

INFLUENCE OF FILM THICKNESS ON ELECTROCHEMICAL PROPERTIES OF LITHIUM MANGANESE OXIDE THIN FILMS

Hee-Soo Moon, Kyung-Chang Ryoo, Tae Jung Kim, Seung Won Lee, Wonhee Lee*, Yoo-Kee Lee**, Philip J. Reucroft***, and Jong-Wan Park

Division of Materials Science and Engineering
Hanyang University
17, Haengdang-Dong, Seongdong-Ku, Seoul 133-791, Korea

*Department of Advanced Materials Engineering
Sejong University
98 Kunja-Dong, Kwangjin-Ku, Seoul 143-747, Korea

**Department of Semiconductor Engineering
Uiduk University
Kangdong, Kyongju 780-713, Korea

***Department of Chemical and Materials Engineering
University of Kentucky
179 Anderson Hall, Lexington, KY 40506-0046

INTRODUCTIONS

In recent years, electronic devices have been considerably improved in integration and power consumption but improvements in size of the power source have been relatively slow compared with others. Accordingly, slow advances in the size of power sources have delayed the miniaturization of electronic devices. The thin film rechargeable microbattery, serving as an independent power supply in micromachining and a backup source for electronic circuits, has been given much attention [1]. The major difficulty in fabricating a microbattery is to prepare layers of electrodes of high intercalation capability and electric conductivity, as well as thermal, electrochemical, and physical stability, in thickness less than one micrometer by using processes compatible with microelectronics fabrication techniques. During cycling, neither the electrode nor the electrolyte material should undergo a morphology change that might lead to the formation of chemically unstable, high surface area materials, even at the high rate of cycling desirable in some on-chip microbattery applications. The fabrication of such a multilayer system would allow integration of power units with MEMS. In this work, lithium manganese oxide, which is more stable and less toxic than other oxides such as lithium nickel oxides and lithium cobalt oxides, was deposited using rf magnetron sputter, and the effect of film thickness on its microstructure, surface morphology, and electrode characteristics was investigated.

EXPERIMENTAL

LiMn₂O₄ thin films were deposited using rf magnetron sputtering. To gain proper crystallization of spinel LiMn₂O₄, post-thermal treatments were done [2]. The film composition was determined by inductively coupled plasma emission spectrometer and Auger electron spectroscopy. The crystal structure of the samples was characterized by X-ray diffraction and transmission electron microscopy. Surface morphology was analyzed using scanning electron microscopy and atomic force microscopy. For electrochemical tests, half cells were made with the lithium manganese oxide thin film as the cathode, the lithium metal as the anode, and a 1-M solution of LiPF₆ in EC-DMC(1:1) as the electrolyte. Charge-discharge experiments were performed with various cut-off voltages and current densities.

RESULTS AND DISCUSSIONS

Since the LiMn₂O₄ thin films were amorphous as deposited, these films were annealed using a horizontal tube furnace. As shown in Fig. 1, 230 nm-thick and 450 nm-thick LiMn₂O₄ thin films had almost same structure and (111) of preferred orientation. But 450 nm-thick film had other orientation peaks like (511) and (440). As film thickness increased, particle size was larger and film had micro-crack on surface. Fig. 3 shows charge/discharge capacity of the thin films. The voltage window and current density were 4.2 ~ 3.8 V and 50 μA/cm², respectively. Initial discharge capacity of 450 nm-thick LiMn₂O₄ was larger. However, its Coulombic efficiency was lower than that of 230 nm-thick film. Because the structure of deposited film changes from amorphous to crystalline during annealing process, thicker film may undergo more stress. We think that this effect causes differences in microstructure, surface morphology and electrochemical properties of thin films.

REFERENCES

1. P. Birke, W.F. Chu, and W. Weppner, Solid State Ionics, **93**, 1 (1997)
2. H.-S. Moon, K.-S. Ji, and J.-W. Park, J. Korean Phys. Soc. In press (2002)

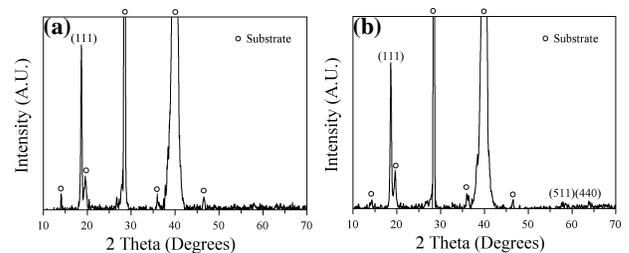


Figure 1. XRD patterns of LiMn₂O₄ thin films (a) 230 nm-thick film, (b) 450 nm-thick film

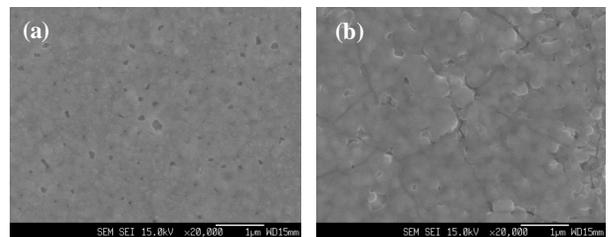


Figure 2. FESEM images of LiMn₂O₄ thin films (a) 230-nm thick film, (b) 450 nm-thick film

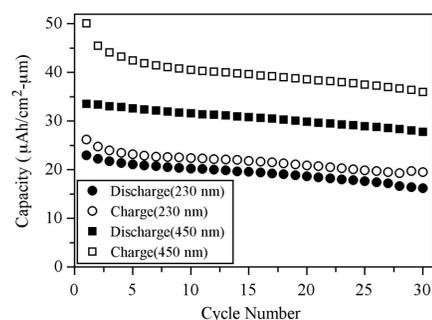


Figure 3. Volumetric capacity of LiMn₂O₄ thin films