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The effect of a thin ZnS passivation layer on q-dot $AgBiS_2$ for enhancing the solar cell performance

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Quantum dot solar cells fabricated with innovative ternary semiconductor materials are emerging as a viable alternative to thin-film solar cells made from CdS and CdTe. Among them, $AgBiS_2$, a non-toxic ternary semiconductor material with a high absorption coefficient, mobility, and configurable band gap, is the forefront material. Coating a wide band gap material such as ZnS on quantum dots notably impacts their performance. In this study, $AgBiS_2$ quantum dots were prepared on a TiO_2 mesoporous layer using the successive ionic layer adsorption and reaction (SILAR) method, and solar cell performance was observed by coating a ZnS layer between the TiO_2/$AgBiS_2$ q-dot interface and the $AgBiS_2$/polysulfide electrolyte interface. The formation of $AgBiS_2$ and ZnS can be confirmed by XRD, EDS, and TEM analysis. The cell configuration FTO/m-TiO_2/$AgBiS_2$/polysulfide electrolyte/Cu_2S-brass without a ZnS layer demonstrated an efficiency of 0.59%. One SILAR cycle at the TiO_2/$AgBiS_2$ interface and two SILAR cycles at the $AgBiS_2$/polysulfide electrolyte interface give the best ZnS coating efficiency of 0.7% and 0.8%, respectively. Using an optimal ZnS layer in the FTO/m-TiO_2/ZnS(I)/$AgBiS_2$/ZnS(II)/polysulfide electrolyte/Cu_2S-brass configuration boosts efficiency to 0.94%. UV-Vis spectra of the FTO/m-TiO_2/ZnS(I)/$AgBiS_2$ cell configuration indicated an increase in light absorption after the first SILAR cycle, followed by a decrease in absorbance with subsequent cycles of $AgBiS_2$. For the TiO_2/$AgBiS_2$/ZnS(II) configuration, UV-Vis spectra indicated that ZnS coating enhanced the light absorption properties of $AgBiS_2$ quantum dots and induced a slight blue shift in the absorption peak after the first and second SILAR cycles. Subsequent coating of ZnS leads to the red-shift of absorption peak while decreasing the light absorption by $AgBiS_2$. Optimizing the number of ZnS cycles at both the TiO_2/$AgBiS_2$ q-dot and $AgBiS_2$/polysulfide electrolyte interfaces can enhance solar cell efficiency and the efficiency can be further improved by incorporating optimal ZnS layers within the FTO/m-TiO_2/ZnS/$AgBiS_2$/ZnS/polysulfide electrolyte/Cu_2S-brass cell configuration.

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