ANISOTROPY OF STRUCTURE AND ITS INFLUENCE ON THERMOELECTRICITY: THE CASE OF INSB-CRSB AND GASB-CRSB EUTECTIC COMPOSITES

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Diluted magnetic semiconductor materials based on III-V compounds and 3d-metals eutectic composites, unlike doped compounds having a stable composition and properties[1-4], are promising materials for spintronic devices [9]. InSb-CrSb and GaSb-CrSb eutectics, where CrSb antiferromagnetic needles are distributed in GaSb, and InSb matrix are of significant interest. One of the main features of eutectic composites obtained based on InSb, GaSb and 3d - transition elements is the anisotropy in kinetic coefficients depending on the direction of metal needles [5-8]. These composites, which combines both semiconductor and metallic properties, behave as nonhomogeneous semiconductors since metal needles are distributed parallel to the crystallization direction. Different models were proposed in order to determine composite physical parameters. In the present study, heat and electrical conductivity of the InSb-CrSb and GaSb-CrSb composites was calculated based on the theory of effective ambient. It has been shown that in calculatin of theheat and electrical conductivity, the inter-phase zones should be taken into consideration. The effective electrical conductivity in the direction of crystallization ($\sigma_\parallel$) and perpendicular to it ($\sigma_\perp$) was calulated by the following expressions:

$$\sigma_\perp = \frac{(\sigma_1 - \sigma_2)\left(1 - \sqrt{\frac{c}{1+c}}\right) + \sigma_1\sqrt{\frac{1+c}{c}}}{1 + \left(\frac{\sigma_2}{\sigma_1}\right)\sqrt{\frac{1+c}{c-1}}}, \quad \sigma_\parallel = \sigma_1 \frac{1}{1+c} + \sigma_2 \frac{c}{1+c}$$

here σ_1 and σ_2 are the electrical conductivity of the matrix and metal phase, c is the volume ofmetal needles in the total volume.

The following formula is used for the effective thermal conductivity in parallel ($K_\parallel$) and perpendicular ($K_\perp$) to the metal needles:

$$K_\parallel = K_2 + (1-c)((K_1 - K_2), K_\perp = K_2 + \frac{2K_2(1-c)(K_1-K_2)}{2K_2 + c(K_1-K_2)}, c = \frac{V_i N_i}{1 - V_i N_i},$$

here N_i is the density of the metal phase, V_i is the volume of the metal needles. It has been shown that the role of the interphase zone in anisotropy of electric and thermal conductivity of eutectic compositions of the semiconductor-metal type is substantial and that it is necessary to take into account volume fractions of the interphase zone in computation of effective thermal conductivity in the framework of the effective medium theory [10]. The influence of the inclusions on the thermal conductivity is negligible due to their low volume fraction.The heat transfer mechanisms have been discussed in the framework Callaway model [11].

The thermal conductivity calculated with taken into account the role of the charge curriers transfer, point defects, three-phonon normal and three-phonon umklapp processes and the mechanism of resonance transfer of ionization energy.

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