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Perspective

Thin Film Solar cells for Future Solar Power Electronics: A Review on CZTSSe

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Abstract

This study reports the deep introduction of thin film CZTSSe solar cells and shows the advantages of CZTSSe solar cells over other semiconductor material thin film based solar cells. Drawbacks like low absorption coefficient, low mobility, optical band gap etc. are also discussed in this study. Various CZTSSe thin film deposition techniques, and many solar cell efficiencies achieved by different researchers are also discussed in this review article.

Introduction

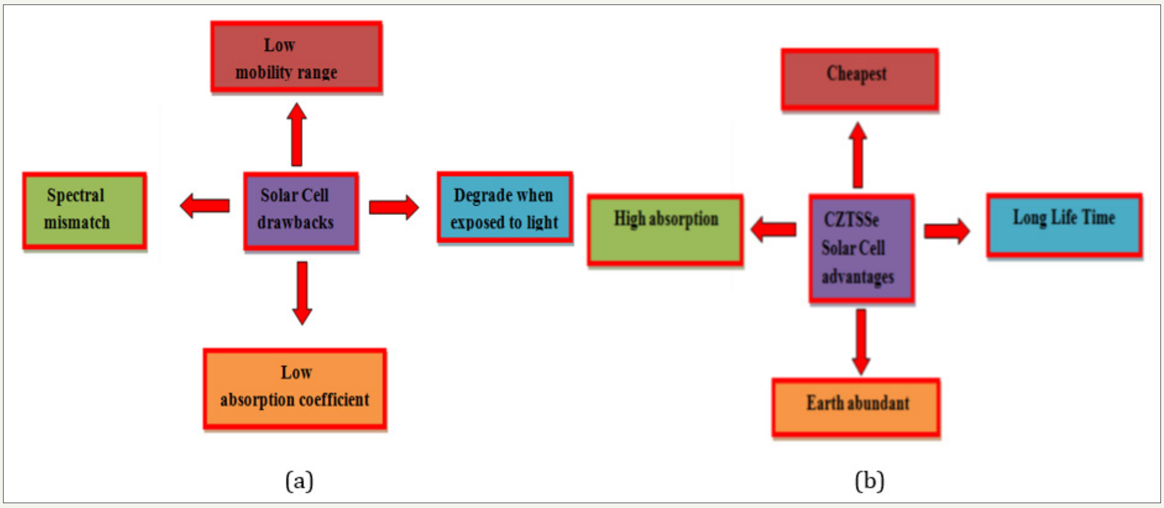

Figure 1: (a) Shows the disadvantages of solar cells and (b) advantages of CZTSSe thin film based solar cells.

Renewable energy sources like solar thermal energy, solar photovoltaic energy, and biomass conversion energy plays a vital role in everyday life, so these sources must be developed to meet the challenges of environment change. Among these energy sources, photovoltaic source is a very standard renewable source is foreseen to solve energy problem, which has the potential to convert a large amount of sunlight into electrical energy. A solar cell is an example of a photovoltaic device, i.e., a device that generates voltage when exposed to light. In such a device, absorption of photons results the excitation of charge carriers into conduction band. The basic mechanism regarding this light induced electron transition to a higher energy states is alike to that of photoelectric effect in which a photon carrying sufficient amount of energy frees an electron from metal surface. The devices which exploiting PV effect are called solar cells, also photovoltaic cells or photovoltaic devices. Solar cells based on thin films is a second-generation solar cell in which a thin layer or multilayer's of semiconducting material deposited on different substrates like glass, plastic or metal. There are several factors like lower absorption, spectral mismatch, lower mobility etc. (Figure1a) which could affect a cell's conversion efficiency. Amorphous silicon based solar cells ultimately degrade when exposed to light and their efficiency decreases by 10-20%. Modern-day technology calls for the development of eco-friendly compound semiconductor thin film having the tailor-made properties. However, chalcogenide based solar cells like CdTe, CIGS, CZTSSe etc. show good advantages over Silicon based solar cells. Selenium based quaternary kesterite compounds like mixed chalcogenide Cu_2ZnSn (SxSe1−x)4 (CZTSSe) and $Cu_2ZnSnSe_4$ (CZTSe) have emerged as the potential alternative to the existing CIGS and CdTe absorbers in thin film solar cells. Among which CZTSSe is an alternative option for absorbing material in thin film solar cells due to its tunable direct band gap of 1.0–1.5eV (optimum band gap), earth abundant having p-type conductivity and large optical absorption coefficient (>104cm^{-1}) [1-6] (Figure 1b). These advantages allow CZTSSe to complete head-to-head with silicon from a performance standpoint, but with the potential of lower cost due to the thin film nature of the solar cell device give extra superiority. CZTSSe conversion efficiency is also very stable over time, means its performance continuous unabated for many years. However, CZTSSe, has a PCE of 12.6%. Compared with CIGS, which has a PCE of 21.7% and CdTe, which has a power conversion efficiency (PCE) of 21.5% [7,8]. To improve the efficiency of a CZTSSe solar cell, it is important to minimize current and voltage losses. To do so, the grain crystallinity must be improved [9,10] the formation of secondary phases must be suppressed [10-13] and the presence of defects [13] the Na content, [13,14] and the band gap [13,15] in the absorber layer must be controlled. To overcome these disadvantages, various efforts had been made so far by different researchers for enhancing the PCE of CZTSSe solar cell up to 12.6% [7,8,13] Figure 2.

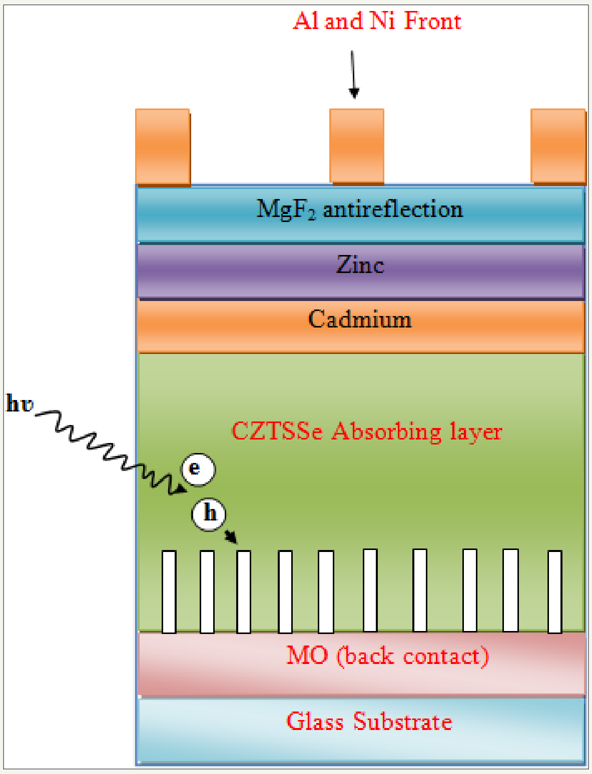

Figure 2: Shows schematic fabrication of CIGS solar cell.

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