Studies on Lithium Electrode Coated with Lithium Phosphorous Oxynitride (LiPON) in Lithium Secondary Batteries

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Though a lithium metal anode has a high energy density compared with a carbon insertion anode, the poor rechargeability prevents the practical use of anode materials. So in this study, the lithium electrode coated with LiPON was prepared as a negative electrode to enhance cycleability through the control of solid electrolyte interface (SEI) layer formation in Li secondary batteries. The LiPON layer was fabricated on Li electrode by RF magnetron sputtering. The electrochemical characteristics of the SEI layer were examined using chronopotentiometry and impedance spectroscopy. In addition the lithium ion diffusion in the SEI layer of the uncoated and the LiPON-coated electrode was evaluated using chronoamperometry when lithium is immersed in electrolyte consisting of 1.0 M $LiPF_6$ in the mixed solvent of ethylene carbonate and diethyl carbonate. We found that the LiPON SEI layer prevented electrolyte decomposition reaction and had low interface resistance.

Fig. 1 shows the impedance spectra measured just after cell fabrication using the uncoated and LiPON-coated lithium electrodes. The complex impedance diagrams for both electrodes consist of semicircles. The impedance spectrum of the uncoated electrode was analyzed using a equivalent circuit composed of the typical resistor/capacitor couplings used to describe the interface of SEI layer/electrolyte and SEI layer/electrode [1, 2]. Interestingly, the LiPON-coated electrode was characterized by a depressed semicircle. To analyze the depressed semicircle we adopted the equivalent circuit as like Fig. 2. The equivalent circuit consists of two parallel circuits in series: R_s as the solution resistance, R_1 as the interface resistance of SEI layer/electrode, R_2 as the interface resistance of SEI layer/electrolyte, W as Warburg impedance related to lithium ion diffusion in the SEI layer, and C_1 and C_2 as the capacities the corresponding to R_1 and R_2, respectively. As shown in Fig. 1, the significant difference between the two electrodes is the diameter of the semicircles. The diameter means the interface resistance between the lithium electrode and electrolyte, which is variable as the characteristic of SEI layer. The effect of LiPON will be discussed in details in the Meeting.

References

[1] J.S. Sakamoto, F. Wudl, B. Dunn, Solid State Ionics, 144 (2001) 295.

[2] J. thevinin, R.H. Muller, J. Electrochem. Soc. 134 (1987) 273.

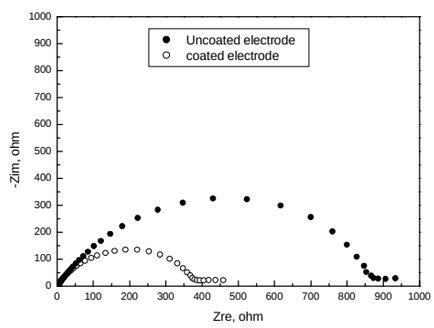

Fig. 1. Impedance spectra of the uncoated and LiPON-coated lithium electrodes soon after cell fabrication

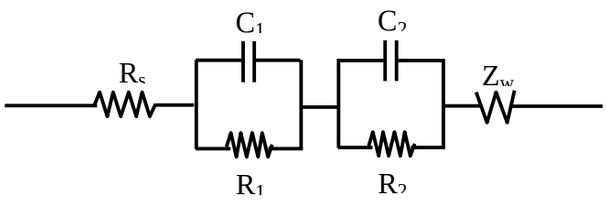

Fig. 2. Equivalent circuit model.