CHARGE CARRIER SCATTERING ON THE SHORT-RANGE POTENTIAL OF THE CRYSTAL LATTICE DEFECTS IN ZnCdTe AND ZnHgTe SOLID SOLUTIONS

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Inroduction

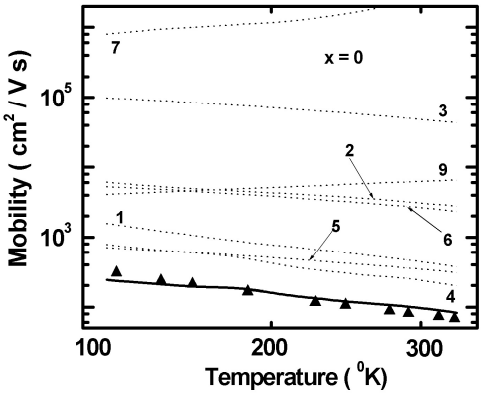
The solid solution $Zn_xCd_{1-x}Te$ is regarded as one of the most promising materials for room temperature nuclear detector. Since, up to our knowledge, the dominant scattering mechanism for carrier transport and their temperature dependences are not well known for CdZnTe system. Also the solid solution $Zn_xHg_{1-x}Te$ has been considered as a potentially superior infrared detector material due to its high material stability compared to HgCdTe alloy. The common feature of the transport phenomena description in these solutions is using the long-range charge carrier scattering models. In these models it is supposed that either charge carrier interacts with all the crystal (electron -phonon interaction) or the charge carrier interacts with the defect potential of the impurity the action radius of which is equal to ~50 – $100a_0$ (a_0 – lattice constant). However, such an assumption contradicts the special relativity according to which the charge carrier should interact only with the neighbouring crystal region. Besides for defects with interaction energy $U \approx \frac{1}{r^n}(n=1,2)$ on distances ~ $10\ a_0$ the potential becomes the magnitude of the second order while all mentioned above theories are considered in the first (Born) approximation. From the other side in [1,2] the short-range models of electron scattering in $Cd_xHg_{1-x}Te$ and $Cd_xHg_{1-x}Se$ were proposed in which the above mentioned shortcomings were absent. There it has been supposed that the carrier interact with the defect potential only within the limits of one elementary cell. The purpose of the present work is to use this approach for description of the carrier scattering processes on the various types of crystal defects in CdZnTe and ZnHgTe solid solutions.

Comparison of theory and experiment

For the charge carrier scattering on the nonpolar optical (NPO) and acoustic (AC) phonons, static strain (SS) center, disorder (DIS) potential and neutral (NI) defects the interaction radius of the short-range potential is limited by one unit cell. For the charge carrier scattering on the ionized impurity (II), polar optical (PO) and piezoelectric (piezoacoustic (PAC and piezooptic (POP)) phonons the interaction radius of the short-range potential is founded in a form $R=\gamma\ a$ (a - lattice constant, γ – the respective adjusting parameters). It must be noticed that the strong power dependence of parameters γ_{PO} , γ_{PZ} , γ_{II} sharply limits opportunities of a choice of their numerical values.

The respective charge carrier transition probability from state k to state k' caused by the interaction with defect potential was chose from [1,2]. To describe the charge carrier – disorder (DIS) scattering the respective transition probability was used. To calculate the conductivity tensor components the method of a precise solution of the stationary Boltzmann equation was used [3].

A comparison of the theoretical temperature dependences of the heavy-hole mobility was made with the experimental data for $Zn_xCd_{1-x}Te$ crystals with compositions x=0; 0.16; 0.40; 0.68; 0.90; 1.0 and of electron mobility for $Zn_xHg_{1-x}Te$ crystal with x=0.15. The solid lines represent the curves calculated on the basis of the short-range models within the



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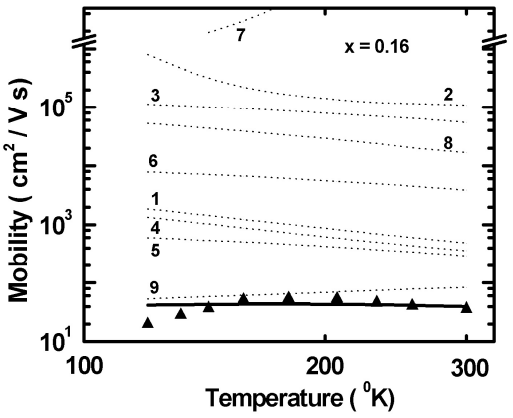

