Deep defect levels in high-resistivity CdMnTe crystals

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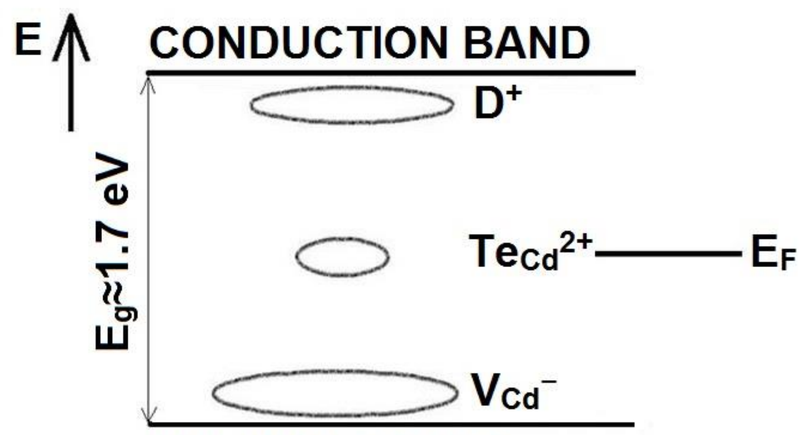
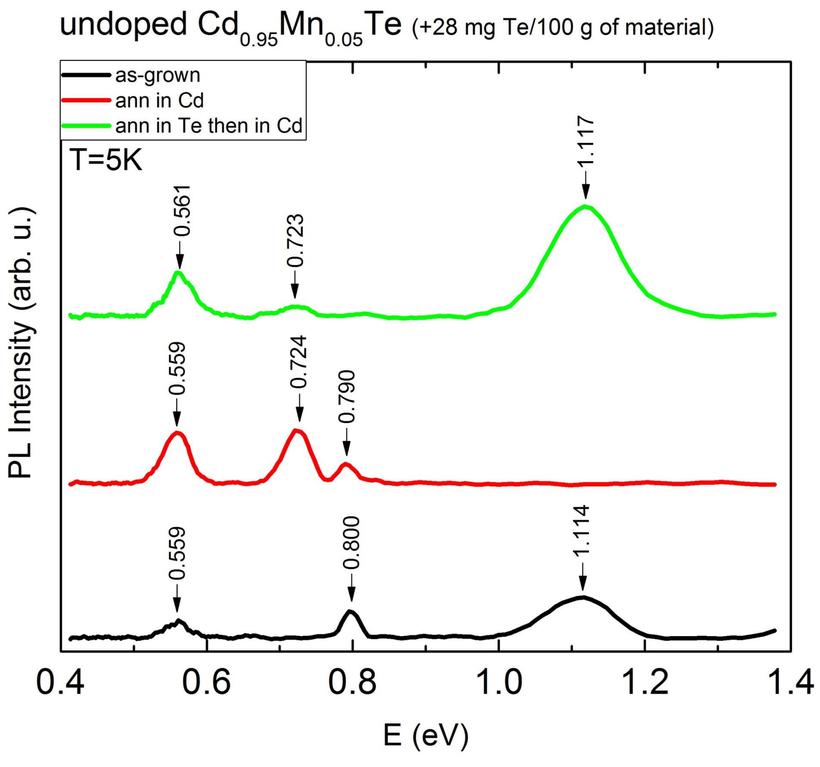
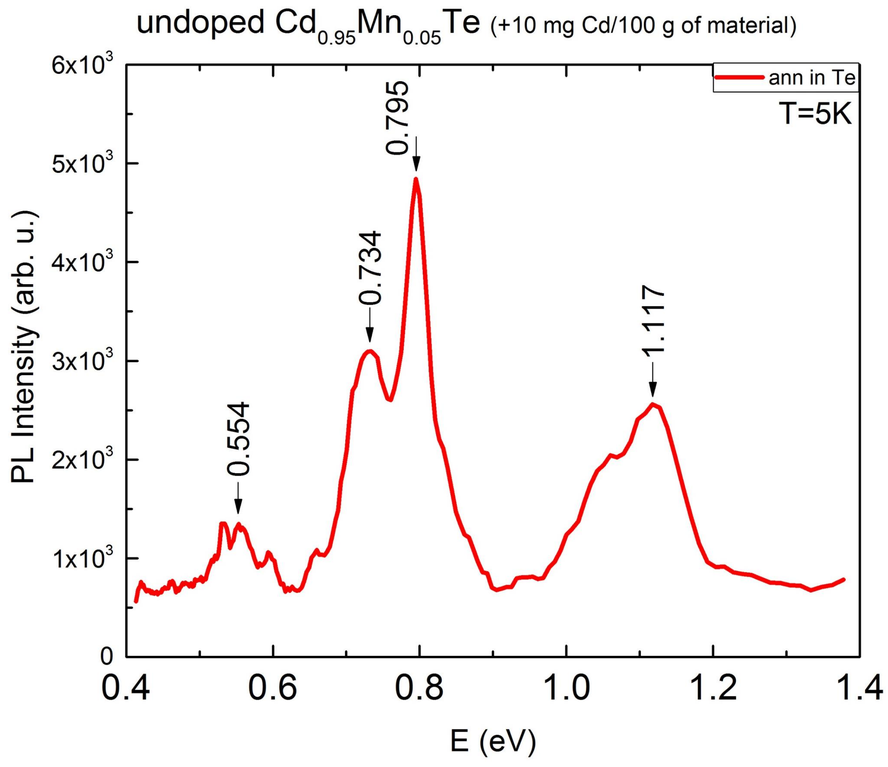
Introduction

- CdMnTe belongs to the group of semiconductors, which is currently studied for room-temperature nuclear detectors.
- In this application a high resistivity value >10^9 Ωcm is necessary.
- Photoluminescence (PL) spectroscopy is a common method of analyzing the defect structure in semiconductors.
- Studies on defect structure in detector-grade CdMnTe are crucial because deep level defects within the material disturb the transport of photo-carriers by acting as recombination- or trapping-centers.
- The origin of many defects is still unknown.



