Electrochemical Processing of ZnO Thin Films under a Magnetic Field

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Introduction

The electrical, optical and acoustic characteristics of zinc oxide have been of considerable interest in microelectronics industry. It is widely applied to chemical sensor, liquid crystal display and dye-sensitized solar cell. Electrodeposition of ZnO films has been reported from aqueous solution containing nitrate ions. [1,2] Moreover, the electrodeposition in non-aqueous solution was also reported. [3,4]

By the way, a high magnetic field has become readily available owing to the rapid advance in both super-conducting magnet and permanent magnet It has been applied to the electrochemical processing for tailored materials. In high magnetic field, the new phenomena are expected not only caused by the Lorentz forces but also by the magnetization forces.

In this study, ZnO films are electrodeposited from propylene carbonate (PC) bath under a magnetic field. The purpose of this work is to investigate the magnetic field effect to the surface morphology as well as microcrystalline structure.

Experimental

ZnO films were potentiostatically electrodeposited onto ITO glass electrode with a conventional three electrode system. Counter electrode was a Zn sheet (200 μm thick). Effective surface of both electrodes were 1 x 1 cm. Zn wire (ϕ = 1 mm) was used as a conventional reference electrode. PC electrolyte containing 0.05 M $Zn(NO_3)_2 \cdot 6H_2O$ and 0.15 M $LiNO_3$ was adjusted. Temperature was maintained at 70 ºC. A magnetic field (0 ~ 0.5 T) was applied parallel as well as perpendicularly to the electrode surface. The variation of surface morphology was observed by SEM and AFM.

Results and Discussion

ZnO films were electrodeposited at the potential between -1.0 V ~ -1.8 V. Figure 1 shows CV curve in PC electrolyte. Two cathodic peaks emerged at –1.0 V and –1.5 V vs. Zn RE, and no anodic peak was detected. ZnO is probably precipitated after reducing nitrate ions. Each peak corresponds to the diffusion limiting of reacting species such as nitrate ion, zinc ion and H_2O. Superimposition of magnetic field tends to increase the cathodic current density. Due to MHD effect, ionic mass transfer rate near the cathode was enhanced.

Figure 2 shows AFM images of electrodeposited ZnO films. The surface morphology of ZnO films electrodeposited without magnetic field was very rough and showed textured surface. A magnetic field introduced more smooth and flatter surface. The direction of applied magnetic field vector significantly changed surface morphology.

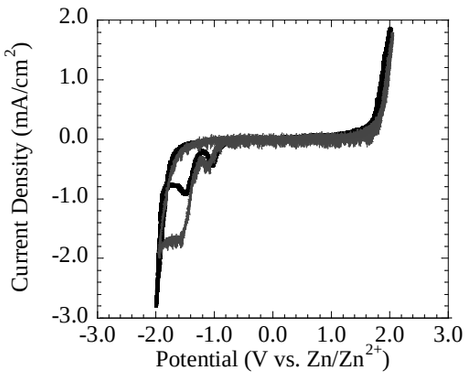

Fig. 1 Cyclic Voltammograms in PC electrolyte. (black line : B = 0 T, red line: B = 0.5 T in a parallel magnetic field)

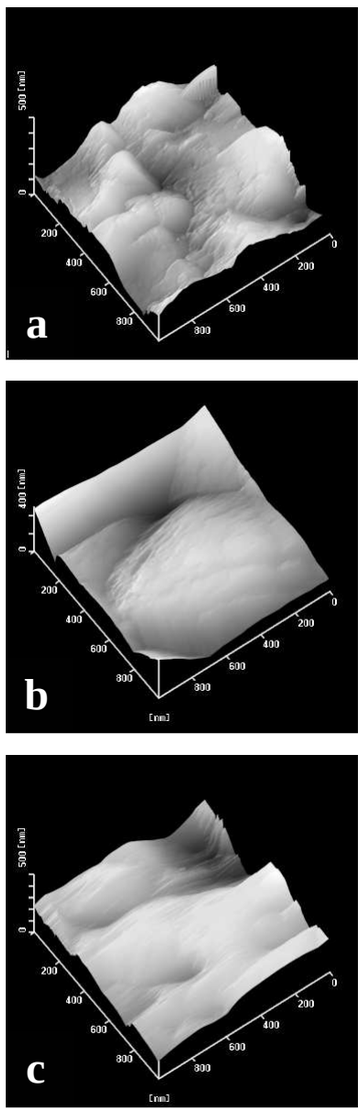

Fig. 2 a) AFM Images of Electrodeposited ZnO films without magnetic field, b) with a parallel magnetic field of 0.5 T, c) with a perpendicular magnetic field of 0.5 T

Reference

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[3] D. Gal et al. *Thin Solid Films*, **361**, 79 (2000)
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