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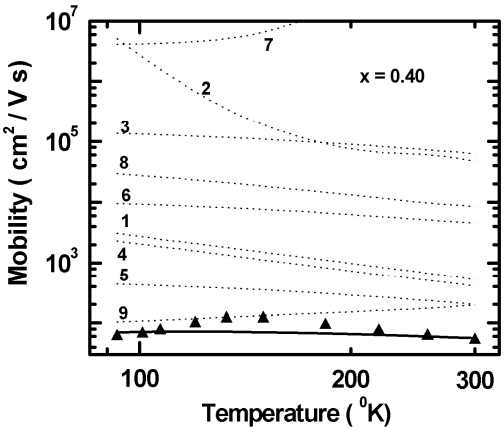
framework of the precise solution of the Boltzmann equation. The obtained scattering parameters for different scattering modes are listed in Table 1. It is seen that the theoretical curves well agree with experimental data in all investigated temperature range. To estimate the role of the different scattering mechanisms in Fig. 1a-g the dotted lines represent the appropriate dependences. It is seen that for x <0.68 the main scattering mechanism is static strain, polar optical and piezoacoustic scattering. For x>0.68 the contribution of



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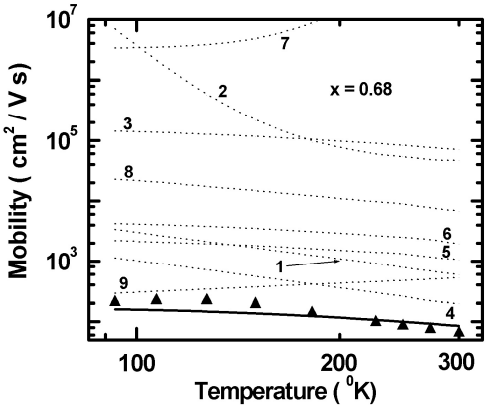

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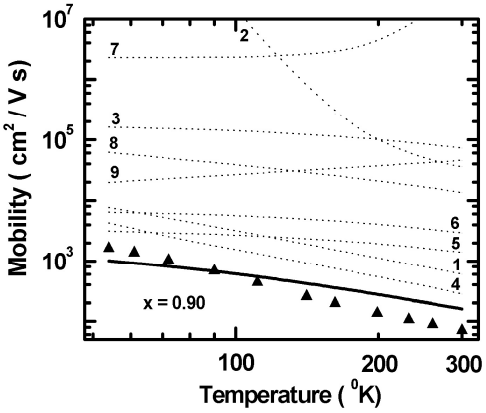

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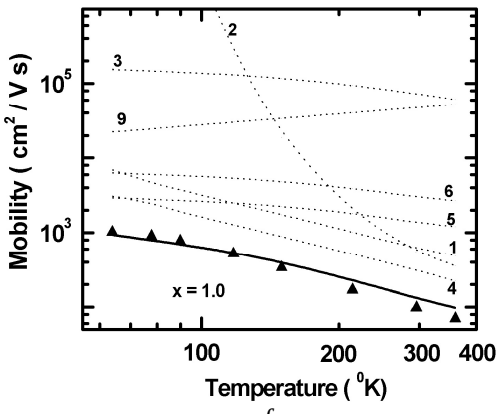

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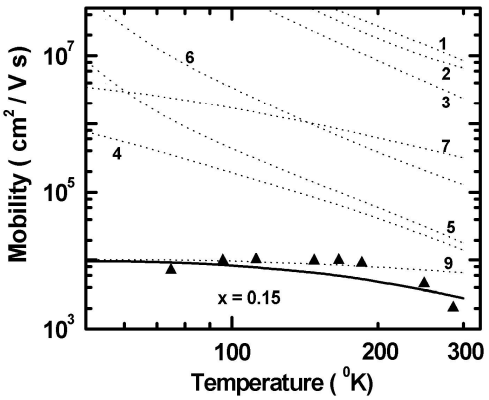

g

Fig. 1. Temperature dependence of the charge carrier mobility in ZnCdTe (a-f) and ZnHgTe (g) crystals. Solid line - mixed scattering mode; 1,2,3,4,5,6,7,8,9 – AC-, II-, NPO-, PAC-, PO-,POP-, NI-, DIS-, SS- scattering mode respectively.

piezoacoustic and acoustic scattering play the main role too. Other scattering mechanisms such as piezooptic and nonpolar optical phonon scattering, neutral and ionized impurity scattering, disorder scattering give negligibly small contributions. For $Zn_xHg_{1-x}Te$ the static strain, the piezoacoustic and the polar optical mechanisms are the dominant scattering mechanisms in all investigated temperature range.

Table 1 Parameters γ for different scattering modes

x	γ_{PO}	γ_{II}	γ_{PZ}	γ_{SS} Nss× 10^{-14} cm^{-3}
		ZnCdTe		
0.00	0.45	1.0	0.33	40.0
0.16	0.47	1.0	0.33	20.0
0.40	0.40	1.0	0.36	8.00
0.68	0.40	1.0	0.37	0.10
0.90	0.35	1.0	0.30	0.10
1.00	0.39	1.0	0.35	0.10
		ZnHgTe		
0.15	0.70	1.0	0.55	70.0

Conclusion

On the base of the short-range principle the charge carrier scattering processes on the various lattice defects in ZnCdTe and ZnHgTe solid solutions were considered. A good agreement between the theory and experimental data in investigated temperature range was established.

References

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