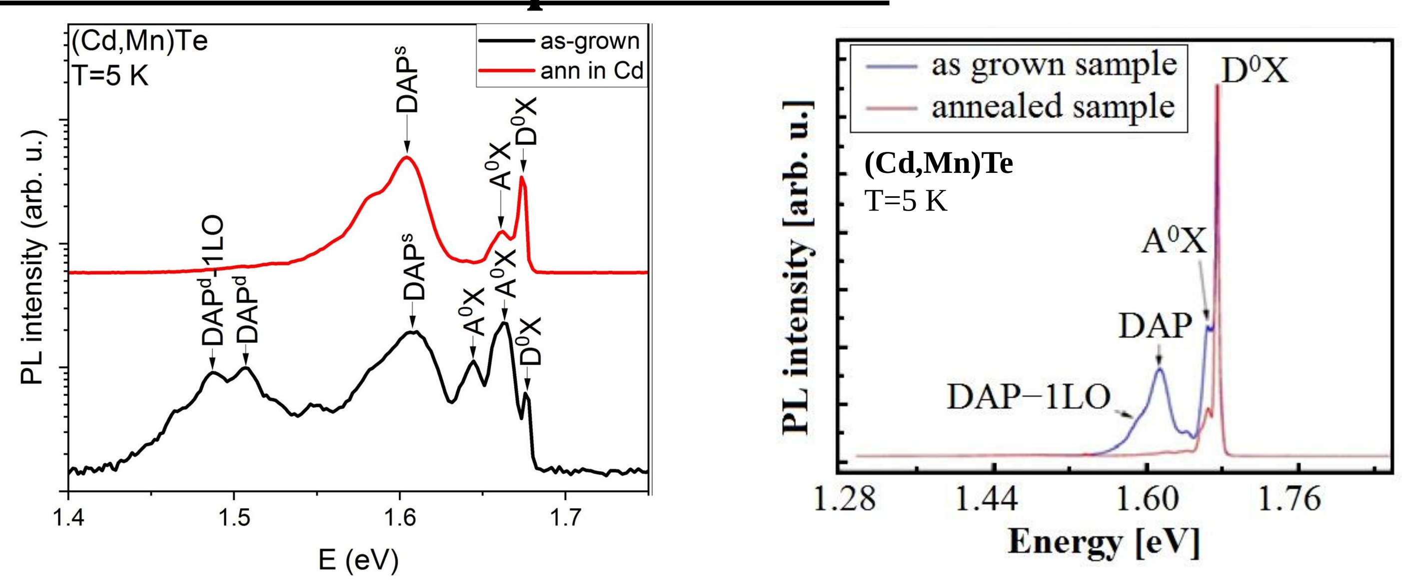
(Cd,Mn)Te

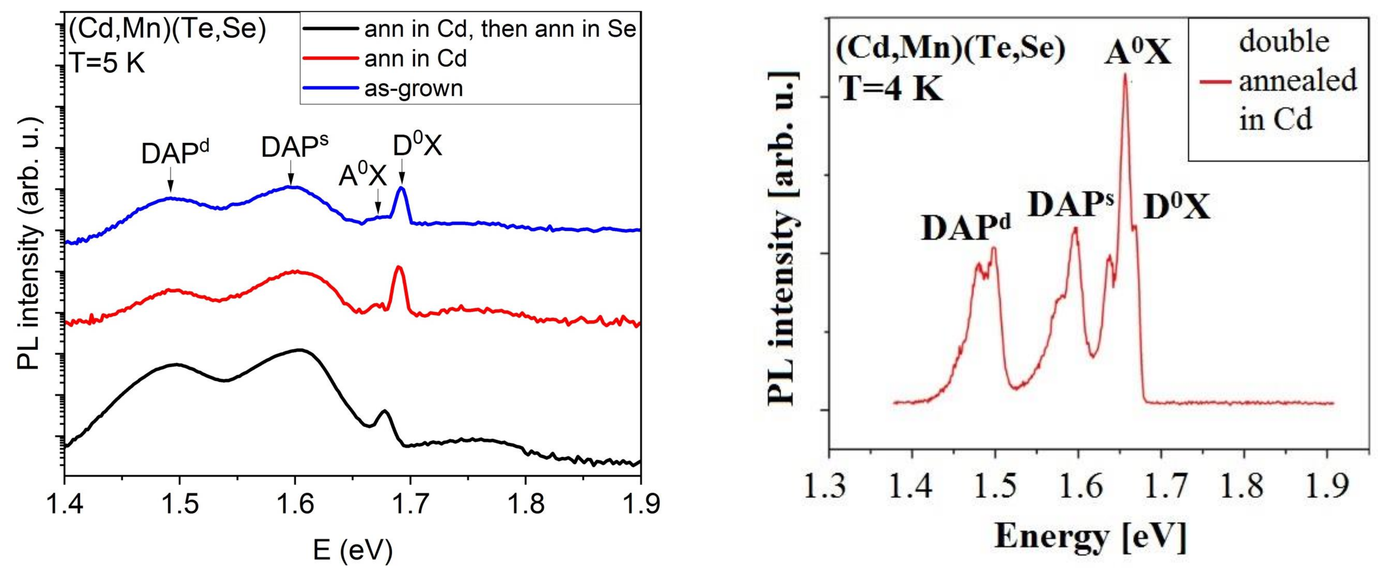


(Cd,Mn)(Te,Se)



