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Seed Layer–assisted Low Temperature Solution Growth of 3D ZnO Nanowall Architecture for Hybrid Solar Cells

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Abstract

Aligned metal oxide nanostructures carry electrons efficiently, and are therefore ideal building blocks for next-generation optoelectronic devices. Herein, we report the seed-layer-assisted low-temperature solution growth of aligned 3D ZnO nanowall architecture on arbitrary substrates. By introducing a controlled amount of Al into a seed-layer, the morphology of ZnO nanostructure is gradually changed from nanowire to 3D nanowalls. Time-dependent growth experiments suggest that hydroxyl-ions present in growth solution react with Al to form Al(OH)$_4^-$ which in turn binds to the positively charged Zn$^{2+}$ surface and partially blocking ZnO growth along the (0001) direction and promoting lateral growth. Such aligned 3D ZnO nanowall architecture, with the unique combination of high surface-area and cage-like pores, grown on seed-layer coated transparent conductive substrate is found to be beneficial for electron transporting material (ETM) in perovskite solar cells and a maximum photocurrent density ($J_{SC}$) of 7.5 mA.cm$^{-2}$ and a power conversion efficiency (\(\eta\)) of 2.4 % are demonstrated. Our facile approach readily allows further growth of ZnO nanowires on 3D ZnO nanowall surface; thereby improving the perovskite-ZnO interface and increasing the $J_{SC}$ and $\eta$ to 9.7 and 3.3 %, respectively. This 3D ZnO nanowall–nanowire architecture opens up a novel configuration for designing high-performance optoelectronic devices.
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