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## TiN-coated micron-sized tantalum-doped Li<sub>4</sub>Ti<sub>5</sub>O<sub>12</sub> with enhanced anodic performance for lithium-ion batteries

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## Abstract

Micron-sized Li<sub>4</sub>Ti<sub>5</sub>O<sub>12</sub> with both surface modification (TiN) and inner Ta<sup>5+</sup> 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<sub>4</sub>Ti<sub>5</sub>O<sub>12</sub> and a thin amorphous TiN coated on the surface of the Li<sub>4</sub>Ti<sub>5</sub>O<sub>12</sub> 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<sub>4</sub>Ti<sub>5</sub>O<sub>12</sub> electrode shows much better electrochemical performance (144.5 mAh g<sup>-1</sup> at 5C after 500 cycles with a capacity retention of 91.63%) than that of pristine Li<sub>4</sub>Ti<sub>5</sub>O<sub>12</sub> and mono tantalum doped or TiN coated  $Li_4Ti_5O_{12}$ , only Ta-doped  $Li_4Ti_5O_{12}$  delivers 112.1 mAh g<sup>-1</sup> at 5C after 500 cycles and the TiN-coated Li<sub>4</sub>Ti<sub>5</sub>O<sub>12</sub> electrode only retains 122.6 mAh g<sup>-1</sup> at 5C after 500 cycles. This design by exploring both surface modification and bulk doping is highly attractive for high performance Li<sub>4</sub>Ti<sub>5</sub>O<sub>12</sub> 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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