High power and high safety oxide-based negative electrode materials for Li-ion battery

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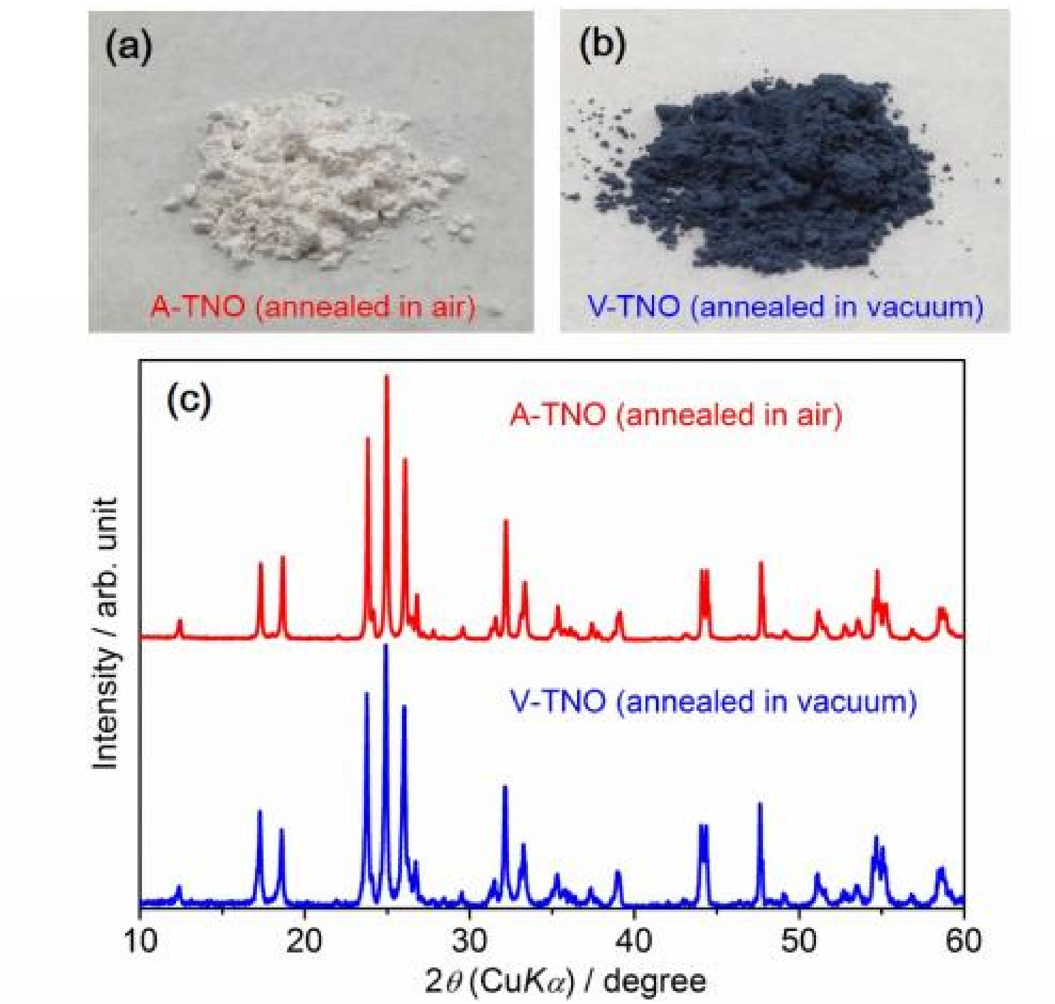


Photos of TNO annealed in air (A-TNO) (a) and vacuum (V-TNO) (b). X-ray diffraction patterns for both samples is also shown in (c). Credit: (c) Toyohashi University of Technology

Toyohashi Tech researchers in Japan show electrochemical Li insertion and deinsertion property of Ti-Nb mixed oxide Ti2Nb10O29 (TNO) at high current rate is greatly improved by vacuum annealing. This is mainly attributed to enhancement of intrinsic electronic conductivity of TNO by introducing oxygen vacancy. Vacuum-annealed TNO is promising negative electrode material of high power and high safety Li-ion battery for large scale application.

