$Cd_{1-x}Zn_xTe$ versus $Cd_{1-x}Mn_xTe$ for detector applications

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1. ABSTRACT

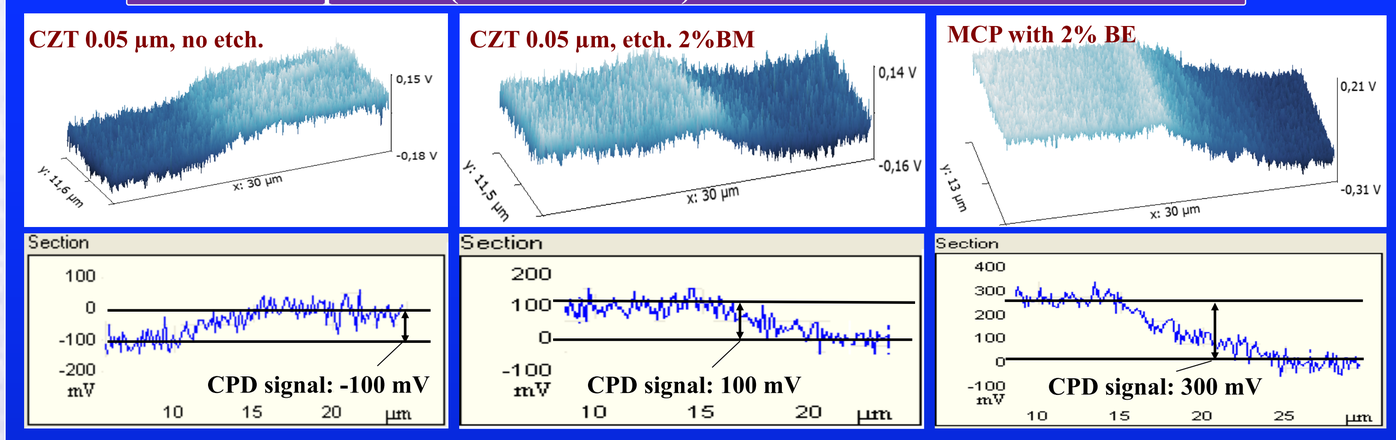
The preliminary material analyses indicate improved material uniformity of $Cd_{1-x}Mn_xTe$ compared to the more established $Cd_{1-x}Zn_xTe$. It is shown that considerably lower content of Mn is needed compared to Zn to obtain similar resistivity, as predicted by Vegard's rule. To benefit from the advantages bulk and surface properties are being studied and optimized. In this work we present a comparison of surface properties of high resistivity Bridgman grown $Cd_{1-x}Mn_xTe$ and $Cd_{1-x}Zn_xTe$ crystals. The crystals were subjected to various surface treatments including: 0.05 μm mechanical polishing; 0.05 μm mechanical polishing followed by etching in 2% bromine methanol (BM); and mechano-chemical polishing (MCP) with 2% Bromine ethylene-glycol (BE). Surfaces were analyzed using XPS, SEM, and AFM related methods. Contacts were deposited by thermal evaporation and patterning was performed by photolithography. The results indicate that $Cd_{1-x}Mn_xTe$ indeed has a great potential and some inherent advantages. However, the existing $Cd_{1-x}Zn_xTe$ technology should not be applied directly to $Cd_{1-x}Mn_xTe$, and detailed study of properties should be conducted in order to obtain improved overall detectors performance.

2. INTRODUCTION

$Cd_{1-x}Mn_xTe$ is a very promising candidate for replacing $Cd_{1-x}Zn_xTe$ material in a field of room-temperature radiation detectors. Both materials are based on group II-VI binary alloy, CdTe, where Zn and Mn are added mainly to increase the bandgap and thus the resistivity. The segregation coefficient of manganese in CdTe is over 30% lower compared to that of zinc, thus theoretically better uniformity is expected in $Cd_{1-x}Mn_xTe$, as well lower defect density. In addition MnTe has a bandgap of ~3.2 eV, compared to the ~2.2 eV of ZnTe. Thus the novel material has better bandgap tunability, and higher resistivity crystals can be achieved. Finally, $Cd_{1-x}Mn_xTe$ growth temperature is slightly lower compared to that of $Cd_{1-x}Zn_xTe$, which reduces the quartz vessel related contaminations.

