Photovoltaic Performance of CZTSe Based Solar Cells Grown by Two-Step Process

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Thin films of $Cu_2ZnSnSe_4$ (CZTSe) have drawn paramount attention to obtain the low-cost high-efficiency solar cells, owing to suitable direct band gap and large absorption coefficient for solar light absorption. In the present work, CZTSe films were grown by two-stage process which involved the deposition of stack CuZn/Sn/Cu precursors on Mo-coated glass substrates using DC-magnetron sputtering, followed by the selenization. Further, CZTSe based solar cell was fabricated with a configuration of Ag/Ni/Ga,Al:ZnO/i-ZnO/CdS/CZTSe/Mo/glass [inset in Fig. 1(a)] and its PV performance was systematically studied by illuminated current density-voltage (J - V) and quantum efficiency (QE) measurements. The X-ray diffraction (XRD) measurements indicated that as-synthesized CZTSe films had an intensive (112) peak at 27.18^o as the preferred orientation and exhibited tetragonal crystal structure with the average lattice parameters of a = b = 5.68 Å, and c = 11.32 Å [1]. The scanning electron microscope (SEM) images revealed that the films were uniform, pin-hole free and had regular grains with compact morphology. A thickness of 1600 nm for CZTSe film was found from cross-sectional SEM. The J - V characteristics of CZTSe cell under illumination with a light source of 100 mWcm^{-2} at AM 1.5 conditions, are shown in Fig. 1(a). The cell showed characteristic parameters such as, an open circuit voltage (V_{oc}) of 0.409 V, short circuit current density (J_{sc}) of 29.94 mA cm^{-2}, a fill factor (FF) of 37.13, giving a conversion efficiency of 4.56 % [2]. In addition, a series resistance (R_s) of 1.22 Ω-cm and a shunt resistance (R_{sh}) of 1976 Ω-cm were also evaluated. The external quantum efficiency (EQE) of CZTSe cell was measured as a function of wavelength of the incident light and is shown in Fig. 1(b). The QE curve showed an average efficiency of ~ 80 % and in the long wavelength region, the spectrum is restricted to the value of ~ 1200 nm corresponding to the absorption edge of CZTSe film. A band gap of 1.03 eV [3] for CZTSe film was calculated from the inset graph of Fig. 1(b). Hence the results suggested that two-stage approach for the fabrication of CZTSe can be adaptable for the low-cost high-efficiency solar cells.

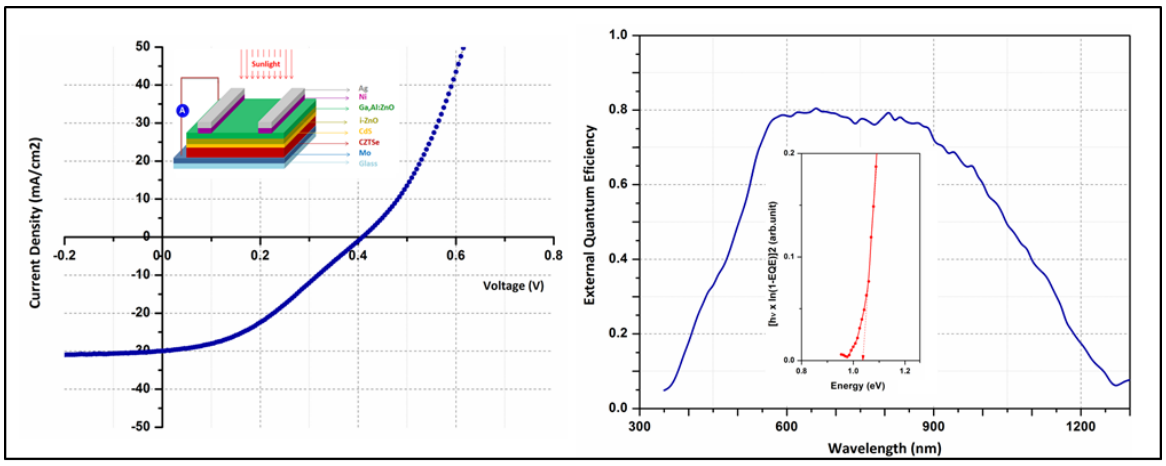

Fig. 1(a). Illuminated J – V (inset: cell structure) and (b) QE curves (inset: band gap graph)

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