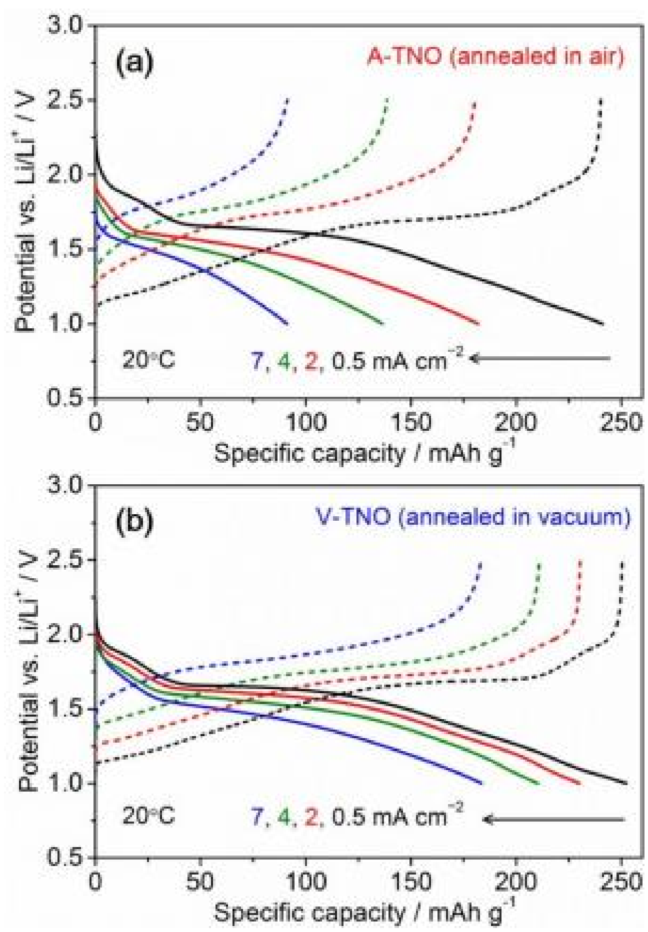
Mixed Ti-Nb oxide Ti2Nb10O29 (TNO) is one of the negative electrode materials for large scale Li-ion battery with high safety because the potential (= 1.6 V vs. Li/Li+) for Li storage of TNO should avoid possible Li plating or formation of Li dendrites and the short circuit of the battery to fire the flammable organic liquid electrolyte.

TNO shows the reversible capacity of 250 mAh g-1 at low current rate and good cycle stability. However, TNO is insulating materials and its electronic conductivity is quite low, which leads to the poor electrochemical performance at high current rate.

Here, Toshiki Takashima, Ryoji Inada, Yoji Sakurai and colleagues at Department of Electrical and Electronic Information Engineering, Toyohashi University of Technology show the improvement of electrochemical performance of TNO at high current rate by vacuum annealing.

The photos and X-ray diffraction patterns of TNO annealed in air and vacuum are compared in Fig. 1. Although the crystal structure is not changed by the difference annealing atmosphere, the color of TNO is changed from white to dark blue by vacuum annealing, indicating that the presence of the mixed Ti4+/Ti3+ ions.

Thermogravimetric analysis clearly shows small amount of oxygen vacancy is introduced by vacuum annealing, which causes partial reduction from Ti4+ to Ti3+ in TNO. By addressing this fact, vacuum-annealed TNO (V-TNO) shows much higher electronic conductivity (10-6?10-5 S cm-1) than air-annealed one (A-TNO) at room temperature.



Charge (solid lines) and discharge (dashed lines) curves at different fixed current densities of 0.5, 2, 4 and 7 mA cm-2 for (a) A-TNO and (b) V-TNO electrodes are shown. Credit: (c) Toyohashi University of Technology

Fig. 2 shows the comparison of charge and discharge curves of both A-TNO and V-TNO electrodes at various fixed current densities per unit electrode area of 0.5, 2, 4 and 7 mA cm-2. The charge and discharge capacities for both electrodes are decreased monotonically with increasing current densities, but V-TNO shows larger capacity than A-TNO under the current density above 2 mA cm-2. This tendency becomes more remarkable as the current density is increased.

The improved electrochemical performance of V-TNO electrode at high current rate is mainly attributed to enhancement of intrinsic electronic conductivity. V-TNO can potentially be used as novel negative electrode material of Li-ion battery with high power and high safety for large scale applications such as hybrid electric vehicles and energy storage system.

More information: *Journal of Power Sources*, 276, 113-119 (2015). DOI: 10.1016/j.jpowsour.2014.11.109

Provided by Toyohashi University of Technology

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