Study on the Li_2ZrO_3-coated $LiNi_{0.6}Co_{0.2}Mn_{0.2}O_2$ as cathode material in all-solid-state Li-ion batteries

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Ni-rich layered oxide materials are the most promising candidates as the cathode material for lithium ion secondary batteries because of its high cut-off voltage, capacity, reasonable price and low toxicity. To avail the advantage of Ni-rich cathode materials, many researches have been conducted to improve the performance of Li-ion secondary batteries. Unfortunately, irreversible cycle ability at high voltage and interfacial resistance between cathode and solid electrolyte can make worse degradations than those of conventional Li-ion battery systems.

Thus, to relieve interfacial resistances made from insufficient contact and prevent space-charge effect, $LiNi_{0.6}Co_{0.2}Mn_{0.2}O_2$ is covered with homogeneous Li_2ZrO_3 coatings. Even the Li_2ZrO_3 possess low electrical conductivity, which is better than other coating substances such as $LiNbO_3$, $LiAlO_2$ and $LiTiO_2$ due to its high available ionic conductivity($\sim 10^{-5}$s/cm). Especially, those materials can prevent direct contact of electrolyte with electrode and is compatible between electrode and cathode material due to inactive electrochemical stability. $Ni_{0.6}Co_{0.2}Mn_{0.2}(OH)_2$ and excess $LiOH\cdot H_2O$ were ground, calcined at 773K for 6h and sintered at 1173K for 15h. Homogeneous coating of Li_2ZrO_3 on $LiNi_{0.6}Co_{0.2}Mn_{0.2}O_2$ was obtained by precipitation method with different weight ratio (0.5 to 6 wt%). Ion-conducing material (Li_3PS_4) was used as the solid electrolyte. The structure details of pristine and coated $LiNi_{0.6}Co_{0.2}Mn_{0.2}O_2$ were studied by powder X-ray diffraction technique. The thermal stability of Li_2ZrO_3-coated $LiNi_{0.6}Co_{0.2}Mn_{0.2}O_2$ material was analyzed by TGA and DSC techniques in air atmosphere. The morphology of Li_2ZrO_3-coated $LiNi_{0.6}Co_{0.2}Mn_{0.2}O_2$ and elemental analysis were carried out by SEM and EDS. The thickness of Li_2ZrO_3 and d-space of Li_2ZrO_3 and $LiNi_{0.6}Co_{0.2}Mn_{0.2}O_2$ were analyzed by TEM. The electrochemical performances of Li_2ZrO_3-coated $LiNi_{0.6}Co_{0.2}Mn_{0.2}O_2$ were elucidated from cyclic voltammetry, charge-discharge curves with DC-cycling test, C-rate performances and electrochemical impedance spectroscopy technique.

References:

[1] P. Yue et al.*, Scripta Materialia 65 (2011) 1077-1080.
[2] Arumugam Manthiram et al., ACS Applied Materials & Interfaces 9 (2017) 9718-9725
[3] Hui Cao et al.*, Solid State Ionics 176 (2005) 1207-1211
[4] Yao Zhang et al*, Solid State Ionics 177 (2006) 3303-3307
[5] Xianyou Wang, Hongbo Shu et al.*, Electrochimica Acta 134 (2014) 143-149