Flame Synthesized Metal Oxide Nanowires as Effective Photoanodes for Photoelectrochemical Water-Splitting

Xiaolin Zheng

Dept. Mechanical Engineering, Stanford University, Stanford, CA 94305, USA

I will discuss an atmospheric, cost-effective and scalable flame synthesis method for the growth and doping of metal oxide nanowires and these nanowires (NWs) exhibit superior photoelectrochemical (PEC) performance due to their high crystallinity, great morphology tunability and chemical composition control. First, arrays of tungsten trioxide (WO_3) NWs are synthesized on fluorinated tin oxide (FTO) coated glass substrates by rapid, atmospheric flame vapor deposition, in which a flame oxidizes and evaporates tungsten metal to produce tungsten oxide vapors that condense onto a colder FTO substrate with tunable morphologies of NWs. Importantly, the WO_3 NWs synthesized by flame have higher areal number density and longer length than state-of-the-art WO_3 NW photoanodes grown by chemical vapor deposition and hydrothermal methods, resulting in stronger light absorption and doubled saturation photocurrent. Second, the flame synthesized WO_3 NWs are further coated with thin $BiVO_4$ shells to form a core/shell heterojunction NW array. The $WO_3/BiVO_4$ heterojunction NW array utilizes the individual strengths of WO_3 (good electron transport) and $BiVO_4$ (strong light absorption) and outperforms all other WO_3 or $BiVO_4$-based photoanodes in the literature, regardless of doping, heterojunction, or catalyst. Finally, we report a novel *ex-situ* method to codope rutile TiO_2 with (W, C) pair by sequentially annealing tungsten (W)-precursor coated TiO_2 nanowires in flame and CO. The unique advantages of the flame annealing are that the high temperature and heating rate of flame enable rapid diffusion of W into TiO_2 that prevents the damage of TiO_2 nanowire morphology and crystallinity, and the delicate glass substrate. Significantly, this is the first experimental demonstration that the codoped TiO_2:(W, C) nanowires doubles the saturation photocurrent of undoped TiO_2 for PEC.

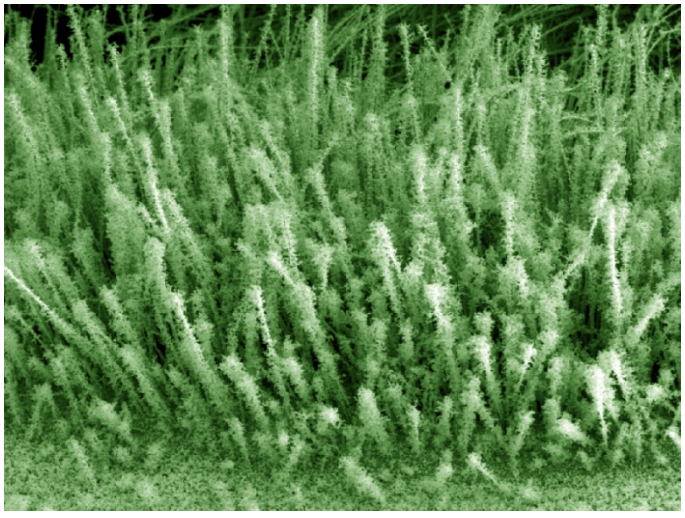

Figure 1. Flame synthesized hierarchical metal oxide nanowires.

For additional information: http://www.stanford.edu/group/zheng