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DEEP LEVEL TRANSIENT SPECTROSCOPY STUDIES OF CdMnTe*

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Deep levels in Ga doped n-type CdMnTe of 1% and 5% Mn contents and In doped n-type CdMnTe of 20% Mn content were studied using deep level transient spectroscopy technique. Our deep level transient spectroscopy results show presence of several groups of different traps.

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1. Introduction

Deep levels in n-type CdMnTe were studied using deep level transient spectroscopy (DLTS) technique. Three different types of samples were investigated: Ga doped sample with 1% of Mn ($G1$ sample) and 5% of Mn ($G2$ sample) contents, as well as In doped sample with 20% of Mn ($I1$ sample) content. The donor net concentrations of the samples are given in Table. In order to perform DLTS studies Schottky barriers were realized for both materials by gold evaporation on one side of the slices etched in a 2% Br_2 methanol solution. To provide an ohmic contact indium was evaporated on the back sides of the samples. C–V and DLTS measurements were performed with the use of a lock-in type deep level spectrometer DLS-82E manufactured by SEMITRAP, Hungary.

2. Results and discussion

Temperature scans of DLTS signal were recorded within 80–300 K temperature range. The working mode of differential DLTS [1] consisting of two filling pulses U_{p1} and U_{p2} of different heights was used. The insets in Figs. 1, 2 and 3

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TABLE

Deep level parameters.

Sample	N_d $\times 10^{16}$ [cm^{-3}]	Enthalpy [eV]			Capture cross-section [cm^2]		
		$E1$	$E2$	$E3$	$E1$	$E2$	$E3$
$G1$	6.0	0.29	0.36	0.41	6.2×10^{-13}	2×10^{-12}	8×10^{-13}
$G2$	1.0	0.21	–	0.45	3.0×10^{-16}	–	3.0×10^{-14}
$I1$	2.0	0.10	0.27	0.45	5.0×10^{-17}	4.0×10^{-14}	5.0×10^{-12}

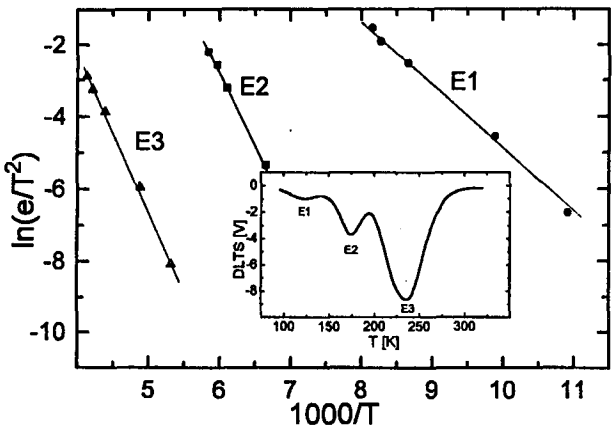

Fig. 1. Arrhenius plots and corresponding thermal DLTS scan (inset in the figure) for the sample $G1$: n-type CdMnTe:Ga doped of 1% Mn content. $U_R = -4$ V, $U_{p1} = -3$ V, $U_{p2} = -3.5$ V and filling pulses widths $t_{p1} = t_{p2} = 50$ μs. The temperature scan presented in the inset was taken for the lock-in frequency $f = 233$ Hz.

present the spectra obtained for three different types of samples ($G1, G2$ and $I1$). Our DLTS results show presence of three dominant electron traps in all types of materials, labeled by us $E1$, $E2$ and $E3$.

The values of activation enthalpies and capture cross-sections σ were obtained from corresponding Arrhenius plots shown in Figs 1, 2 and 3. Straight lines represent the least squares fit to the experimental data. The results of fitting are given in Table.

