Electron microscopy studies of the crystallization of $Ge_2Sb_2Te_5$ thin films for phase change memory

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The $Ge_2Sb_2Te_5$ (GST225) thin films are widely used in the nonvolatile phase change memory (PCM) [1]. The crystallization process is the slowest part of a PCM operation, thus limiting the overall performance of the PCM devices [2]. Understanding of the crystallization process is critically important for the optimization of the material and increasing the processing speed of PCM. So, the aim of this work was studying the phase transitions of GST225 thin films by transmission electron microscopy (TEM).

The GST225 thin films were prepared by the magnetron sputtering. The temperature dependence of the resistivity for GST225 sample was measured from 30 to 400°C. To prepare the samples for TEM, specific annealing temperatures were chosen in the range of sharp drop of resistivity due to the phase transition. Cross section specimens were prepared by the in-situ lift-out method. The TEM studies were carried out on a FEI Titan Themis 200-80 microscope.

It was observed that heating sample to 168°C leads to the homogeneous nucleation in the amorphous films. Dimensions of the face-centered cubic grains do not exceed a few nanometers. At the same time, 30-minute exposition at 168°C leads to the complete crystallization, and formation of the polycrystalline structure with a cubic lattice. Heating to 183°C without exposure leads to exactly same result. The fully crystalline films are comparatively large grain size of several tens of nanometers in the near-surface layer of the film.

The most interesting result of the work is the two orders of magnitude drop of the film resistance after formation of small crystalline nuclei in the film volume. In this case, negligible crystalline fraction detected by the TEM facility exclude formation of the percolation channels. Possible explanation of the result obtained can be structural relaxation of the material.

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References

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Influence of corona discharge on photoinduced modification of optical characteristic of Cu–As_2Se_3 thin film srructures.

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It was established [1], that application of negative corona discharge during recording of optical holographic diffraction gratings in Cu-As_2Se_3 thin film structures, in comparison of positive corona discharge, increase the holographic sensibility, the diffraction efficiency and the depth of the chemical etched relief. But in this work was not investigated the photoinduced modification of the transmission spectra of the Cu-As_2Se_3 structure during the light irradiation without and in the field of corona discharge. In the present paper the investigation nof the corona discharge, applied during light exposure on the photoinduced modification of the transmition spectra of the as-deposited Cu-As_2Se_3 thin film structure. Thin films of Cu and As_2Se_3 were sequentially deposited by the vacuum thermal evaporation ($p = 4x10^{-3}$ Pa) from the Mo boats onto unheated glass substrates. The Cu-As_2Se_3 thin film structures were exposed for different polarities and values of the electrical field of corona discharge and without corona discharge. In the region of weak absorption coefficients in the transmission spectra of the investigated structures was observed photobleshing, while in the region of fundamental absorption the thin film structures exhibit photodasrkening (Fig. 1 and Fig. 2). All spectral dependences of the photoinduced changes of the transmission coefficient represent a curve with minimum. In the region o weak absorption higher values of photobleshing was observed during exposure of the investigated thin film strucure in the field of positive corona discharge. When is applied the negative corona discharge the weakness photobleshing was observed. The ratio of achieved values of the maxima in the expositional dependences of the diffraction efficiency of the holographic gratings using simultaneously during recording the corona discharge of different polarity [1] are in accordance with the respective photoinduced changes of the transmission The obtained results qualitatively are analyzed taking into account the photodarkening of the semiconductor during it doping with Cu and increasing of the transmission of the structure during photodiffusion of the cupper in the amorphous semiconductor.