FREQUENCY-COMPENSATING EFFECT AT ELECTRIC CONDUCTION OF BISMUTH OXIDE FILMS

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Bismuth oxide is a perspective material was used in the glass and the ceramics productions for optimization of their optical and electrical parameters [1]. Electrical transfer in Bi_2O_3 films was an issue of discussions in many publications [2-5]. However, evidence about its properties at alternating current are very scarce [6], though they sometimes allow to consider from new point both physical nature of observed electronic processes and prospects of practical use of material. Results of research of electrical transfer at films Bi_2O_3 with alternating current, varying at broad frequency and temperature limits are given below. These researches allowed to discover the frequency and compensation effect [7-8] in electric conduction of Bi_2O_3, , parameters of which at inorganic semiconductor are determined firstly.

Films Bi_2O_3 were produced by means of thermical sublimation of metallic Bi (99,999%) with following oxidation of film in the air. Electronic and graphical researches indicated, that films, first produced on glass and then burned in the air at temperature 473 K during 10 hours period are polycrystallic and correspond to phase δ of Bi_2O_3 (a=0,552 nm) [9]. Chemical composition of films was determined by local X-ray analysis by means of comparison of ratios of intensities of spectral lines for films and standard sample.

Sandwich shape samples with electrodes SnO_2 and Ag are used. Thickness of films Bi_2O_3 is equal to 2÷6 mkm. Electric conduction of sandwiches is obtained by electric and mechanic scheme at direct current and by bridge scheme- at alternating current. The measurements indicated that conduction of films δ Bi_2O_3 depends on frequency of alternating field. This dependence has the following form:

$$\sigma = a f^s \quad , \qquad (1)$$

where S=1,0 at room temperature, $0 \le S \le 1{,}0$ at relatively high temperatures.

If this case, the linear dependence between σ and f is discovered only at narrow of high frequency band. Dependence of σ on frequency influences on the type of temperature dependence of Bi_2O_3 at different frequencies too. These dependences are given at Fig. It's possible to detail two characteristic regions on the curves $\sigma(T, f)$. They are: low temperature region where the dependence of σ in relation to T is relatively small, and with decrease of temperature the energy of activation decreases and high temperature of region, where dependence of σ on T is significant, is obtained by concrete energy activation E_σ and pre-exponent factor σ_0.

Measurement, taken at samples with various thickness of films Bi_2O_3 in phase δ, indicated that both factor σ_0 and energy of activation E_σ decreases with increase of frequency, at the same time its values are interrelated. The fact witnessing about it indicates, that at extrapolation towards $(10^3/T) \to 0$ of high temperature sections of curves of dependence $lg\sigma$ on $10^3/T$, all of them intersect at single point, for which $(10^3/T_0) = 1{,}3\ K^{-1}$. Thus, linear dependence exists between $lg\sigma_0$ and E_σ . It is obvious, that E_σ decreases at direct current from 0,58eV to 0,21eV at frequency $1{,}4 \cdot 10^4$ Hz and relation

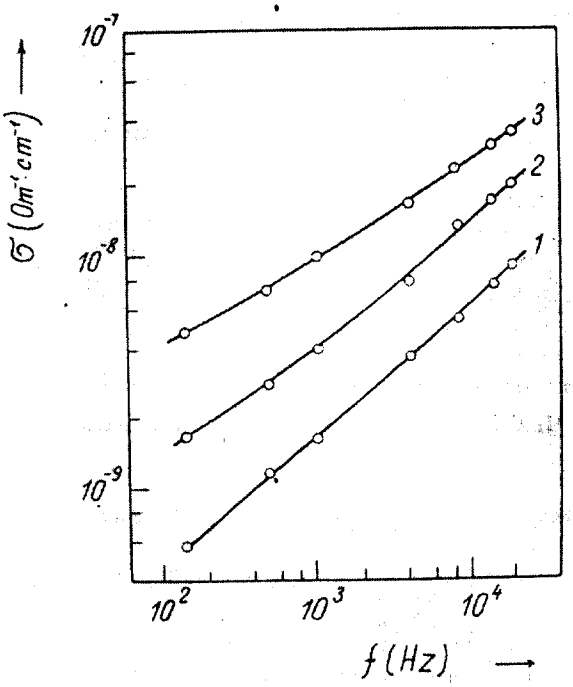

Fig. Dependence of electric conduction of film δ-Bi_2O_3 on frequency at temperatures 297 K (1), 443 K (2), and 496 K(3).

is fulfilled where σ_{00} – is a characteristic factor. It means the accomplishment of linear relation of type

$$lg\sigma_0 = \alpha + \beta E_\sigma \qquad (3)$$

where $\alpha = lg\sigma_{00}$ and $\beta = 0{,}43\ (kT_0)$, σ_{00} and $(kT_0)^{-1}$ are coordinates of intersection points of rectilinear section of dependences $lg\sigma$ on T^{-1} at various frequencies. Its values are given in table. Values α and β are indicated there also, which are obtained from dependence $lg\sigma_0$ on E_σ. There is a good agreement of results, obtained by two independent ways.

Way of determination	σ_{00}, (10^{-7} $Om^{-1}cm^{-1}$)	T_0, K	α	β, eV
$lg\sigma \sim 10^3/T$	1,8	769	-6,74	6,48
$lg\sigma_0 \sim E_\sigma$	1,85	764	-6,73	6,53

Obtained data allow to conclude, that at relatively high temperatures, when energy of activation E_σ is a function from frequency, electric conduction of Bi_2O_3 is described as follows:

$$\sigma_0=\sigma_{00}exp\,(E_\sigma/kT_0)\,exp-(E_\sigma/kT) \qquad (4)$$

Equation (4) indicates, that for this material the electronic heterogeneity of structure is typical, and relevant energetical level of flow decreases with the increase of frequency. Thus, for the first time the frequency-compensating effect was discovered at film δ-Bi_2O_3 and studied. This effect was established and investigated at high ohmic polymer semiconductors. Obviously, effect is common for all non regulated high ohmic semiconductor systems.

It turned out that $E_\sigma \sim lg(f_0/f)$ at alternating current, and value of characteristic frequency f_0 for film Bi_2O_3 is equal to $5\cdot10^5$ Hz.

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VİSMUT OKSİD NAZİK LÖVHƏLƏRİNDƏ ELEKTRİK KEÇİRİCİLİYİNİN TEZLİK-KOMPENSASİYA EFFEKTİ

Vismut oksid şüşə və keramik materialların istehsalında və onların optik, elektrik parametrlərinin optimallaşdırılmasında perspektiv materialdır.Tezlik-temperatur intervalı geniş dəyişən δ-Bi_2O_3 lövhələrində elektron daşınmasının öyrənilməsi zamanı δ-Bi_2O_3-də elektrik keçiriciliyinin tezlik-kompensasiya effekti aşkar edilmişdir. Bu effektin parametrləri qeyri-orqanik yarımkeçiricilərdə ilk dəfə tə'yin edilmişdir.

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ЧАСТОТНО-КОМПЕНСАЦИОННЫЙ ЭФФЕКТ В ЭЛЕКТРОПРОВОДНОСТИ ПЛЕНОК ОКИСИ ВИСМУТА

Окись висмута является перспективным материалом, применяемым в производстве стекол и керамик для оптимизации их оптических и электрических параметров.

Исследования электропереноса на пленках Bi_2O_3 на переменном токе в широких частотно-температурных пределах позволили обнаружить в электропроводности δ-Bi_2O_3 частотно-компенсацнонный эффект, параметры которого в неорганическом полупроводнике определяются впервые.

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