High-performance perovskite/silicon heterojunction solar cells enabled by industrially compatible post annealing

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Abstract

In recent years, developing dopant-free carrier-selective contacts, instead of heavily doped Si layer (either externally or internally), for crystalline silicon (c-Si) solar cells have attracted considerable interests with the aims to reduce parasitic light absorption and fabrication cost. However, the stability still remains a big challenge for dopant-free contacts, especially when thermal treatment is involved, which limits their industrial adoption. In this study, a perovskite material $ZnTiO_3$ combining with an ultrathin (˜1 nm) SiO_2 film and Al layer is used as an electron-selective contact, forming an isotype heterojunction with n-type c-Si. The perovskite/c-Si heterojunction solar cells exhibit a performance-enhanced effect by post-metallization annealing when the annealing temperature is 200-350 °C. Thanks to the post-annealing treatment, an impressive efficiency of 22.0% has been demonstrated, which is 3.5% in absolute value higher than that of the as-fabricated solar cell. A detailed material and device characterization reveal that post annealing leads to the diffusion of Al into $ZnTiO_3$ film, thus doping the film and reducing its work function. Besides, the coverage of SiO_2 is also improved. Both these two factors contribute to the enhanced passivation effect and electron selectivity of the $ZnTiO_3$-based contact, and hence improve the cell performance.

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challenge for dopant-free contacts, especially when thermal treatment is involved, which limits their industrial adoption. In this study, a perovskite material $ZnTiO_3$ combining with an ultrathin (~1 nm) SiO_2 film and Al layer is used as an electron-selective contact, forming an isotype heterojunction with n-type c-Si. The perovskite/c-Si heterojunction solar cells exhibit a performance-enhanced effect by post-metallization annealing when the annealing temperature is 200-350 °C. Thanks to the post-annealing treatment, an impressive efficiency of 22.0% has been demonstrated, which is 3.5% in absolute value higher than that of the as-fabricated solar cell. A detailed material and device characterization reveal that post annealing leads to the diffusion of Al into $ZnTiO_3$film, thus doping the film and reducing its work function. Besides, the coverage of SiO_2 is also improved. Both these two factors contribute to the enhanced passivation effect and electron selectivity of the $ZnTiO_3$-based contact, and hence improve the cell performance.

Keywords: perovskite, dopant-free, carrier-selective contacts, thermal stability, silicon solar cells.