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Comment on "Characterization of In_4Te_3 Single Crystals"

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In a recent paper entitled "Characterization of In_4Te_3 Single Crystals" Dongol et al. [1] reported the results of electrical conductivity, Hall effect and thermoelectric power measurements on single-crystal samples of In_4Te_3, grown by a modified Bridgman technique. The measurements were carried out as a function of temperature in the range 200−500 K. It was shown that the samples used in the study were p-type semiconductors. The variation of electrical conductivity and Hall coefficient with temperature were used to determine the activation energy of acceptor levels, forbidden energy gap, hole density, and hole mobility. The width of the forbidden energy gap was found to be E_g=0.28 eV.

From a comparison of their experimental data for the temperature dependence of thermoelectric power (TEP) with the theoretical formula taken from the literature, Dongol et al. [1] obtained the values of $m_p^* = 4.6 \times 10^{-7} m_0$ and $m_n^* = 3.5 \times 10^{-8} m_0$, respectively, for the effective mass of holes and electrons in p-type In_4Te_3 single crystals. These effective masses are about seven orders of magnitude smaller than the free electron mass, $m_0 = 9.11 \times 10^{-31}$ kg.

In a semiconductor of energy gap E_g=0.28 eV, the electron (hole) effective mass is expected to be in the order of $0.01 m_0$ (see, for instance, Ref. [2]). Therefore, the anomalously small values found by Dongol et al. [1] for the effective mass of electrons and holes in In_4Te_3 are non-physical. By definition, the electron (hole) effective mass in a semiconductor is inversely proportional to the curvature of the conduction (valence) band. The anomalously small effective masses ($m_n^* = 3.5 \times 10^{-8} m_0$ and $m_p^* = 4.6 \times 10^{-7} m_0$) describe conduction (valence) bands with extremely large curvature, which is practically impossible to assess with experimental methods such as cyclotron resonance.

By using the effective masses $m_n^* = 3.5 \times 10^{-8} m_0$ and $m_p^* = 4.6 \times 10^{-7} m_0$, Dongol et al. [1] estimated the values of $\tau_n = 3.36 \times 10^{-16}$ s and $\tau_p = 8.86 \times 10^{-16}$ s, respectively, for the momentum relaxation times of electrons and holes in In_4Te_3, which are several orders of magnitude smaller than those measured/calculated for most semiconductors. It is well established that the momentum relaxation times for most scattering mechanisms in semiconductors fall in the range from about 1×10^{-13} s to 1×10^{-10} s (see, for instance, Ref. [3]).

Therefore, we consider that the anomalously small values found in Ref. [1] for the effective mass, momentum relaxation times (and, hence, diffusion lengths) of charge carriers in In_4Te_3 have no physical significance. We calculated the TEP (α) using Eq. (3) of Ref. [1] with $m_p^* = 4.6 \times 10^{-7} m_0$ and hole density $p = 2.0 \times 10^{14}$ cm^{-3}. We found that TEP is **negative** over the extrinsic region and its magnitude is about an order of magnitude larger than that measured by Dongol et al. [1]. For example, at T=300 K, the calculated TEP is -700 μV/K, however, the measured TEP is +84 μV/K (Ref. [1]). Therefore, it appears that, if the

experimental TEP data presented in Ref. [1] are accurate enough, the data analysis is questionable.

In conclusion we stress that some of the results of Ref. [1] are non-physical and should be treated cautiously.

References

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