Formation, enhanced crystallization, optical absorption and electrical conduction in copper indium selenide thin films prepared via pulse laser welding technique

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Abstract

In this study, thin films of $CuInSe_2$ (CIS) were expeditiously fabricated within one second utilizing the pulsed laser welding (PLW) technique. Preceding the PLW process, thin films of InSe (500 nm) were coated with Cu nanosheets of 60 nm and 120 nm thicknesses using vacuum coating systems. The optimal PLW parameters leading to the formation of CIS films included a pulse width of 1.0 ms, a spot diameter of 2.0 mm, and a repetition frequency of 10 Hz. The resulting CIS films exhibited a well-crystalline cubic structure with lattice parameters of 5.265 Å. Surface morphology analyses revealed the preferential formation of porous films with varying stoichiometry, a characteristic that could be manipulated by adjusting laser welding parameters. The energy band gap and room temperature electrical conductivity displayed values of 1.80 eV and 2.06×10^{-5} $(\Omega cm)^{-1}$, respectively. Cu-rich samples exhibited a wider energy band gap of 1.94 eV and lower electrical conductivity values of 4.78×10^{-7} $(\Omega cm)^{-1}$. The CIS film demonstrated n-type conductivity attributed to the formation of donor levels centered at 0.24 eV and 0.10 eV. This study presents an ultrafast method for fabricating CIS films with physical properties compatible with those produced using traditional methods.

Keywords: $CuInSe_2$; Pulsed laser welding; structural parameters; band gap; electrical conduction

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