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TiN-coated micron-sized tantalum-doped $Li_4Ti_5O_{12}$ with enhanced anodic performance for lithium-ion batteries

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Abstract

Micron-sized $Li_4Ti_5O_{12}$ with both surface modification (TiN) and inner Ta^{5+} doping has been synthesized via a combination of solid-state reaction and surface thermal nitridation. The physical and chemical properties of all samples are tested systematically. The results demonstrate that tantalum is successfully doped in the lattice of $Li_4Ti_5O_{12}$ and a thin amorphous TiN coated on the surface of the $Li_4Ti_5O_{12}$ particles. The TiN coating layer enhances surface electronic conductivity and electrical contact between particles, while Ta^{5+} bulk doping in the lattice improves the intrinsic ionic conductivity and electronic conductivity inside particles. Being used as anode materials for lithium-ion batteries, the co-doped $Li_4Ti_5O_{12}$ electrode shows much better electrochemical performance (144.5 mAh g^{-1} at 5C after 500 cycles with a capacity retention of 91.63%) than that of pristine $Li_4Ti_5O_{12}$ and mono tantalum doped or TiN coated $Li_4Ti_5O_{12}$, only Ta-doped $Li_4Ti_5O_{12}$ delivers 112.1 mAh g^{-1} at 5C after 500 cycles and the TiN-coated $Li_4Ti_5O_{12}$ electrode only retains 122.6 mAh g^{-1} at 5C after 500 cycles. This design by exploring both surface modification and bulk doping is highly attractive for high performance $Li_4Ti_5O_{12}$ manufacturing and may be applicative to other micron-sized electrode materials with inferior conductivity.

Keywords: Lithium titanate; Surface modification; Bulk doping; Lithium-ion

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