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Optical properties of $Cu_6PS(Se)_5I$ superionic thin films

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$Cu_6PS(Se)_5I$ 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 films of $Cu_6PS(Se)_5I$ 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. Computer processing of the interferential transmission spectra enabled the dispersion dependences of the refractive index for the investigated films to be 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. The dispersion dependences of refractive index are well described by the relation, relating the refractive index, optical pseudogap and energy of the valence electron plasma vibrations.

Isoabsorption studies of $Cu_6PS(Se)_5I$ thin films show the absence of phase transition within the temperature interval 77–300 K. Based on the interferential transmission spectra, the spectral dependences of absorption coefficient were obtained. 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. An essential characteristic of the absorption edge spectra of the $Cu_6PS(Se)_5I$ thin films is a lengthy Urbach tail.