

## Copper Molarity Effect on the Optical Properties of Cu<sub>2</sub>CdSnS<sub>4</sub> Quaternary Thin Films

The quaternary alloy of Cu<sub>2</sub>CdSnS<sub>4</sub> (CCSS) is one type of thin film materials that contributes to the field of photovoltaic devices manufacturing, the importance of which has not been commonly enlightened as most of the other materials. For the preparation of CCSS thin films at 350 °C on glass substrates, the chemical spray pyrolysis technique was used. The optical properties of thin films prepared under the influence of the variation of copper solution molarity (0.03, 0.05, 0.07, and 0.09 M) on the quaternary compound were examined using a UV-vis spectrophotometer. The findings of the AFM study showed the atoms on the surface that are acclimatized in the form of nanorods with an increase in the average grain size from 62.72 to 79.17 nm. The results also showed an improvement in the average surface roughness from 5.69 to 12.8 nm when copper concentration increased from 0.03 to 0.09 M. The UV-vis results showed that the optical transmittance of CCSS decreases by increasing the solution molarity of copper, with a change in the absorption edge toward the low energy side (redshift). With an increase in the wavelength between 725 and 960 nm, a low absorption coefficient was found in the infrared region, while a strong absorption coefficient in the visible range was observed with the increase in copper solution molarity. The energy gap values decreased from 1.6 to 1.47 eV when copper solution molarity increased from 0.03 to 0.09 M. By raising copper solution molarity to 0.09 M, the refractive index at the absorption edge was increased from 1.6 to 1.97, while the extinction coefficient reduced.