Engineering artificial solid electrolyte interface via carbon coating and VC additive for SnO_2 thin-film lithium-ion anodes

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Lithium-ion microbatteries (LIBs) are energy storage systems that can power at microscale. They should have a high energy density and show durable cycling behavior [1]. Tin dioxide (SnO_2) is of particular interest as an anode material, as it has a high theoretical capacity of 1494 $mAhg^{-1}$, which significantly exceeds the performance of traditional graphite anodes. Furthermore, SnO_2 is an accessible, inexpensive, and environmentally friendly material, making it promising for the creation of next-generation environmentally friendly microbatteries [2]. However, the huge volume changes during lithium ion insersion/extraction led to capacity decay due to materials pulverization and solid electrolye interface (SEI) redormation.

In this study, we attemted to build stable SEI layer, which can prolong cycle life of SnO_2 anode. SnO_2 thin-film anodes were obtained by RF magnetron sputtering, followed by thermal treatment to increase crystallinity and enhance surface morphology. First, the film surface was coated with carbon in order to prevent the initial side reactions on the SnO_2 surface. Secondly, the vinylene carbonate (VC) additive was added to electrolyte to create more smooth inbreakable SEI layer.

Electrochemical performance was evaluated using cyclic voltammetry and galvanostatic charge–discharge measurements conducted at a current rate of 0.1 C in the voltage range of 0.01-3.0 V. A comparative study was conducted to evaluate the electrochemical properties of C-coated SnO_2 anodes in two types of electrolytes: a bare 1 M $LiPF_6$ in a mixture of EC:DEC:EMC (1:1:1 by volume) and the same electrolyte mixture but with the addition of 5 wt.% VC. Thus, the electrode was covered by carbon and then additional VC-based layer during SEI formation in the initial cycles. The obtained data indicate a significant influence of the each layers on the behavior of the anode.

Figure 1 shows SEM images of the surface of thin films. The pure SnO_2 sample showed a porous surface with visible microcracks, caused by thermal treatment. In comparison, the C-coated SnO_2 had a morphology that is more dense and even, with a smoother surface and fewer cracks, indicating increased structural stability.

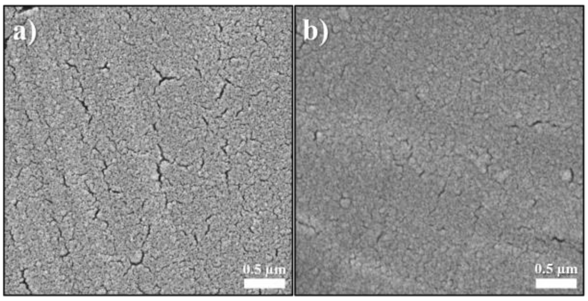

Figure 1. SEM surface images of SnO_2 (a) pure SnO_2, (b) C-coated SnO_2 thin film.

The presented electrode material exhibits outstanding stability and capacity retention, making it a promising candidate for next-generation energy storage systems.

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References

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