Optical studies of Cu_7GeS_5I superionic Thin Films

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Cu_7GeS_5I crystals belong to the argyrodite family of tetrahedrally close-packed structures and are known as superionic conductors. Due to their high ionic conductivity, they are attractive materials for applications in the different functional elements of the solid state ionics. Thin amorphous films prepared on the base of Cu_7GeS_5I compound are shown to be characterised by a high value of the electrical conductivity which can be used for the creation of miniature solid electrolyte batteries and supercapacitors of new generation.

Thin films of Cu_7GeS_5I superionic compounds were deposited onto silicate glass substrates by non-reactive radio frequency magnetron sputtering. The structure of the deposited films was analyzed by X-ray diffraction; the diffraction patterns show the films to be amorphous. Structural studies were performed using SEM technique and EDX spectra measurements which give the evidence for the formation of a homogeneous two-dimensional structure.

The transmission spectra were studied in the interval of temperatures 77–300 K by a MDR-3 grating monochromator. Based on the interferential transmission spectra, the spectral dependences of absorption coefficient and the dispersion dependences of the refractive index were obtained. The increase of the refractive index dispersion in short-wavelength region as well as increase of the refractive index value with temperature are observed.

It is shown that the optical absorption edge in the region of its exponential behaviour are described by Urbach rule. The main Urbach absorption edge parameters as well as the temperature dependences of optical pseudogap and Urbach energy are determined. The temperature behaviour of the Urbach absorption edge is explained by electron-phonon interaction which increases at the transition from the three-dimensional bulk structure to the two-dimensional planar structure. An essential characteristic of the absorption edge spectra of the thin film under investigation is a lengthy Urbach tail which results in the Urbach energy being more than three time higher than that in the crystal. The transition from the crystalline three-dimensional Cu_7GeS_5I superionic conductors to the two-dimensional amorphous thin films is characterized by a decrease of the electrical conductivity and the optical pseudogap, an increase of the Urbach energy, an enhancement of the electron-phonon interaction as well as an increasing structural disordering.