Ni-Based Nanowire Co-catalysts Integrated with a Si Photoanode for Efficient Water Oxidation

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Photoelectrochemical water splitting is a sustainable pathway to produce clean hydrogen fuel. Due to the slow kinetics of the oxidation evolution reaction (OER), the realization of an efficient photoanode remains a great challenge. To lower the overpotential (η) for OER, crystalized and amorphous metal oxides integrated with photoanodes have been recently utilized as excellent co-catalysts. Considering the high cost of noble metal oxide catalysts due their scarcity, such as IrO_2 and RuO_2, earth-abundant transition metal oxides, such as Ni-based nanowire electrocatalysts, hold promises for cost-effective and yet efficient water splitting. Compared to the limitation in charge extraction capability and light blocking of the conventional particle-based co-catalysts, the flexibility of engineering the morphology and the surface properties of templated Ni-based nanowire co-catalyts is enormous. That is, highly-ordered templated Ni-based nanowire co-catalyts can be advantageous for their light trapping, large surface-to-volume ratio, rapid carrier extractions, anti-reflection properties beside lowering the overpotential (η).

We demonstrate that engineering the morphology of templated Ni-based nanowire co-ctaltysts on Si photoanode can lead to efficient OER. We shall further show that optimizing the surface properties of the nanowire co-catalysts by incorporating other divalent metal dopants such as Co and Fe can lead to efficient and stable water oxidation with low overpotentials.

In this work, Ni-based nanowires arrays are deposited electrochemically and physically on various substrates using ultrathin anodic aluminum oxide (AAO) template. The length, diameter and thickness of nanowires can be varied depending on the pores' dimensions and thickness of the AAO membrane leading to controllable co-catalysts morphology. Shown in Fig. 1 is the scanning electron microscopy (SEM) image of pristine NiO nanowires deposited electrochemically on ITO substrate. We shall further show that by optimizing the surface charge properties through the deposition techniques and incorporating Co and Fe dopants, the overpotential for OER can be substantially reduced. Full electrochemical properties using three-electrode configuration in NaOH electrolyte will be presented. Further elemental and structural properties of the nanowire co-catalysts shall be thoroughly discussed.

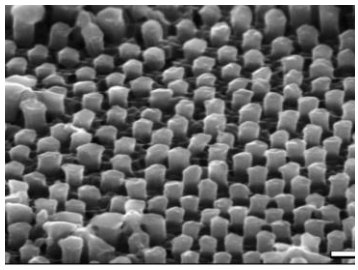


Fig. 1. SEM image of NiO nanowire arrays electrochemically deposited on ITO substrate.

In brief, the use of such nanowire co-catalysts integrated with Si photoanode for high efficient and stable photoelectrochemical water splitting shall be demonstrated. This detailed study confirms that the morphology and surface Ni-based nanowire co-catalysts doped with Co and Fe can lead to lower OER overpotential.

Keywords: Photoelectrochemical water splitting, Ni-based electrocatalysts, Hydrogen generation
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