Exploiting the Sb^{3+}-Thiourea complex for smooth and homogeneous Sb_2S_3 polycrystalline films.

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ABSTRACT

In recent years, antimony trisulfide (Sb_2S_3) has attracted increasing attention in solar cell research. As an alternative to other recent established technologies such as GaAs and formamidinium lead iodide perovskite, it possesses attractive properties such as suitable band gap (1.7 eV), high absorption coefficient (10^5 cm^{-1} at 450 nm), air/moisture-stability, and relative non-toxicity and earth-abundance of constituent elements. The key for an efficient photovoltaic device is the development of thick-enough, homogeneous, pinhole-free, smooth films with perfect optoelectronic quality. Several techniques have been utilized to deposit good Sb_2S_3 films, such as CBD [1], ALD [2], hydrothermal growth [3] and evaporation under vacuum [4]. Even though the results were promising, these techniques have specific disadvantages such as enhanced energy consumption and complexity of the experimental setup. On the other hand, spin-coating is a very attractive and simple method assuring fast deposition and quality for the produced films. However, the attempts to fabricate Sb_2S_3 films without the need of a porous substrate (usually mesoporous titania) are limited, either resulting in too thin films, or not exhibiting great coverage and homogeneity [5]. Herein we report a facile and, seemingly, highly reproducible one-step deposition method to prepare Sb_2S_3 thin films, where antimony acetate ($SbAc_3$) au lieu of $SbCl_3$, and thiourea (TU) as sulfur source, are employed, targeting at the $SbAc_3$.TU adduct as a precursor compound to control crystallization kinetics and form highly crystalline Sb_2S_3 after thermal decomposition. Several optimizations including the concentration of $SbAc_3$ and TU in DMF solvent, different solvent media (DMSO, methanol) as well as molar ratio between $SbAc_3$ and TU have been carried out. The films were characterized by optical (UV-Vis, photoluminescence) spectroscopies along with AFM and SEM microscopies. Amorphous orange Sb_2S_3 films will serve as window layers in conventional lead halide perovskite solar cells, while black orthorhombic Sb_2S_3 will be implemented in n-i-p solar cells and their photovoltaic performance and stability will be properly examined.

KEYWORDS: antimony sulfide, thin film, solar cells, photoactive layer, spin coating, perovskites, electron transfer layer.

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