ELECTRON MOBILITY IN HgTe

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Fig. 1

Figure 1: Fig. 1

Abstract

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There are various points of view concerning the nature of conductivity in HgTe. However, regardless of whether HgTe is a semimetal ([1]) or a semiconductor with an extremely narrow forbidden-band width ([2]), in both cases, taking into account the large ratio of the electron mobility to the hole mobility (~ 100), the transition region from impurity conductivity to intrinsic conductivity should occupy a large temperature interval. This circumstance makes it difficult to determine the conductivity type of HgTe from Hall-effect measurements. It is especially easy to mistake a p-type sample for an n-type one if the measurements are carried out in a relatively limited temperature range, as was done in earlier works ([3]). In addition, it should be borne in mind that in semiconductors with a large mobility ratio, p-type samples in the region of mixed conductivity have a Hall coefficient larger than that of n-type samples ([4]).

Taking the above into account, in the present work the samples were investigated over a wide temperature range. The measurements were carried out on single-crystal HgTe samples prepared by zone melting with subsequent annealing in mercury vapor. Figure 1 presents the temperature dependences of the Hall coefficient (for samples 13-14-O and 13-14-X), the conductivity, and the Hall mobility for 13-14-O.

Fig. 1. Dependence of the Hall coefficient, specific electrical conductivity, and Hall mobility on temperature. $R_H(T)$ was measured in a field $H = 6000$ oersted.

From the latter example one can see that the dependence $R_H(T)$ is typical for n-type semiconductors. In addition, there is a sufficiently extended region in which the Hall coefficient does not depend on temperature, and, finally, in the mixed-conductivity region, which occurs with increasing temperature, the Hall

Fig. 2

Figure 2: Fig. 2

coefficient for this sample has the smallest values in comparison with pure *p*-type samples. All this makes it possible to assert that in this case we have an electronic HgTe sample. The dependence of mobility on temperature is typical for a degenerate electron gas in semiconductors and metals. It is not difficult to verify that the electron mobility is high at all temperatures, and in the low-

temperatures, taking into account the dependence of the Hall coefficient on the magnetic-field strength (Fig. 2), exceeds 200,000 $cm^2/V \cdot sec$.

The Hall coefficient for an *n*-type sample, as follows from Fig. 2, depends noticeably on the magnetic-field strength. Assumptions about a dependence of the mobility on the magnetic-field strength and about the possible influence of an impurity band cannot explain this fact, since the electron gas is strongly degenerate, especially at low temperatures, because of the small effective mass ([5,6]). Geometrical effects, as an estimate shows, do not exceed 1% of the observed values and, consequently, also cannot exert an influence. Apparently, the possible inhomogeneity of the crystal ([7]) or the complexity of the energy spectrum of electrons in HgTe may be responsible for such behavior of the Hall coefficient. It should be noted in this connection that, according to measurements of the Hall coefficient at two positions of the measuring probes, the inhomogeneity of the sample does not exceed 3% at 4.2 K.

Fig. 2. Dependence of the Hall coefficient and of the change in transverse resistance on the magnetic-field strength. Sample 13-14-0.

The change in resistance in a magnetic field (Fig. 2) is characterized by curves with a continuously varying slope. Saturation is not reached in the investigated range of fields.

In work ([8]) the presence of a mobility maximum in the system of solid solutions $Hg_xCd_{1-x}Te$ was reported. The maximum value was attributed to solid solutions containing 10% CdTe. Taking our results into account, these data cannot be regarded as final. As the quality of HgTe crystals improves, the mobility values obtained in the present work will apparently be surpassed.

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Note: Figure translations are in progress. See original paper for figures.