Materials of Conferences

INVESTIGATION OF SURFACE LAYERS FOR POWER DETECTORS OF ELECTROMAGNETIC IRRADIATION

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It is known [l] that for increasing of transformation coefficient of power detectors of electromagnetic irradiation, it is necessary to increase the coefficient of thermoelectromotive force (CTF) of thermocouple α, to decrease heat capacity of detector C_Q and to increase substrate thermoconductivity (or to decrease the detector thermal resistance R_Q). Decrease of value of C_Q is achieved by decreasing the volume of the detector. For decreasing of R_Q, which in the case of layered form is determined by the substrate properties, it is necessary to use substrate with high specific heat capacity. The operation temperature of hot welded contact of thermocouple depends on operation conditions, the power measured and thermistoric resistance. Usually it lays in the range 220 to 550 K. Therefore in order to increase the value of CTF α it is reasonable to use the most effective low temperature thermoelectrical materials, such as $Bi_{0.5}Sb_{1.5}Te_3$ of p-type of conductivity and $Bi_2Te_{2.4}Se_{0.6}$ of n-type of conductivity [2]. Synthetic sapphire α-Al_2O_3 better than others suits to the requirements which must satisfy the substrate because it has quite high value of thermal conductivity $k = 2,3$ Wt $m^{-1} \cdot K^{-1}$ and the dielectric parameters $\varepsilon = 11,5$, $tg\delta = 0,0001$ which are necessary for conjugation of detector with the wave leading track.

The above mentioned requires the necessity of obtaining of qualitative films of as $Bi_{0.5}Sb_{1.5}Te_3$ and $Bi_2Te_{2.4}Se_{0.6}$ on sapphire. However obtaining of the films under consideration is associated with technological difficulties due to thermal dissociation. Vapor of these materials may contain the following components:

BiTe, BiSe, SbTe, Te_2, Se_2, Sb_4. Therefore for maintaining the initial contents in the condensed films some special measures are used [3]. We have obtained the films of $Bi_xSb_{2-x}Te_3$ and $Bi_2Te_ySe_{3-y}$ on sapphire plates with of $(01\bar{1}2)$ surface structure by the method of discrete evaporation with additional homogenization of the gas phase. The process was realized in the vacuum with base pressure of 10^{-4} Pa. Evaporation rate was determined by the temperature of tantalum heater and by the input amount of bulk deposited material. Substrate temperature can be varied in the range 300 to 700 K. Film thickness depended on the rate and duration of condensation and was about 0.5 to 3 tm. Before deposition the substrates were chemically etched and cleaned by ion bombardment. All films under investigation were deposited at a temperature of evaporator of 1050-1070 K.

Investigations on chemical content, structure, surface relief, specific conductivity, thermoelectromotive force of films obtained at different condensation temperatures have been carried out. Film content was investigated b means of X-ray chemical microanalysis using analyzer "Comeka". The structure was determined with the aid of electronograph and the surface relief was studied on scanning electron microscope.

Films obtained at substrate temperature lower than 420 K had structure of unoriented polycrystals with grain size less than 50 nm. Substrate temperature rise leads to enlargement of grain sizes up to 300-400 nm. At condensation temperature of 570-590 K there is appearance of [0001] texture and both smallcrvstalline fraction and separate large grains of sizes of 800-1000 nm. Film surface becomes more smooth. As we consider this may be due to decrease of concentration of appearance centers at low densities and coincidence of two growth modes of the films, that is normal and tangential.

According to results of investigation (Fig. 1 and 2) the film content is not changed up to condensation temperature of 570 K for $Bi_{0.5}Sb_{1.5}Te_3$ of and 530 K for $Bi_2Te_{2.4}Se_{0.6}$ that corresponds to the content of original bulk deposit. Above these temperatures there is steady decrease of amount of volatile components, Se, Te, Sb, that we explain by reevaporation of them from the substrate. This assumption is confirmed by results of measurement of specific electric conductivity and CTF (Fig. 3). Decrease of concentration of Se and Te in the films leads to substantial decrease of the value of CTF. Weakly detectable maxima on the $\alpha(Tk)$ dependence probably are due to optimal grain size and are determined by scattering process at their borders. Substantial increase of electroconductivity of films as condensation temperature rises is due to appearance of metallic phase of Bi and Sb in the films.

In order to obtain films of $Bi_{0.5}Sb_{1.5}Te_3$ and $Bi_2Te_{2.4}Se_{0.6}$ on sapphire with maximal CTF one should not try to obtain perfect crystallographic structure and to increase substrate temperature. The optimal condensation temperatures are: 570-590 K for $Bi_{0.5}Sb_{1.5}Te_3$ and 510-530 K for $Bi_2Te_{2.4}Se_{0.6}$.

