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Fabrication of electrode materials for energy conversion and storage by electrochemical deposition

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Abstract:

In this presentation, the facile and low-cost electrodeposition techniques would be introduced for the fabrication of electrode materials in energy conversion and storage systems. Firstly, we successfully employed electrodeposition techniques to modify the TiO_2 photoanodes in dye-sensitized solar cells (DSCs) and fabricate the TiO_2 thin films as photoanodes in perovskite solar cells (PSCs). For instance, an efficient post-treatment of photoanodes including mesoporous TiO_2 beads in DSCs using a facile and low-cost pulsed deposition technique. As result of the post-treatment with pulse-current (PC) anodic deposition of a TiO_2 thin film, the cell performance of a DSC assembled with the PC-modified photoanode is significantly improved from 7.82% to 8.57%, due to the significantly increased photocurrent (from 16.87 to 18.80 mA cm^{-2}), which was even higher than those using the photoanodes modified with $TiCl_4$ post-treatment (7.82%) and direct-current (DC) anodic deposition (8.28%). Secondly, the electrodeposition of TiO_2 thin film with soft-template technique will be demonstrated to modify the as-prepared blocking layer (BL) and functionalize the porous layer (PL) of photoanodes in PSCs. We found that the pin holes displayed in the as-prepared TiO_2 BLs can be addressed after the TiO_2 electrodeposition, and therefore reduce the electron recombination. Moreover, the cell performance of the PSCs based on the electrodeposited TiO_2 thin films was remarkably improved from 12.38% to 13.09%, while the soft template was employed during the electrodeposition. The enhancement in the cell performance can be ascribed to the significantly increased photocurrent density (from 16.78 to 18.51 mA cm^{-2}) due to the increased surface area. Secondly, a pulse-reversal deposition mode was developed to directly fabricate Ni_3S_2 thin film on nickel foam as electrode for supercapacitors (SCs). The pulsed Ni_3S_2 electrode can deliver remarkable specific capacity up to 179.5 mAh g^{-1} and 105.9 $mAhg^{-1}$ at charge–discharge current density at 2 A g^{-1} and 32 A g^{-1} in 1.0 M KOH aqueous electrolyte, respectively. Additionally, the optimal pulsed Ni_3S_2//carbon fiber cloth hybrid SC can be reversibly charged and discharged at a stable cell voltage of 1.8 V and generate an impressive specific capacity of 25.5 mAh g^{-1} at current density of 0.5 A g^{-1}, which can deliver a maximum energy density of 28.8Wh kg^{-1} at a power density of 684Wkg^{-1}.