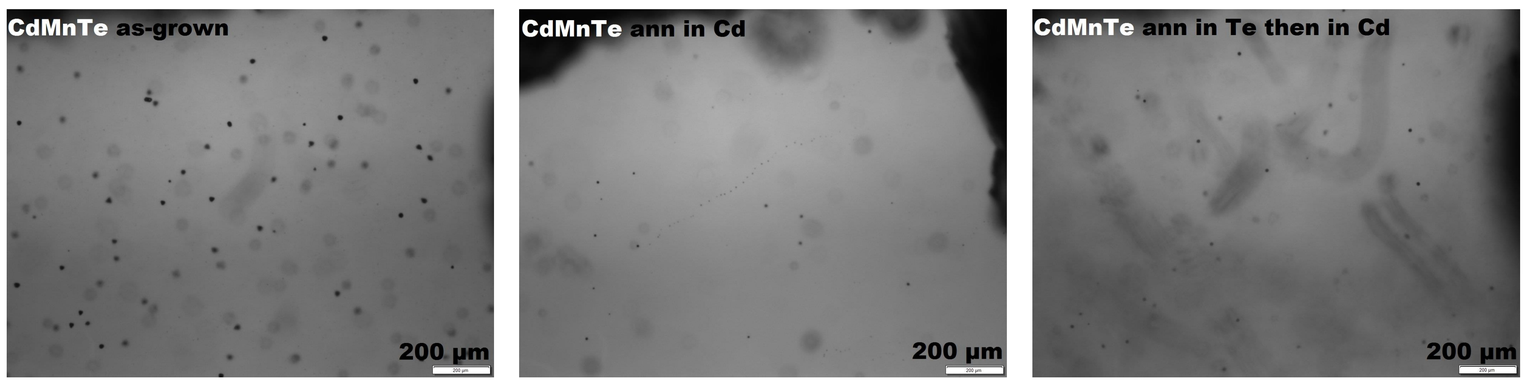
PL spectra at 5 K in 0.4-1.4 eV range





The origin of 1.1 eV PL peak

- This PL peak is related to Te secondary phases.



Microstructure images of investigated crystals made by transmission infra-red microscopy.

The origin of 0.55 eV PL peak

- Deionization of a deep acceptor, like Cd^{2-}
  $h^+ + Cd^{2-} \rightarrow Cd^-$
- The presence of such deep acceptor is more likely after annealing in Te atmosphere.

➢ OR recombination center linking two transitions: the electron one with 1.1 eV energy radiation and the hole one with 0.55 eV energy radiation.

➢ 1.1 eV + 0.55 eV = 1.65 eV = E_g (5 K) for $Cd_{0.95}Mn_{0.05}Te$

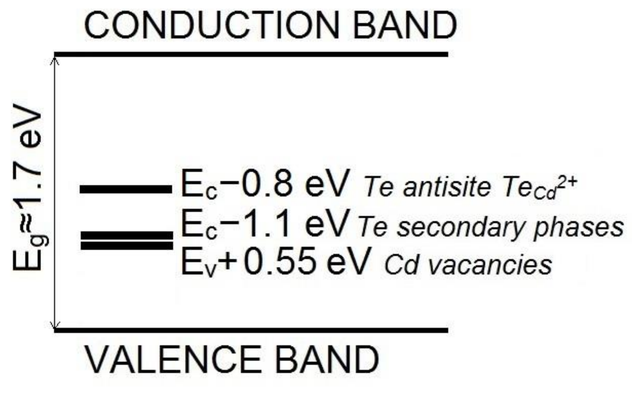
The origin of 0.8 eV PL peak

- The presence of a deep donor Te_{Cd}^{2+} ensures high resistivity in CdMnTe crystal.

	Excess /per 100 g	Treatment	Resistivity [Ωcm]
1	+ 28 mg Te	as-grown	2.0×10^6
2		ann in Cd	2.5×10^6
3		ann in Te then in Cd	2.5×10^6
4	+ 10 mg Cd	as-grown	2.0×10^6
5		ann in Te	**2.0×10^8**

Summary

- The **0.8 eV PL band** is connected with Te antisite Te_{Cd}^{2+}. This deep donor can pin the Fermi level in the midgap, ensuring high resistivity values of CdMnTe crystals.
- The origin of the **0.55 eV PL band** may be related to the deionization of a deep acceptor, such as Cd^{2-}, or with the recombination of an electron (1.1 eV) and a hole (0.55 eV) at the recombination center.
- The **1.1 eV luminescence** is associated with defects induced by Te secondary phases, which is confirmed by IR microscopy images of the crystals' microstructure.



Acknowledgments

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