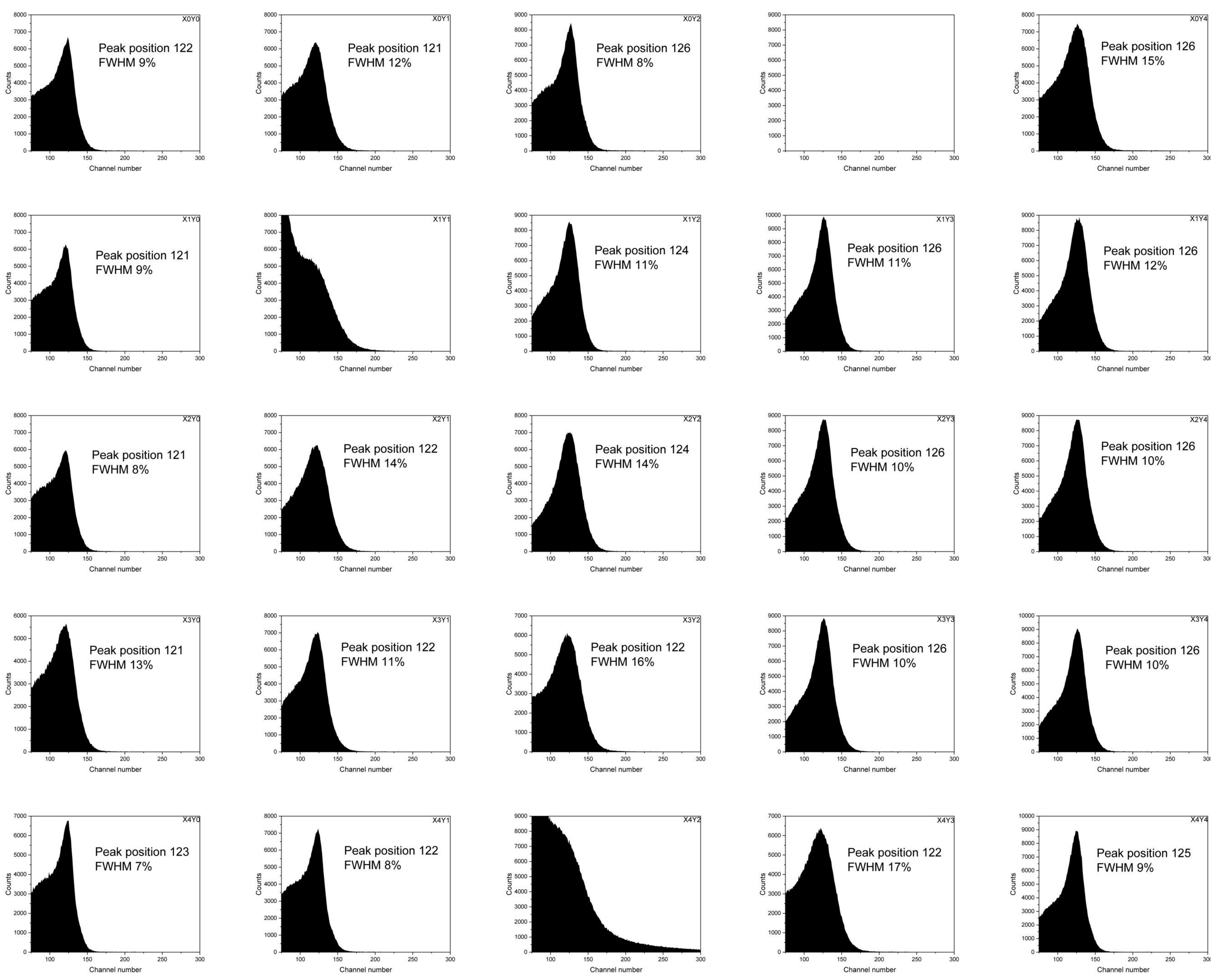
Photoluminescence spectra at 5 K





Detector response at 300 K

(Cd,Mn)Te pixelated detector



Spectroscopic performance from each pixel of a (Cd,Mn)Te 5 × 5 detector (25 pixels) made at 300 K using a **Co-57** source.
The peak in each spectrum is related to **122 keV**. The cathode was biased with −700 V.

Summary

- The addition of Mn and Se to CdTe increased the hardness of both investigated compounds.
- Using the etching technique, no subgrain structure was observed in any of the compounds. (Cd,Mn)Te sample has the lowest etch pit density – it has the best quality, which was also confirmed by X-ray diffraction studies.
- In both compounds, two donor-acceptor pair transitions (DAP) exist. Shallow (s) and deep (d) DAP transitions are about 70 meV and 200 meV below exciton lines, respectively.
- The annealing process in Cd vapors eliminates or reduces the intensity of the DAP^d and DAP^s PL lines in (Cd,Mn)Te, whereas in (Cd,Mn)(Te,Se) even double annealing does not affect these lines. The Cd-annealing was aimed at reducing the concentrations of Cd vacancies, which are acceptors.
- We investigate both compounds as X- and gamma-ray detectors using a Co-57 source. Only (Cd,Mn)Te detectors can distinguish the 122 keV peak – they are the best.

Acknowledgments

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