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Ultra-thin metallic oxide nanowires synthesized by plasma afterglow-assisted oxidation

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Many parameters can affect the efficiency of water splitting, which requires a smart engineering of the photocatalyst in order to enhance light absorption, charge diffusion and splitting efficiency of water molecules.
The photocatalyst's band gap is an important parameter that controls photon absorption. The narrower the band gap the broader the absorbed part of the solar spectrum and the higher the number of generated charge carriers. Besides, small dimensions and high crystallinity can reduce the loss of charge carriers by recombination. Then, in order to achieve high-efficiency water splitting effect, the conduction band of the semi-conductor should lie slightly below the H^+/H_2 potential (NHE) while the valence band edge should be pinned slightly above the O_2/H_2O potential. As a result, the photocatalyst material should possess a band gap slightly larger than 1.23 eV for overall water splitting.
In this work, we show how to control the size of CuO and ZnO nanowires by oxidizing respectively an iron-copper alloy and a zinc-copper bi-layer film by using a flowing microwave plasma afterglow oxidation process. The aspect ratio of the nanowires can be controlled by the experimental parameters: treatment duration, furnace temperature, oxygen concentration, etc. So, by adjusting these treatment parameters, we succeed in decreasing the average diameter of these nanowires down to 4 nm in the case of ZnO and to 5 nm in the case of CuO, with a fairly high surface number density for very short treatments, typically less than 1 minute.
For CuO nanowires, which already possess a narrow band gap (2.2 eV), quantum confinement effects should be observed and shift the conduction band to a suitable position for hydrogen production. For ZnO nanowires, which possess a large band gap (3.4 eV), nitriding should allow us decrease their band gap.

Keywords
low-pressure plasma
flowing afterglow
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