

OPTICAL PROPERTIES OF Cu_xS THIN FILMS DEPOSITED BY CHEMICAL BATH TECHNIQUE

Tomas Petraškauskas¹, Neringa Petraškauskienė², Rasa Alaburdaitė², Edita Paluckienė²

¹ Faculty of Physics, Vilnius University, Lithuania

² Department of Physical and Inorganic Chemistry, Kaunas University of Technology, Lithuania
tomas.petrasauskas@ff.stud.vu.lt

Copper sulfide (Cu_xS) is wide-band-gap *p*-type semiconductor material with modern applications ranging from industrial to biomedical. Various polymers, modified by copper sulfides, represent a new class of materials – composites with novel properties. Cu_xS is an interesting material for its metal-like electrical conductivity, chemical-sensing capability and ideal characteristics for solar energy absorption. Consequently, polymers modified by Cu_xS are used: as the conductive substrates for deposition of metal and semiconductors; as gas sensors functioning at temperatures tending to room temperature; as polarizer of infrared radiation; and as active absorbents of radio waves.

Electrically conductive Cu_xS films can be prepared by the chemical bath technique or sorption-diffusion methods [1-3]. Polyamide (PA) as semi-hydrophilic polymer is capable to absorb ions or molecules of various electrolytes from aqueous and non aqueous solutions.

Cu_xS thin films were deposited on PA (Tecamid 6, density $1.13 \text{ g}\cdot\text{cm}^{-3}$, $500 \mu\text{m}$ thick) using CuCl_2 and $\text{Na}_2\text{S}_2\text{O}_3$ mixture for 16 h. The deposition process was carried out by repeating such deposition cycles till 3 times.

The aim of this work was to obtain Cu_xS thin films by the chemical bath deposition method and determine the effect of variation of number of cycles of deposition on the optical properties with a view to ascertaining the possible applications. The UV-Visible absorption spectroscopy is a powerful tool for the investigation of optical properties of material. Absorbance of the films was characterized using PerkinElmer Lambda 35 UV/VIS spectrometer. The absorption spectrum for copper sulfide thin films was recorded in the wavelength region from 200 nm to 1100 nm.

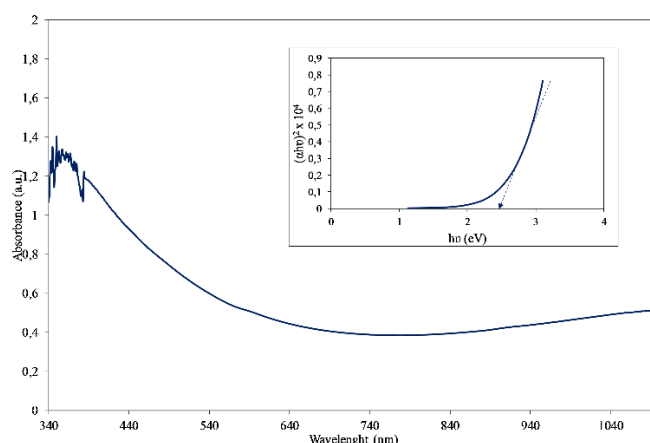


Fig. 1. UV-VIS absorption spectra of Cu_xS thin films after. The optical band gaps of the Cu_xS thin films are plotted in the inset.

Fig.1 shows that absorbance of Cu_xS films (after 3 cycles of deposition) is generally high in the UV region (300-400 nm) and low absorbance in the visible spectrum (400-765 nm). This makes the films suitable for coating of eye glasses to prevent UV radiation from getting to the eyes. It is also useful for coating of windows to prevent UV radiation and aid visibility since absorption in the visible region is low. Low absorption in the visible region makes it a veritable material for buffer layer in solar cell. The absorbance of the films is directly proportional to number of cycles of deposition.

The optical bandgap of the Cu_xS thin films was determined from the absorption spectra using Tauc's relation

$$\alpha h\nu = A(h\nu - E_g)^n \quad (1)$$

where $h\nu$ is the photon energy, α – optical absorption coefficient, E_g – the optical energy bandgap, A – the optical transition dependent constant, and n – characterizes the transition. For allowed direct transitions, $n = 2$ and allowed indirect transitions, $n = 1/2$. Fig. 1 shows the plot of $(\alpha h\nu)^2$ against $h\nu$. The variation of $(\alpha h\nu)^2$ with $h\nu$ is linear which indicates that the direct transition is present. Extrapolating the straight line portion of the plot of $(\alpha h\nu)^2$ against $h\nu$ to energy axis for zero absorption coefficient give optical bandgap energy value as 2.5 eV. The films were found to have average transmittance of about 40 % in the UV-VIS regions while exhibiting average reflectance of about 20 % in the same regions. Some of the films could be effective for solar control, eyeglasses, and as well good materials for solar cell fabrication.

[1] V. Janickis, N. Petraškauskienė, S. Žalėnienė, I. Morkėvėnaitė-Vilkonėienė, A. Ramanavičius, *Journal of nanoscience and nanotechnology*, **18**(1), 604-613 (2018).

[2] V. Janickis, N. Petraškauskienė, *Chemija*, **28**(4), 214-225 (2017).

[3] R. Alaburdaitė, E. Paluckienė, S. Grevys, *Chalcogenide Lett*, **13**(12), 529-536 (2016).