Model for anomalous electron transport in $(Cd_{0.38}Zn_{0.62})_3As_2$

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Semiconducting alloys of Cd_3As_2-Zn_3As_2 are interesting because a transition from a Dirac semimetal to an open gap semiconductor is expected for an intermediate composition [1-3]. In the present work, we study $(Cd_{0.38}Zn_{0.62})_3As_2$ bulk crystals obtained by the growth from molten phase. X-ray analysis points to a single phase *I4₁/amd* tetragonal structure, which remains unchanged in the temperature range between 150 and 300 K. Optical measurements of the fundamental absorption edge show an energy gap that varies in a standard way with temperature (see Fig. 1 inset). In contrast to such rather typical semiconductor properties, the resistivity reveals very odd temperature dependence, as shown in Fig. 1. Moreover, the mobility spectrum analysis demonstrates the coexistence of electrons and holes with $n = 5\cdot10^{16}$ cm^{-3}, $\mu_n = 2\ 600$ cm^2/Vs, $p = 2.6\cdot10^{16}$ cm^{-3}, μ_p=210 cm^2/Vs above 250 K. Since these values are weakly temperature dependent the presence of thermally activated intrinsic conductivity can be ruled out. Importantly, the rapid resistance increase below 220 K is correlated with the vanishing of *n*-type conductivity.

The observed data can be understood as resulting from the presence of *n*-type islands superimposed on a p-type percolating background. At high temperatures, efficient transmission through *n-p-n* barriers leads to transport dominated by high mobility electrons and, therefore, a quasi-metallic behavior is observed. At lower temperatures, the transmission disappears and we observe an exponential growth of the resistivity with the activation energy close to the energy gap value. Finally, in the range below 150 K, variable temperature hopping in the p-type background dominates.

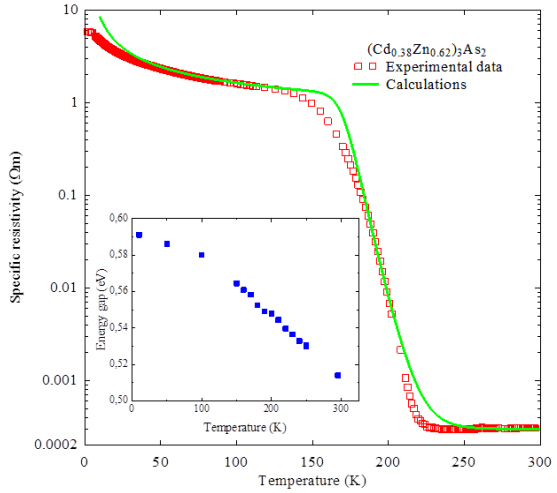

Fig. 1. Measured temperature dependence of the specific resistivity in $(Cd_{0.38}Zn_{0.62})_3As_2$ bulk sample (squares). Solid green line represents results of calculation within a model previously used for polycrystalline semiconductors [4]. The obtained value of an averaged activation energy of the *n-p-n* barriers is 0.5 eV. Inset: temperature dependence of the energy gap measured for the sample cut from the same region of the crystal.

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