Atomic concentration of Bi, Sb, Te in the films of $Bi_xSb_{2-x}Te_3$ on sapphire, obtained at different condensation temperatures: 1-Te, 2-Sb, 3-Bi.

Atomic concentration of Bi, Se, Te in the films of $Bi_2Te_ySe_{3-y}$ on sapphire, obtained at different condensation temperatures: 1-Bi, 2-Te, 3-Se.

Values of CTF and specific electric conductivity of films of $Bi_xSb_{2-x}Te_3$ and $Bi_2Te_ySe_{3-y}$ on sapphire obtained at different condensation temperature: 1-α, $Bi_xSb_{2-x}Te_3$, 1,3-α, σ $Bi_xSb_{2-x}Te_3$, 2,4-α, σ $Bi_2Te_ySe_{3-y}$.

References

1. Kunze H.-J. In Physikalische Messmethoden / Ed. B.C. Teubner. –M.: Stuttgart, 1996.
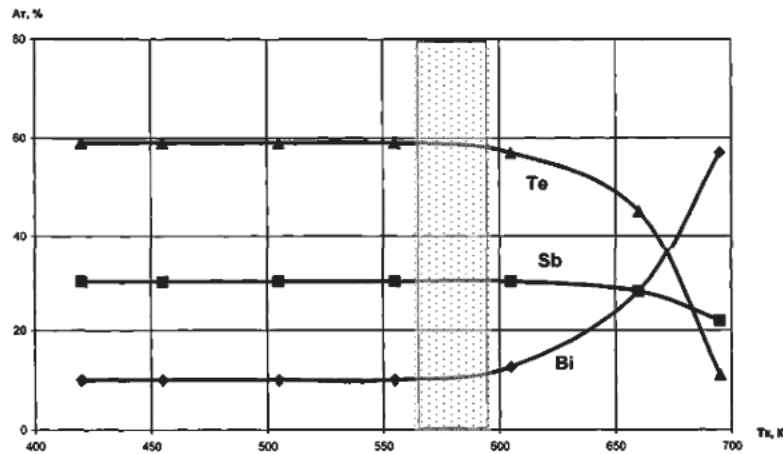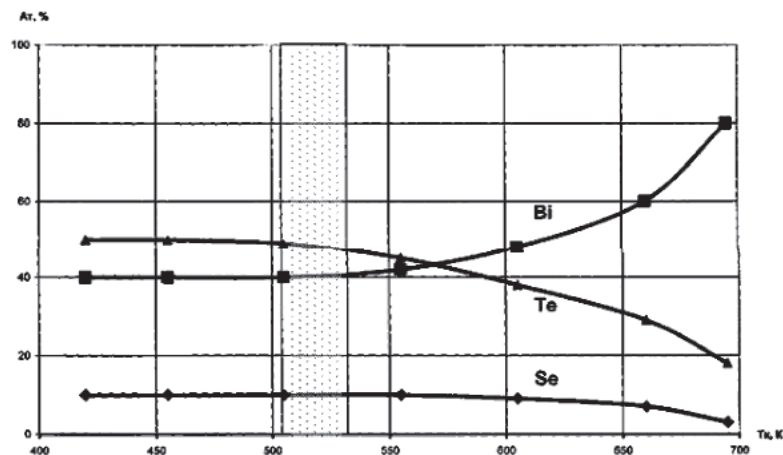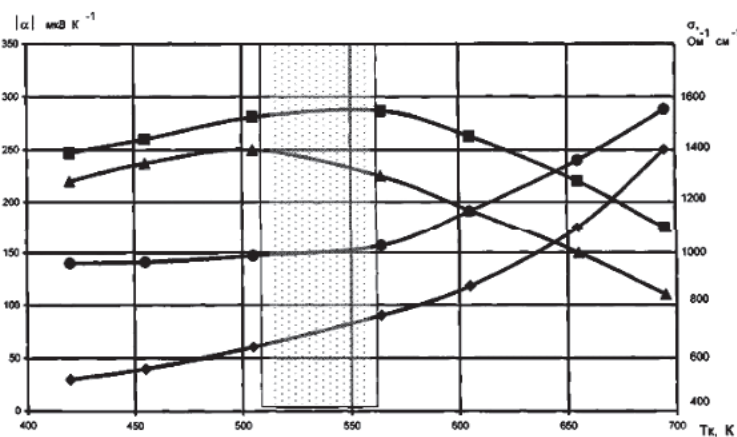
Fig. 1

Fig. 2

Fig. 3

2. Gol'tsman B.M., Dashevskij S.M., Kajdanov V.I., Ko-lomoets N. In Film Thermoelements // Physics and Applications. – M., 2000.

3. Handbook of Thin Film Technology // Ed. L.J. Maissel, R. Clang. – McGraw Hill, 2002.