Depth profile measurements [1] were performed for all samples under study. In the case of $G1$ and $G2$ samples the concentrations of the defects corresponding to $E1$ and $E3$ increase towards the bulk of semiconductor. In $G1$ for $E1$ from 10^{13} cm^{-3} up to 5×10^{13} cm^{-3} and for $E3$ from 10^{14} cm^{-3} to 4×10^{14} cm^{-3}. In $G2$ for $E1$ and $E3$ from 4×10^{13} cm^{-3} to 2×10^{14} cm^{-3}. The third defect, responsible for the middle temperature maximum $E2$, seems to be homogeneously distributed for both $G1$ and $G2$ samples with concentrations of 1.4×10^{14} cm^{-3}. In the $I1$ samples the traps $E1$ and $E3$ have homogeneous distribution of concentration of

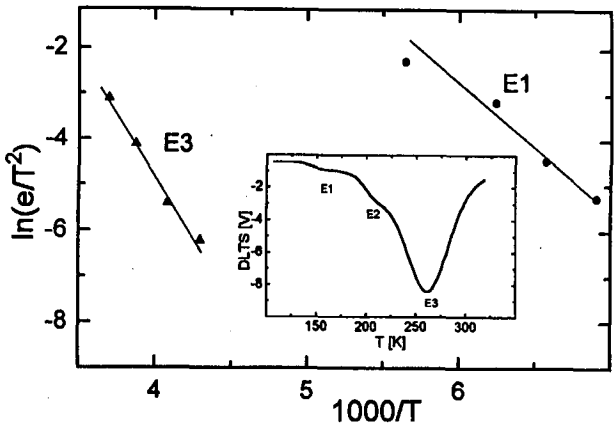

Fig. 2. Arrhenius plots and corresponding thermal DLTS scan (inset in the figure) for the sample $G2$: n-type CdMnTe:Ga doped of 5% Mn content. $U_R = -3$ V, $U_{p1} = -2$ V, $U_{p2} = -2.15$ V and filling pulses widths $t_{p1} = t_{p2} = 5$ μs. The temperature scan was taken for the lock-in frequency $f = 500$ Hz.

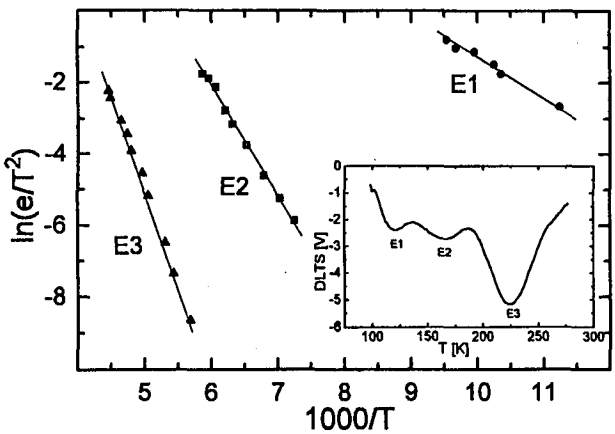

Fig. 3. Arrhenius plots and corresponding thermal DLTS scan (inset in the figure) for the sample $I1$: n-type CdMnTe:In doped of 20% Mn content. $U_R = -4$ V, $U_{p1} = -3$ V, $U_{p2} = -3.5$ V and $t_{p1} = t_{p2} = 0.5$ μs. The temperature scan was taken for the lock-in frequency $f = 2500$ Hz.

3.5×10^{14} cm^{-3} and 3.5×10^{13} cm^{-3}, respectively, whereas the defect connected with $E2$ has its maximum of concentration equal to 3.5×10^{14} cm^{-3} and its value close to the surface is equal to 2×10^{14} cm^{-3}.

The electric field dependence was also checked for the samples investigated. For this purpose the temperature scans of DLTS signal were taken for different heights of the pulse U_{p1} whereas the reverse bias U_R and ΔU were kept constant. No electric field enhanced emission rate for electrons were observed in the case of $I1$

samples inferring acceptor type of the defects responsible for its DLTS spectrum. For $G1$ samples the peak $E3$ exhibited a weak electron emission rate dependence on electric field described in terms of Poole–Frankle theory [2]. No electric field dependence was observed for the $E1$ and $E2$ peaks.

3. Conclusions

Several groups of traps can be distinguished in our samples. The activation enthalpies of traps are around 0.1, 0.2, 0.3 and 0.41–0.45 eV.

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