Microstructure and Electrochemical Properties of LBO-coated Li-Excess $Li_{1+x}Mn_2O_4$ Cathode Material at Elevated Temperature for Lithium Ion Battery

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In a lithium-ion battery system, the cathode material plays an important role in its electrochemical performance. $LiMn_2O_4$ with spinel structure is one of the most promising cathode material due to the merit of cost effectiveness and friendly environmental issue. However, the poor cyclability of $LiMn_2O_4$ would limit its utilization in commercial usage. Surface modification on cathode electrode is an effective way to solve this problem. In this study, lithium borate glass (Li_2O-$2B_2O_3$) coated on the surface of the lithium manganese oxide cathode material has been synthesized to achieve electrochemical cyclability and structural stability.

In this work, an amorphous glass film was coated on the surface of the cathode material by solution method. The Li-excess cathode powder $Li_{1+x}Mn_2O_4$ derived from co-precipitation method [1] was calcined with various weight percentage of the surface modified lithium boron glass. Fine powders with distinct particle size, size distribution and morphology were fabricated. The appropriate heat treatment temperature was evaluated by thermogravimetry/differential thermal analysis (TG/DTA). The structure of LBO-coated $Li_{1+x}Mn_2O_4$ was confirmed to be the pure spinel phase by the X-ray diffractometer (XRD), as shown in Fig. 1. The electron probe microanalyzer (EPMA) was employed to evaluate the composition of LBO-coated $Li_{1+x}Mn_2O_4$. Figure 2 shows the field emission scanning electron microscope (FE-SEM) image, and the particle size was measured by Laser Scattering. The morphology of LBO-coated $Li_{1+x}Mn_2O_4$ with an amorphous film was corresponding to that of well-defined crystal facet and regular shape of octahedral, and the average particle size was in the range of several microns. The electrochemical behavior of the cathode powder was examined by using two-electrode test cells consisted of a cathode, metallic lithium as anode, and an electrolyte of 1M $LiPF_6$. Cyclic charge/discharge testing of the coin cells, fabricated by both LBO-coated and bare $Li_{1+x}Mn_2O_4$ material were conducted. Figure 3 indicates that the coated cathode powder showed better cyclability than the bare one after the cyclic test. The phase and morphology of LBO-coated $Li_{1+x}Mn_2O_4$ after cycling were also investigated by XRD, TEM and FESEM. It is demonstrated that the employment of LBO glass coated $Li_{1+x}Mn_2O_4$ cathode material exhibited higher discharge capacity and significantly reduced the fading rate after cyclic test.

[1] H.W. Chan, J.G. Duh and S.R. Sheen, J. Power Sources, 115 (2003) pp. 110

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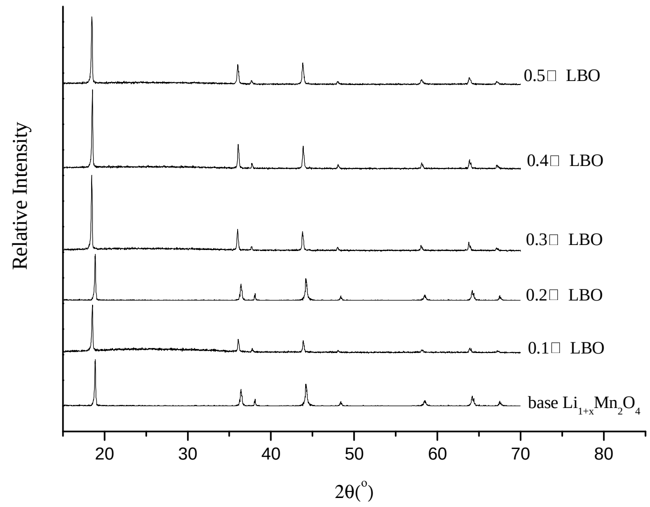

Fig. 1. XRD pattern of $Li_{1+x}Mn_2O_4$ coated with various wt percent of LBO glass calcined at 500°C for 10 hr.

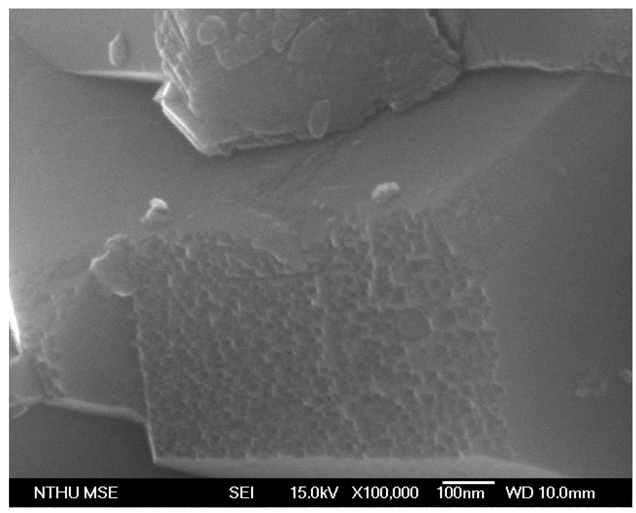

Fig. 2. FE-SEM images of LBO-coated $Li_{1.08}Mn_2O_4$.

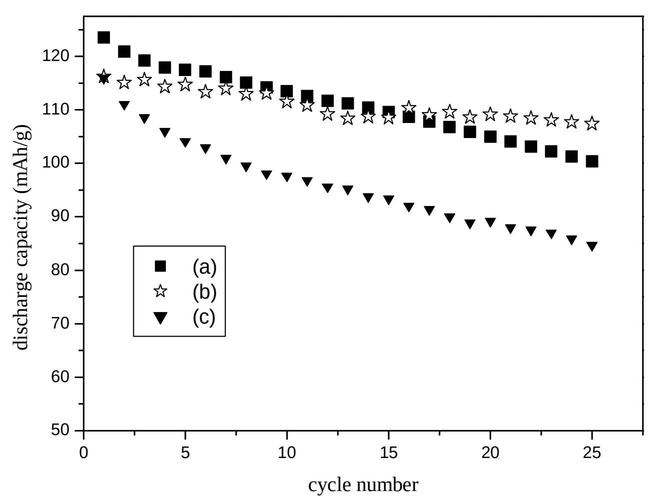

Fig. 3. Specific discharge capacity of various powders calcined at 500°C for 10 hr (a) uncoated $Li_{1+x}Mn_2O_4$, (b) 0.3 wt％ LBO-coated $Li_{1+x}Mn_2O_4$, and (c) uncoated $Li_{1+x}Mn_2O_4$ at 60°C.