Optical properties thin films of $Cu_2ZnSnSe_4$

Andriy I. Mostovyi, Mykhaylo M. Solovan, Viktor V. Brus, Pavlo D. Maryanchuk

Chernivtsi National University, 2 Kotsyubynsky str.,
58012 Chernivtsi, Ukraine

Development of photovoltaic PV materials comprised of non-toxic, earth abundant elements are considered to be a major criterion to meet the ever increasing demand for energy. Current PV technologies are mostly dominated by the two most promising thin-films solar cells i.e., CdTe and Cu(In, Ga)Se_2 (CIGS). However, due to price volatility issues (In, Ga), supply issues (In, Te) and environmental issues (Cd), these solar cell technologies are under scanner. Hence, the current research efforts are directed to search the new inexpensive and earth abundant materials as thin-film solar cells. To meet the aforementioned demands, one of the suitable candidates is $Cu_2ZnSn(S,Se)_4$ (CZTSSe) type compound, primarily because they contain only the abundant and inexpensive elements like Cu, Zn, Sn, S, and Se in compared with the corresponding CIGS [1]. The possibility of p-type doping by intrinsic defects and a high absorption coefficient, exceeding 10^4 cm^{-1}, in the visible range [2], make this new compound attractive for the application as an absorber layer in thin film solar cells.

This work is focused on the investigation of the optical properties thin films of $Cu_2ZnSnSe_4$. The precursors Cu_2ZnSn were fabricated in a universal coating system Laybold–Heraeus L560 by magnetron sputter deposition of a high-purity (99,99 %) target of Cu_2ZnSn in atmosphere of the argon at room temperature. The total thickness of the precursor was 500 nm.

The target of Cu_2ZnSn, a cylinder of 100 mm diameter and 5 mm thickness, was mounted on the magnetron table under water cooling 7 cm from the substrates. Before the deposition process started, the vacuum chamber was pumped down to a residual pressure of $5 \cdot 10^{-5}$ mbar. During the deposition process, the partial pressures of argon were equal to $3.5 \cdot 10^{-3}$ mbar. The magnetron power was 120 W. The substrate temperature was 300 K. The deposition process lasted for 30 min.

Precursors of Cu_2ZnSn were converted into the thin film $Cu_2ZnSnSe_4$ by annealing in Se vapor. The selenization procedure was carried out in a vapor of elemental selenium in a vacuum chamber. The highest selenization temperature is approximately 450-500°C at the 5-10 minutes. Obtained using this method thin film $Cu_2ZnSnSe_4$ is continuous and uniform of the thickness.

The transmission spectra of the $Cu_2ZnSnSe_4$ thin films were obtained by a spectrophotometer SF-2000. Experimental points were taken within the wavelength range 200 - 1100 nm in 1 nm. The effect of annealing in Se vapor on the energy band gap was studied.

[1] M.Kumar, C.Persson, *International Journal of Theoretical & Applied Sciences,* **5**, 1 (2013).
[2] F.Luckert, et al., *Applied Physics Letters,* **99**, 062104 (2011).