THE CRYSTALLIZATION KINETICS OF THE $YbAs_2S_4$ AMORPHOUS FILMS

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The crystallization kinetics of $YbAs_2S_4$ ternary amorphous thin films have been investigated by kinematic electron diffraction method. The crystallization is shown to occur in accordance with Avrami – Kolmogorov law.

The crystallization growth dimensionality and the kinetics parameters of the phase transition have been determined during crystallization of the amorphous $YbAs_2S_4$ thin films; the growth dimensionality equals to two, the summary activation energy E_s=128,7 kcal/mol

Amorphous materials, thin layers, heterostructures, defined structures on a level comparable with the atomic level are the fields of material research which stimulated the development of new technologies and which led to the unbelievable expansion of microelectronics, optoelectronics and to the preparation of materials with unique properties.

The amorphous semiconductor materials containing f-elements represent a new class of amorphous materials. The Ln-As-X(S,Se,Te) systems represent this class of materials, where Ln-rare each elements. İn these systems, it was determined the formation of ternary compounds that may be applied in devices which are controlled by external magnetic fields. As_2S_3 – Yb system is one of these classes of above mentioned materials. According to state diagram, the $YbAs_2S_4$, $YbAs_4S_7$ and $Yb_3As_4S_9$ ternary compounds are formed in this system. The purpose of the present work is study the crystallization process and is determine the kinetic parameters of crystallization of $YbAs_2S_4$ amorphous films.

The general form describing the kinetics of growth is written as

$$V_t=V_0[1-exp(-kt^m)] \qquad (1)$$

where V_t - volume of substance transforming to t time, V_0-initiation volume of substance, k-reaction rate constant. "m" quantity is different for variety transformation types and is depend on growth measure. It is need to have exact experimental data for V_t in order to obtain reliable results using this theory.

Thin amorphous films of $YbAs_2S_4$ with thickness ~25nm were obtained by vacuum evaporation on substrates of fresh cleavage surfaces of NaCl and KCl crystals and amorphous celluloid at room temperature.

Using electron diffraction method we have investigated the structure of obtained films. The electron diffraction pattern shows four diffuse diffraction ring corresponding $S=4\pi sin\theta/\lambda$=11; 19; 36; 55 нм$^{-1}$. Amorphous films crystallization at T=673K results in the formation of $YbAs_2S_4$ polycrystalline with parameters of the rhombic lattice rhombic unit cell with a=1,115; b=1,1387; c=0,995 нм. This is in agreement the data of ref: [1].

To determine the kinetic parameters of crystallization of $YbAs_2S_4$ amorphous films we have used kinematic electron diffraction method from amorphous films with thickness ~25 nm at T=673K, T=683K, T=698K temperatures. It is quaty clear, that much more temperature, than fastly occurs the crystallization process.

Electron diffraction pattern taken from annealing samples shows how diffuse rings relating to amorphous phase are disappearance and the lines of the polycrystalline phase of $YbAs_2S_4$ are occur. There is the area where crystal and amorphous phases exist together.

Intensities of lines of the $YbAs_2S_4$ polycrystalline phase were measured by micro photometric method. The intensities of diffraction lines were determined depending on annealing time. To get quantity of crystallized matter we use standardization method taking account of intensity of scattering of electrons is proportional to the volume of scattering matter [2].

In investigation interval of temperature the kinetic curves of crystallization of $YbAs_2S_4$ amorphous films have been calculated i.e. the curves of the crystallized volume as a function of the time for variety temperatures.

The $lnln(V_0/(V_0 - V_t))$ depended of ln t were calculated at T=673, T=683, T=698K temperatures. The lines drawing through the experimental points are straight lines for all temperatures (fig.).

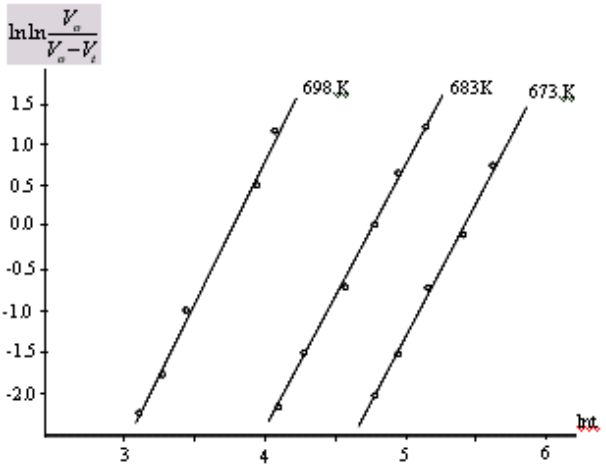

Fig. The $lnln\ (V_o/(V_o-V_t))$ depence on $ln\ t$ for $YbAs_2S_4$.

The value of "m" in (1) form determined from slope is equal to about 3 (m=2,95 at 673K; m=3,05 at 683K; m=3,10 at 698K). That is witness for the three-dimensionality growth of crystals at investigation temperatures.

$ln\ k$ dependence on $1/T$ is linear . The nucleation rate and crystal growth rate are described by Arrenius form

$$\upsilon_n = C\ e^{-\frac{E_3}{RT}}$$
$$\upsilon_g = C\ e^{-\frac{E_p}{RT}} \qquad (2)$$

where υ_n is the formation rate of the nucleation centre and determined by as datum of nucleus transformating to centre in unit time in volume unit of metastable phase; υ_g is crystal growth linear rate and determined as the increase rate of linear sizes of growthing centre of the new phase.

Summary nucleation activation energy - E_s is determined from slope of the *ln k* curve as function *1/T* and equal to 128,7 kcal/mol. The nucleation activation energy is calculated from slope of the $1/\tau_o$ curve as a function *ln t* (where τ_o – experimental beginning time of crystallization) and equal to 38, 3 kcal/mol. E_g – crystal growth activation energy is determined by $E_g = (E_s - E_n)/2$ form and is equal to 45,2 kcal/mol.

The results obtained show that amorphous thin films of above mentioned compounds are more thermal stability than before investigated other triple $YbAs_4S_7$ compound containing chalcogenide [3].

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$YbAs_2S_4$ AMORF NAZİK TƏBƏQƏLƏRİNİN KRİSTALLAŞMA KİNETİKASI

Kinematik elektronoqrafiya metodu ilə vakuumda çökdürmə üsulu ilə alınmış $YbAs_2S_4$ birləşməsinin amorf nazik təbəqələrinin kristallaşma kinetikası tədqiq edilmişdir.

Göstərilmişdir ki, $YbAs_2S_4$ amorf nazik təbəqələrinin kristallaşması Avraami-Kolmoqorovun qanunauyğunluğu ilə baş verir və $V_t=V_o[1-exp(-kt^m)]$ analitik tənliyi ilə ifadə olunur. Kristallaşmanın kinetik parametrləri təyin edilmişdir.

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КИНЕТИКА КРИСТАЛЛИЗАЦИИ АМОРФНЫХ ПЛЕНОК $YbAs_2S_4$

Методом кинематической электронографии исследована кинетика кристаллизации тонких аморфных пленок $YbAs_2S_4$, полученных вакуумным испарением синтезированного соединения. Показано, что кристаллизация тонких аморфных пленок $YbAs_2S_4$ происходит по закономерностям, установленным Авраами – Колмогоровым и описывается аналитическим выражением $V_t=V_o[1-exp(-kt^m)]$. Определены мерность роста и значения кинетических параметров кристаллизации.

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