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IMPACT OF POST-ANNEALING TEMPERATURE ON SILVER BISMUTH SULFIDE QUANTUM DOT-SENSITIZED SOLAR CELLS FABRICATED BY SUCCESSIVE IONIC LAYER ADSORPTION AND REACTION METHOD

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Nontoxic semiconductor materials are becoming increasingly used for solar cell fabrication and among them, silver bismuth sulfide ($AgBiS_2$) is a forefront ternary semiconductor material. $AgBiS_2$ nanocrystal has a high absorption coefficient, high mobility, and tunable bandgap. In this study, the performance of $AgBiS_2$ quantum dot-sensitized solar cells was investigated based on post-annealing temperature. $AgBiS_2$ quantum dots (QDs) were deposited on a TiO_2 mesoporous layer using the successive ionic layer adsorption and reaction (SILAR) method, with the optimal number of SILAR cycles being determined to be three. After deposition, $AgBiS_2$ QDs solar cells were kept overnight and subsequently annealed at 50, 100, 150 and 200 °C for one hour on a hotplate in ambient air. Raising the annealing temperature to 100 °C increased the short-circuit current density, open-circuit voltage, and fill factor. However, further increasing the annealing temperature resulted in degradation of solar cell performance. The cell with the configuration of FTO/m-TiO_2/$AgBiS_2$/polysulfide-electrolyte/Cu_2S-brass plate annealed at 100 °C has the maximum power conversion efficiency of 0.6%. The observed variations in solar cell performance of FTO/m-TiO_2/$AgBiS_2$/polysulfide-electrolyte/Cu_2S-brass plate electrodes have a direct relationship with the post-annealing temperature of $AgBiS_2$ QDs. Transmission electron microscopy study showed the formation of $AgBiS_2$ QDs with crystalline phases of 200 and 220 for the pre-annealed $AgBiS_2$ QDs at 100 °C, and Energy-dispersive X-ray spectroscopy data validated the presence of Ag, Bi, and S on the TiO_2 mesoporous layer. X-ray diffraction analysis revealed that post-annealing of $AgBiS_2$ film enhanced the 111 and 222 crystalline phases, while the 200 and 220 crystalline phases increased up to 100 °C and subsequently decreased. UV-Vis spectra revealed that increasing the annealing temperature up to 100 °C increased the absorption of $AgBiS_2$ QDs, whereas above 100 °C absorbance was reduced and the absorption peak was red shifted by 70 nm.

Keywords: $AgBiS_2$, Crystallinity, Nontoxic, Post-annealing