Dependence of characteristics on cathode thickness for all-solid-state thin-film lithium rechargeable battery

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In this study, discharge properties of all-solid thin –film lithium batteries with cathode film thickness from 3μm to 20μm have been evaluated. In a high current density, density of discharge capacity is not matched in each sample because it might be limited by the lithium diffusivity in $LiCoO_2$.layer. As a result of charge-discharge cycle, it is observed that discharge capacity gradually reduces under high $LiCoO_2$ thickness. Capacity retention is improved by adjusting lithium anode.

1. Introduction

Lithium batteries are currently generally used flammable organic electrolyte have been used between the positive and negative electrodes. However, safety problems are pointed out. Therefore, practical use of the lithium secondary batteries using a solid electrolyte in order to solve this problem is expected. Lithium thin-film batteries of all solid-state (TFBs) obtained by adding lighter, the characteristics of flexibility by thinning the lithium secondary batteries are applied to many applications (wireless sensors, smart card, etc.), in order to the market requested TFBs cost reduction of the battery (material cost, mass production) and it also requires high capacity of the battery, and a high output power. To produce the TFBs were used as the positive electrode the Lithium cobalt oxide (LCO) have layered structure, intended to improve the charge-discharge capacity per unit area deposition, the contents invention with varying thickness of the LCO. Report the results to observe the influence of cell characteristics due to the change in LCO film thickness, and its mechanism was considered the effect of thicker LCO film.

2. Experimental

The LCO film was prepared by RF and DC convolution magnetron sputtering method. Process gas was only Ar, and pressure was 3.0 Pa. After deposited, LCO was annealed 600 degree C at atmospheric pressure by lamp heater. In this study, the LCO thickness was 3, 10, 20μm.The solid electrolyte was prepared lithium phosphate nitride (LiPON) by RF-reactive sputtering method. The anode was prepared Lithium by vacuum evaporation method. TFBs cells were measured electrical properties at room temperature in glove box of Ar atmosphere.

3. Results and discussion

Fig.1 shows charge capacity when current density was changed. (LCO thickness is 3, 10, 20μm, Li thickness is 2μm) The charge condition is CCCV method. (Current: 0.21mA/cm^2, Cut off voltage: 4.2V,<0.021A/cm^2)、The discharge condition is CC method. (Current: x mA/cm2, Cut off voltage: 3.0V) The capacity density was decreased in same current density with the LCO film thickness was decreased. I think it was the rate-limiting effect of Li ions diffusion in the thicker LCO film. Because the diffusion distance was extended(1).Fig.2 shows properties of charge- discharge cycle when lithium thickness was 2μm. The discharge current density is 0.21mA/cm^2.The capacity loss rate was increased by LCO film thickness was increased. If LCO thickness was 20μm、the capacity was lost about 20 % after 20 charge-discharge cycle. I think the segregation of lithium was occurred when lithium was extracted by charge. Therefore, the contact area between anode and electrolyte was decreased and the capacity was decreased. Fig.3 shows properties of charge- discharge cycle when lithium thickness was 10μm.I have found that the cycle characteristics is improved by the thick lithium film.

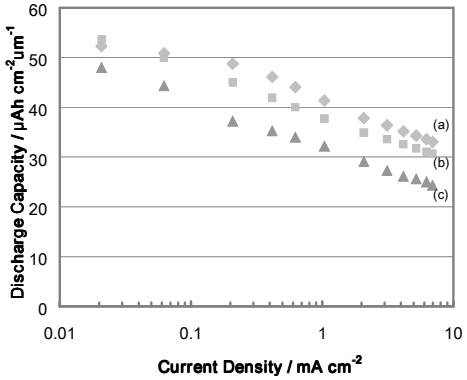

Fig. 1 Current density vs. discharge capacity of TFB cell with 2um Li thickness and $LiCoO_2$ thickness; (a)3μm, (b)10μm, (c)20μm

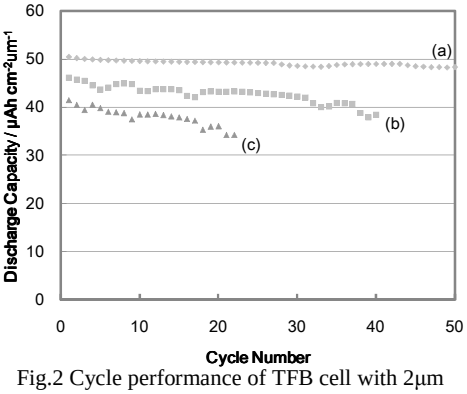

Fig.2 Cycle performance of TFB cell with 2μm Li thickness and $LiCoO_2$ thickness; (a)3μm, (b)10μm, (c)20μm

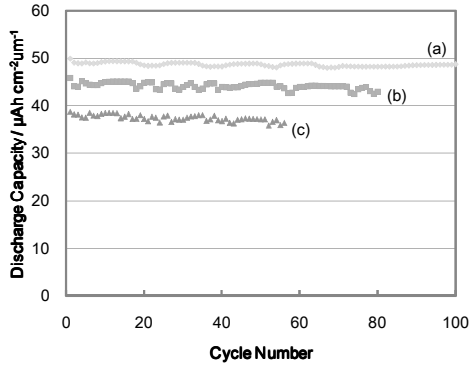

Fig.3 Cycle performance of TFB cell with 10μm Li thickness and LiCoO2 thickness; (a)3μm, (b)10μm, (c)20μm

References

1) Nancy J. Dudney, Young-Il Jang, *J. Power Sources*, **119-121** 300 (2003)