3. SURFACE & BULK CHARACTERIZATION

3a. Surface potential (AFM CPD mode) for various surface treatments of CZT



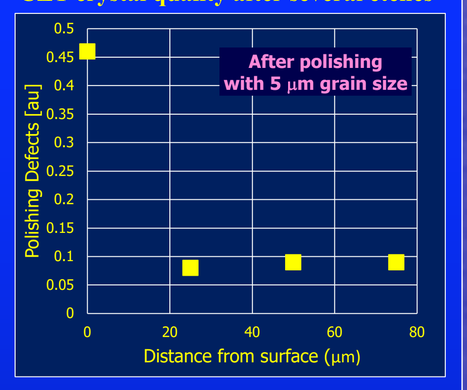
3b. Composition (SEM)

CZT	Atomic %:	Cd	Zn	Te
average		45.78 %	5.07 %	49.153 %
Standard deviation		0.28 %	0.49 %	0.53 %

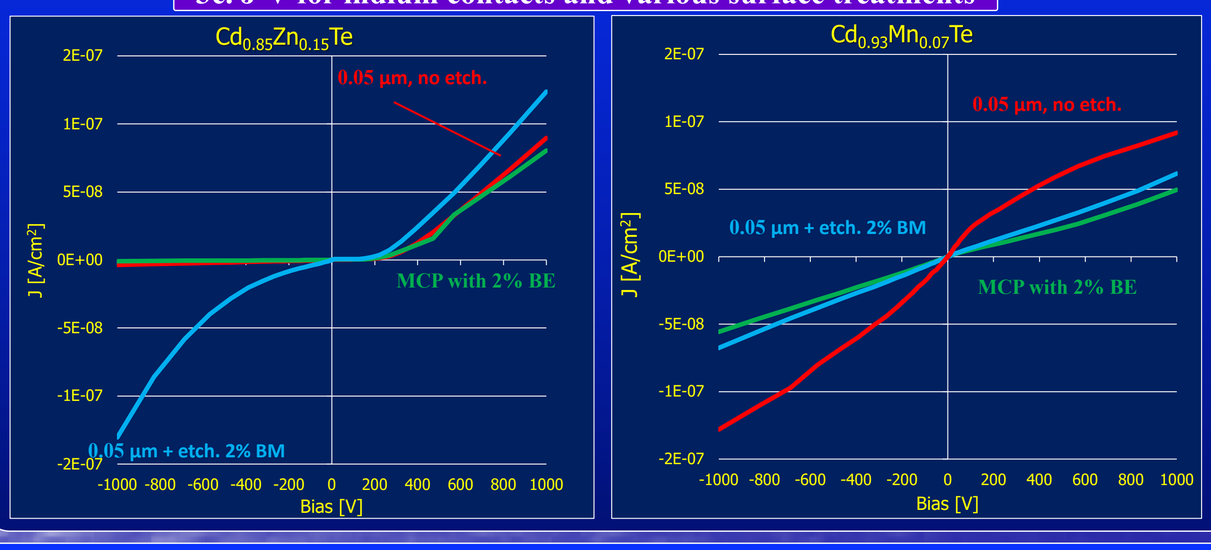
CMT	Atomic %:	Cd	Mn	Te
average		47.3 %	3.2 %	49.5 %
Standard deviation		0.06 %	0.15 %	0.15 %

3d. Damage (XRD)

