EFFECT OF HEAT TREATMENT ON THE ELECTROCHEMICAL CHARACTERISTICS OF COBALT OXIDE THIN FILM ANODE FOR MICROBATTERY

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INTRODUCTION

Recent research on the anode material for lithium ion battery has been focused on carbonaceous materials and alternative materials like tin oxide.[1] Carbonaceous materials has high stability, but low volumetric capacity mainly due to large initial irreversible capacity. There have been many studies on new materials for good electrochemical characteristics. Cobalt oxide as an anode material for lithium secondary batteries has recently attracted much attention. Cobalt oxide anode material has a good electrochemical capacity and high recharging rate.[2]

In this work, the effect of heat treatment on the electrochemical characteristics of cobalt oxide as anode material was investigated.

EXPERIMENTAL

Cobalt oxide thin films were deposited on a Pt/Si substrate using an radio frequency (RF) magnetron sputtering at room temperature. CoO target of 2-inch in diameter was used. Prior to the cobalt oxide film deposition, Pt films with thickness of 500 Å as a current collector were predeposited onto a boron-doped p-type Si (111) substrate by DC magnetron sputtering (400W, 5.0 x 10^{-3} Torr). On top of the Pt film, a 2000 Å thick cobalt oxide film was deposited using an RF magnetron sputter.

The chamber was evacuated to 5.0 x 10^{-6} Torr as a base pressure and working pressure was maintained to 1 x 10^{-2} Torr with a forming gas of Ar.

Deposited films were annealed by Rapid Thermal Annealing(RTA). Fabricated film thickness was measured by alpha-setp, and film structure was analyzed by X-ray diffractometer. Qualitative analysis of the Co/O composition of the deposited CoO films was conducted using energy dispersive X-ray spectroscopy(EDS) and auger electron spectroscopy(AES). Surface roughness of the film before and after the heat treatment was measured by atomic force microscopy(AFM). Surface morphologies of the films were obtained by field emission scanning electron microscopy(FESEM). For electrochemical analysis, half cells were assembled with a Li foil as the counter and reference electrodes, and 1M $LiPF_6$ in a 1:1 mixture of ethylene carbonate (EC) and dimethylcarbonate (DMC) as an electrolyte. The cells were used to evaluate the charge-discharge performance of the cobalt oxide film anode. Galvanostatic charge-discharge tests were perfomed with a constant current of 50 μAh/cm^2 in the voltage range 3-0.01V

RESULTS AND DISCUSSION

To investigate the effect of the heat treatment on the electrochemical characteristics of cobalt oxide as an anode material, RTA heat treatment was performed at 200ºC, 400ºC, 600ºC and 800ºC for 5 min. After the RTA treatment, as shown in Fig. 1, CoO thin film had wire-liked particles. As the heating temperature increased, the number of particles and surface roughness were larger than those of as-deposited film . Fig. 2 shows the discharge capacity of the heat treated anode thin films at 800ºC for 5 min. The area of cell was 1cm^2 and cut-off voltage and current density was 3.0-0.01 V and 50 μA/cm^2, respectively. Discharge capacity of the annealed CoO thin film was larger than the as-deposited CoO thin film. At first cycle, cobalt oxide anode had a large irreversible capacity, but CoO film exhibited the highest reversible volumetric capacity about 300 μAh/cm^2-μm over 50 cycles. Based on this experiment, the correlation between heating temperature and number of particles was validated. And through the heat treatment, structural stability was also able to be attained. Moreover, it was verified that this type of RTA treatment is related to the increase in capacity. Further research will proceed in regards to this relationship between them.

REFERENCES

1. P. Poizot, S. Laruelle, S. Grugeon, L. Dupont and J-M. Tarascon, J. Power Sources, **97-98**, 235 (2001)
2. P. Poizot, S. Laruelle, S. Grugeon, L. Dupont and J-M. Tarascon, Nature, **407**, 6803 (2000)

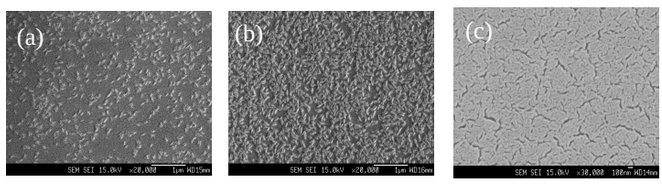

Figure 1. SEM images of CoO thin films with various annealing temperatures for 5 min
(a) 400 ºC, (b) 600 ºC, (c) 800 ºC

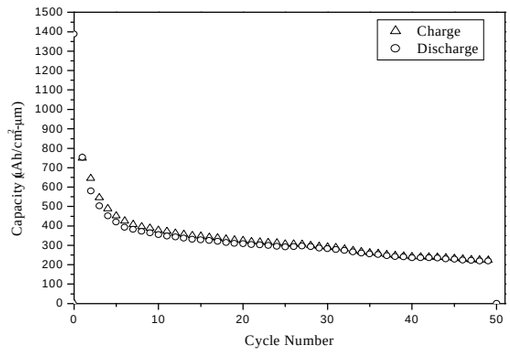

Figure 2. Volumetric capacity of annealed CoO thin Films(RTA treatment at 800 ºC for 5 min).