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Deposition of Ni Nanoparticles on Black TiO_2 Nanowire Arrays for Photoelectrochemical Water Splitting by Atomic Layer Deposition

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Abstract

Ni nanoparticles were deposited on to black TiO_2 nanowire arrays by atomic layer deposition (ALD) using $Ni(dmap)_2$ (dmp = dimethylamino-2-propoxide) as precursors. The size of the Ni nanoparticles was well controlled by the number of ALD cycles. The growth rate of the nanoparticles on the black TiO_2 nanowire arrays was 0.5 Å/cycle, which was comparable with that on the pristine samples, even though a surface amorphous layer was formed. When the Ni ALD was applied to the pristine and black TiO_2 nanowire arrays, both samples exhibited an enhanced absorption in the visible light range. Interestingly, the maximum absorption was observed for the black TiO_2 nanowire arrays due to the higher polarization that induced the stronger surface plasmon resonance (SPR) of the Ni nanoparticles. The wavelength of the absorption red shifted from 440 to 500 nm when the cycle number increased from 25 to 100. The highest intensity of the absorption was obtained for 50 cycles of Ni ALD. This was attributed to the inter-particle interaction related to the size and loading density of the Ni nanoparticles. 50 cycles of Ni ALD on the black TiO_2 nanowire arrays exhibited the most effective photoresponse in the visible light range, resulting in a higher carrier concentration. As a consequence, a superior photoelectrochemical water splitting property was obtained.

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