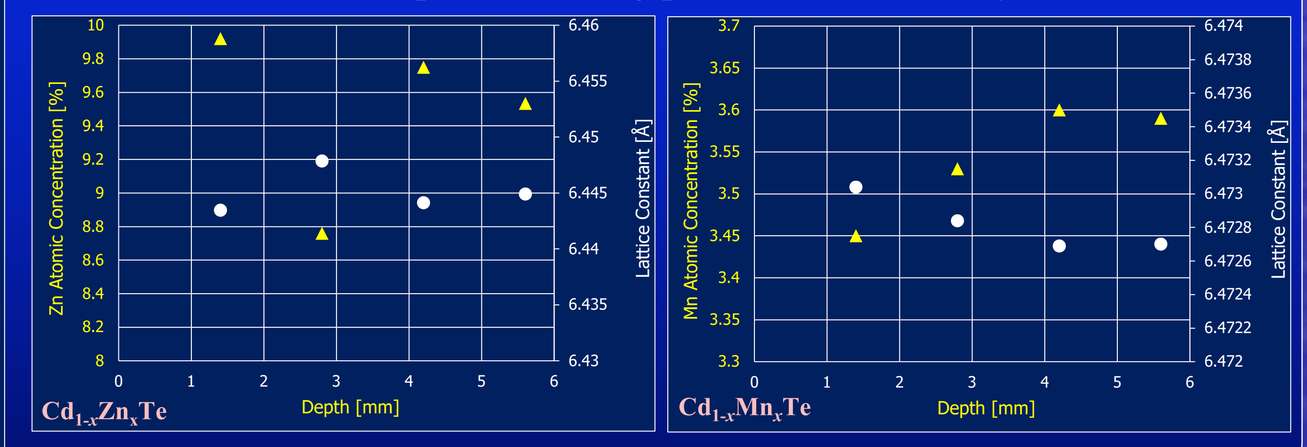
CZT crystal quality after several etches



3c. J-V for indium contacts and various surface treatments



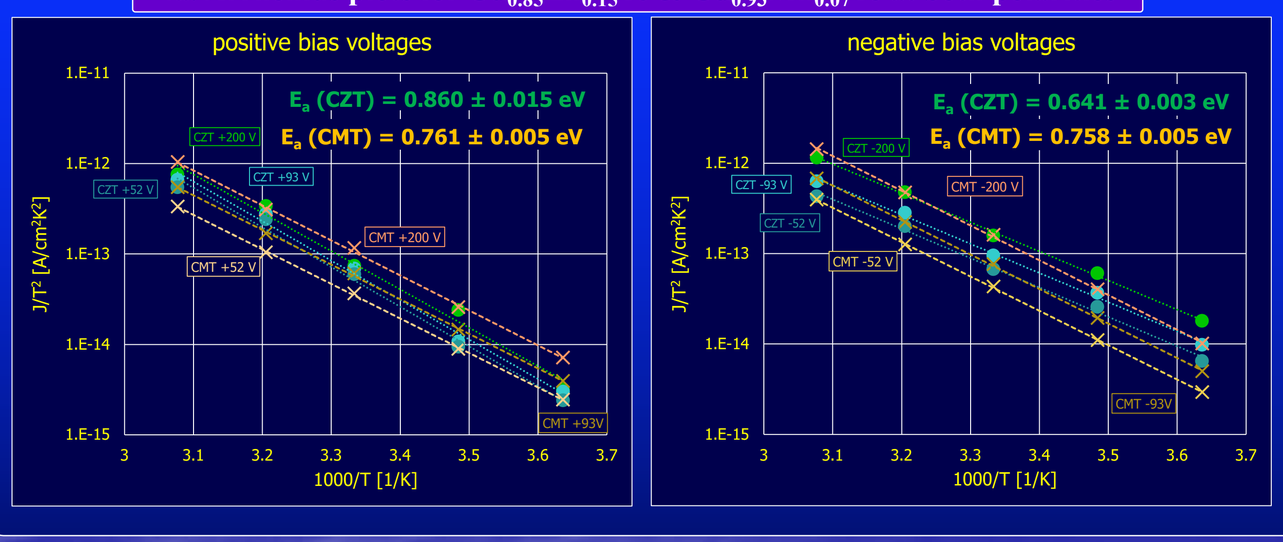
Elemental composition & bandgap (from lattice constant by XRD) :



