Properties of semiconducting $Cd_xHg_{1-x}Te$ solid solutions under pressure

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We have investigated the galvanomagnetic properties of the superconducting solid solutions $Cd_xHg_{1-x}Te$ ($x = 0.2$ and $x = 0.23$) at pressures up to 14 katm. It is shown that hydrostatic compression eliminates the low-temperature anomalies, the nature of which is the same for all values of the parameter x ($x \leq 0.23$).

The change in the properties of p-type $Cd_xHg_{1-x}Te$ solid solutions under pressure, at values of x corresponding to the semimetallic composition, was investigated in detail in[1,2] in a study of the transition to the gapless state. It was shown[2] that the galvanomagnetic phenomena and the transport phenomena are determined by the presence of acceptor levels that are superimposed on the continuous-spectrum states and split into an impurity acceptor band at impurity-center concentrations on the order of 10^{17} cm^{-3}.[3] The impurity-band conductivity constitutes in this case a noticeable (or even predominant) fraction of the total conductivity.

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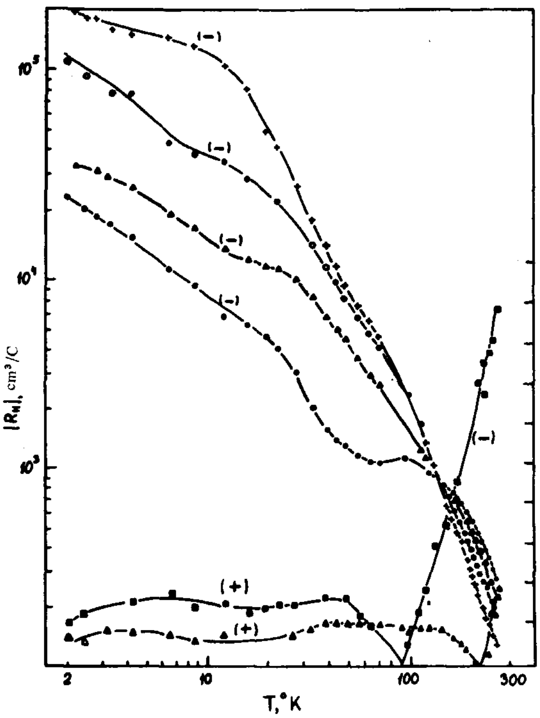

FIG. 1. Dependence of the Hall constant R_H on the temperature at different pressures for sample 5—2: +) $P=0.15$ katm, ○) $P=1.3$ katm, ▲) $P=1.8$ katm, ●) $P=2.65$ katm, left-hand scale; ■) $P=4.4$ katm, △) $P=8.95$ katm, right-hand scale.

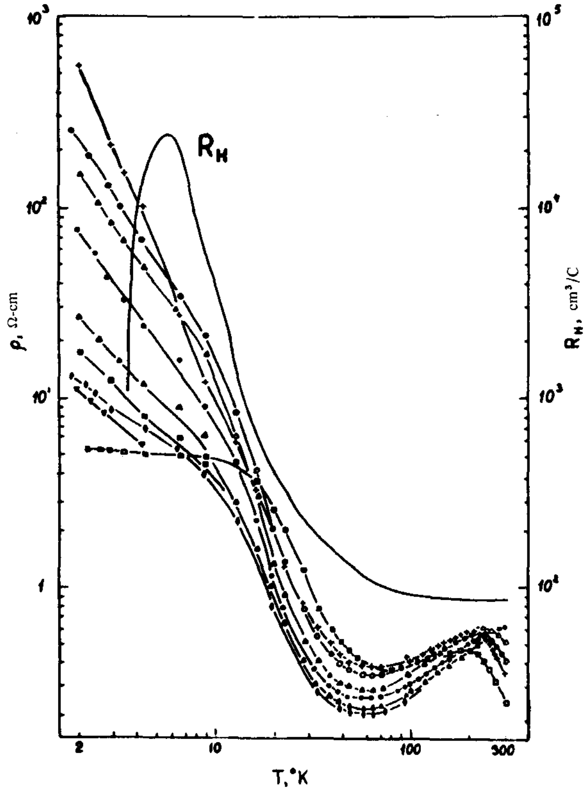

FIG. 3. Temperature dependence of the resistivity at various pressures and of the Hall constant at $P=12.5$ katm for sample 5—1: □) $P=0.15$ katm, +) $P=1.3$ katm, ○) $P=1.8$ katm, △) $P=2.65$ katm, ●) $P=4.4$ katm, ▲) $P=8.95$ katm, ■) $P=9.7$ katm, ♦) $P=12.7$ katm, ▽) $P=14.1$ katm.

