SnO_2–Embedded Nanoporous Carbons as an All-Solid-State LIB Electrode

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Conventional researches on all-solid-state lithium ion batteries (ASS–LIBs) have focused on the fabrication of highly dense electrode layer and solid electrolyte (SE) layer as well as their close contact interface to yield enough Li ion conducting paths. However, large capacity active materials such as Si, Sn, SnO_2 and so on, which were accompanied with large volume change in their Li–alloying/dealloying and metal oxide to metal conversion reactions, were difficult to apply to the present ASS–LIB system. Here, we report on the first attempt of applying active material-embedded porous carbon electrode materials to ASS–LIBs. A SnO_2–embedded nanoporous carbons in ASS-LIB system showed high capacity and good cycle stability superior to those in the organic electrolyte system.

Experimental: Synthesis of SnO_2 nanocrystallites in porous carbons was carried out by introducing $SnCl_2$ vapor into the carbon nanopores with the average diameter of 45 or 140 nm, a subsequent hydrolysis and dryness according to the previous report [1, 2]. In the following, the porous carbon and the SnO_2-embedded carbon nanocomposites are denoted as C*X* and SnO_2/C*X*[*Y*], where *X* and *Y* indicate the pore diameter of porous carbon and the loading amount of SnO_2, respectively. The charge-discharge measurements were carried out on an all-solid-state (ASS) half-cell, which was composed of a working electrode (WE) of mixture of SnO_2/C*X*[*Y*] sample and LiI-Li_2S-P_2S_5 (SE), SE layer and a Li-In counter electrode.

Results and discussions: Preferential embedding of SnO_2 nanocrystallites with the size of ca. 3 nm into nanopores of porous carbons was confirmed by XRD measurements, SEM, TEM (Figure 1) and N_2 ad-/desorption isotherm measurements. Figure 2 shows the charge-discharge properties of SnO_2/C*X*[*Y*] in the ASS system during cycling. The charge-discharge capacity based on SnO_2 weight was increased with increasing the loading amount. The tendency was quite different from that in organic liquid electrolyte system, which was previously reported that the capacity was almost constant with the increase in SnO_2-loading amount and dropped above 65 wt% loading [2]. It can be considered that Li ions were conducted in the composite though the active materials in carbon nanopores. The SnO_2/C*X*[*Y*] also showed good cycle performance.

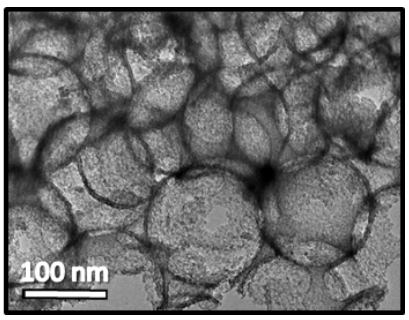

Figure 1 TEM image of SnO_2/C140[65]

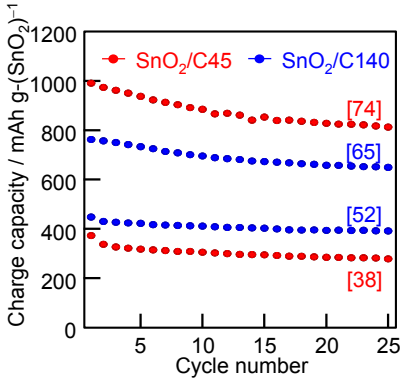

Figure 2 Charge capacities of SnO_2/CX[Y] as a function of cycle number

References:
[1] S. Oro, K. Urita, I. Moriguchi, *J. Phys. Chem. C* **,** 120 (2016) 25717-25724.
[2] S. Oro, K. Urita, I. Moriguchi, *Chem. Commun*., 50 (2014) 7143-7146.