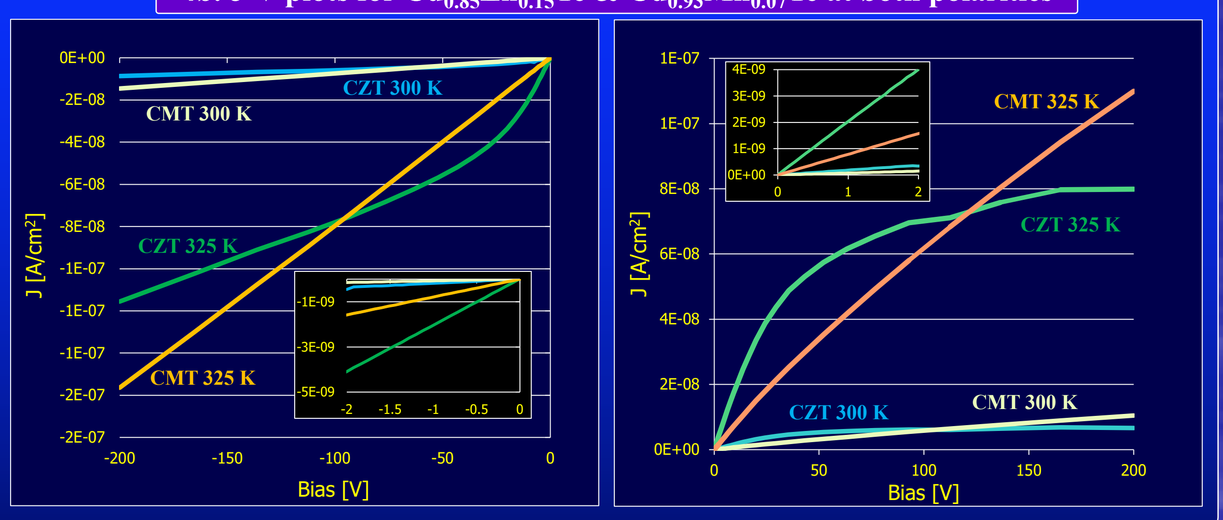
4. TEMPERATURE BEHAVIOUR AND CURRENT ACTIVATION ENERGY (E_a)

$Cd_{0.85}Zn_{0.15}Te$ and $Cd_{0.93}Mn_{0.07}Te$ samples were studied in 275 – 325 K temperature range. Current activation energies were calculated at positive and negative bias voltages.

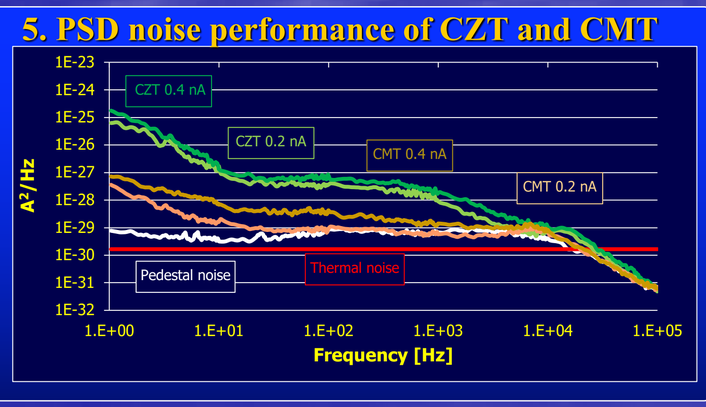
4a. Arrhenius plots for $Cd_{0.85}Zn_{0.15}Te$ & $Cd_{0.93}Mn_{0.07}Te$ at both polarities



4b. J-V plots for $Cd_{0.85}Zn_{0.15}Te$ & $Cd_{0.93}Mn_{0.07}Te$ at both polarities



5. PSD noise performance of CZT and CMT



6. CONCLUSIONS

Both elemental analysis methods (XRD and SEM) showed that the lower concentration of Mn (compared to that of Zn in $Cd_{1-x}Zn_xTe$) is sufficient to obtain similar resistivity (3.5 % and 8%, respectively). Studying of surface treatments shows that $Cd_{1-x}Zn_xTe$ is quite sensitive for bromine-methanol etching (current dramatically increased), while $Cd_{1-x}Mn_xTe$ "prefers" chemical treatment of it's surface. Current activation energies of $Cd_{1-x}Mn_xTe$ were equal at positive and negative polarities, which may indicate the same conductivity mechanism. However, in $Cd_{1-x}Zn_xTe$ the activation energy under positive and negative bias deviates by ~ 0.2 eV. That may indicate contact related (rather than bulk related) mechanism. Comparison of PSD noise performances revealed a considerable advantage of $Cd_{1-x}Mn_xTe$ device.