We report here the results of experiments on the action of hydrostatic compression on the properties of semiconducting p-type solid solutions. The samples have the following parameters at $P=1$ atm and $T=4.2$°K: sample 5—1) $n=1.6\times10^{12}$ cm^{-3} $\mu_n=1.1\times10^{6}$ cm^2/V sec, $p=1\times10^{17}$ cm^{-3}, $\mu_p=160$ cm^2/V sec, $E_g=60$ meV; sample 5—2) $n=2.5\times10^{13}$ cm^{-3}, $\mu_n=2\times10^{5}$ cm^2/V sec, $p=3.3\times10^{16}$ cm^{-3}, $\mu_p=270$ cm^2/V sec, and $E_g=120$ meV. The parameters of the samples were calculated from the results of galvanomagnetic measurements in a weak field, and the forbidden-band width E_g was determined by optical methods, from the slopes of the $\rho(T)$ in the high-temperature region and from the values of R_H at $T=300$°K, [4] and was calculated from the values of x measured with the "CAMECA" x-ray microanalyzer.[5] The data obtain by different methods agree well with one another.

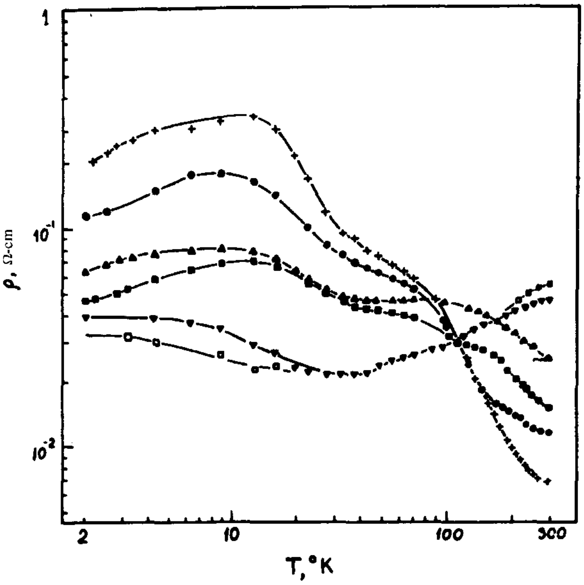

FIG. 2. Temperature dependence of the resistivity ρ of sample 5—2 at different pressures: +) $P=0.15$ katm, ●) $P=1.3$ katm, ▲) $P=1.8$ katm, ■) $P=2.65$ katm, ▼) $P=4.4$ katm, □) $P=8.95$ katm.

Figure 1 shows the temperature dependence of the Hall constant R_H at pressures $0.15\leqslant p\leqslant 8.95$ katm for sample 5—2. Just as in the case of the semimetallic samples, R_H reverses sign at a pressure P_{cr} ranging from 2.65 to 4.4 katm. The measurements were performed in a weak magnetic field, $\mu_n H/c \ll 1$. The transverse magnetoresistance of sample 5—2 at pressures $P\leqslant 2.65$ katm decreases monotonically with temperature, just as when the pressure is increased from 0.15 to 2.65 katm at a fixed temperature. The reversal of the sign of the Hall constant at $P=P_{cr}$ is accompanied by an abrupt decrease of the transverse magnetoresistance constant $\beta=\Delta\rho_\perp/\rho_0 H^2$, from a value $\beta=2\times10^{-4}$ Oe^{-2} at $P=2.65$ katm to $\beta<10^{-8}$ Oe^{-2} at $P=4.4$ katm. It should be noted that in a strong magnetic field ($H=4$ kOe) the ratio $\Delta\rho_\perp/\rho_0$ reaches the anomalously large value $\Delta\rho_\perp/\rho_0\sim 60$ at atmospheric pressure.

Plots of the resistivity ρ against the temperature at different pressures are shown in Fig. 2 for sample

5—2. Similar plots for sample 5—1 are shown in Fig. 3.

The Hall constant of sample 5—1 in a weak field has a double inversion of the sign when the temperature is varied from 2 to 300 °K at $P \leqslant 2.65$ katm. When the pressure is increased to 4.4 katm and more, the Hall constant of this sample is positive at all temperatures $T \leqslant 300$ °K. A plot of $R_H(T)$ for sample 5—1 at $P = 12.5$ katm is also shown in Fig. 3.

A characteristic feature of the investigated samples is the decrease of the resistivity with pressure (at $P \geqslant 1.3$ katm for 5—1) and the presence of "activation" sections on the $\rho(T)$ and $R_H(T)$ curves (more pronounced for sample 5—1) at low temperatures. It appears that hopping conductivity over the acceptor centers is observed in the temperature region $2 \leqslant T < 10$ °K (Fig. 3). The slopes of the $\rho(T)$ curves at $10 < T < 25$ °K are practically independent of the pressure and the activation energy of the hole conductivity corresponding to this slope is approximately 10 meV. An "activation" section is observed also on the $R_H(T)$ curves (Fig. 3).

The causes of the abrupt jump of the resistivity of sample 5—1 when the pressure is increased from 0.15 to 1.3 katm are still unclear.

The equality of the pressures at which the sign of the Hall constant reverse in samples 5—1 and 5—2 ($P_{cr} = 3$—3.5 katm for both samples), which have essentially different forbidden band widths, and also the correlation with the data of[2] for semimetallic compositions, allow us to assume that the low-temperature anomalies of the galvanomagnetic properties in $Cd_xHg_{1-x}Te$ single crystals are similar in nature for all values of the parameter x ($x \leqslant 0.23$).

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