Temperature-Dependent Anisotropy of the Electric Conductivity of $TlB^{III}C_2^{VI}$ Single Crystals

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The aim of the present paper is the investigation of the anisotropy degree of the conductivity of the layer semiconductors $TlInS_2$, $TlGaS_2$ and $TlGaSe_2$ in the dependence on the temperature, and the finding of the energy barrier value between the layers.

The results of the conductivity investigation of the given layer single crystals in the constant electric field are given below. Indium was used in the capacity of the contact material, which was melted in the single crystals and it creates the ohmic contacts. The samples for the measurements have thickness of about 80-130 μm and were prepared as in the planar-, or in the sandwich-variant. For the samples in the planar variant, the indium contacts were carried on the lateral terminate edges so, that the electric current was directed along the natural layers of the single crystal, i.e. perpendicularly to the single crystal *C* axis ($\sigma_{\perp C}$). In the samples prepared in the sandwich-variant, the electric current was directed transversally to the natural layers, i.e. along the single crystal *C* axis ($\sigma_{||C}$). The amplitude of the constant electric field applied to the samples ($F=10^2 \div 10^3$ V/cm) corresponded to the ohmic region of VAC. During the measurements the samples were established in the cryostat of the "Utrex" mark with the system of the temperature stabilization (the accuracy of the stabilization was 0.02 K).

The energy barrier $\Delta\varphi$ between the layers can be evaluated because of the jump conductivity in the given crystals along *C* axis by the relation:

$$\sigma_{\perp C} / \sigma_{||C} \sim \exp(\Delta\varphi / kT). \quad (1)$$

From all three investigated crystals, the $TlGaSe_2$ single crystals had the greatest energy barrier between the layers: $\Delta\varphi = 0.30$ eV. In the $TlGaS_2$ $\Delta\varphi$=0.17 eV, and in $TlInS_2$ the value $\Delta\varphi$ was less: 0.04eV.

The experimentally obtained dependence $\lg(\sigma_{\perp C}/\sigma_{||C})$ on $\Delta\varphi$ is linear that is in the agreement with the formula (1).

The value of the interlayer energy barrier can be estimated also by the difference of the activation energies of the conductivity transversally and along the layers, i.e. as follows:

$$\Delta E = E_{\sigma||C} - E_{\sigma\perp C} \quad (2)$$

The obtained values of the activation energies of the conductivity are given in the table, where the values $\Delta\varphi$ and ΔE are given for comparison also.

Single crystal	Δφ, eV	$E_{\sigma\|\|C}$, eV	$E_{\sigma\perp C}$, eV	ΔE, eV
$TlInS_2$	0.04	0.39	0.34	0.05
$TlGaS_2$	0.17	0.50	0.31	0.19
$TlGaSe_2$	0.30	0.54	0.20	0.34

Thus, the values of the interlayer energy barrier, obtained by two independent methods, agreed well with each other in the $TlInS_2$, $TlGaS_2$ and $TlGaSe_2$ single crystals.