Transparent ZnO Thin Films Prepared by Anodization

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In this study, we have successfully obtained the transparent ZnO films by anodizing Zn plates at room temperature. The key issue is surface cleanness of substrates. The transparent ZnO films have grown on the polished Zn plate substrates for 5 min. ZnO growth was confirmed by XRD and reflectivity spectrum measurements. When the surface of the Zn plates was not polished, only white or black films were obtained, depending on deposition conditions. The transparent ZnO films were obtained in a NaOH solution of 0.1 mol/l at 20 V

Key words: ZnO, transparency, anodization, thin film solar cells

1. Introduction

ZnO is one of attractive semiconductor materials for transparent electrodes [1], blue, violet and ultraviolet LEDs [2] and TFTs [3]. Anodization is one of low cost thin oxide film preparation methods. Kusakari *et al*. have reported that transparent ZnO films for photocatalyst application have been obtained at around 0 ^{o}C by anodization with cooling [4]. However, such films have not been obtained at room temperature by anodizing Zn plates yet. This report describes on the transparent ZnO films prepared at room temperature by anodizing Zn plates.

2. Experiment

Zn plates of 1x2 cm^2 were potentiostatically anodized at room temperature for 10 min in NaOH solutions of 0.1 to 0.5 mol/l at applied voltages of 5 to 30 V to obtain ZnO thin films with the following reaction [5] ;

$Zn \rightarrow Zn^{2+}+2e^{-}$

$Zn^{2+}+2(OH^{-}) \rightarrow Zn(OH)_2$

$Zn(OH)_2 \rightarrow ZnO + H_2O$.

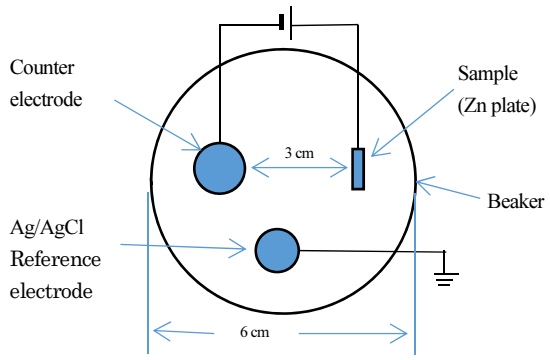

Fig. 1. Top view of cell for anodization. Diameter of beaker is about 6 cm. Distance between sample and counter electrode is about 3 cm.

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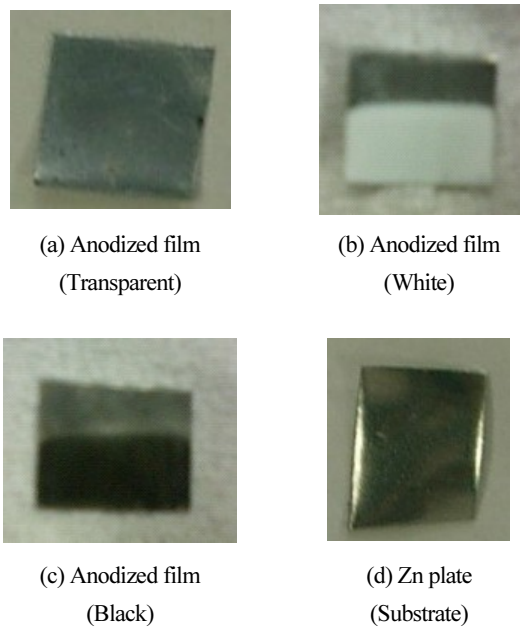
The Zn plates were polished with diamond paste and ultrasonically cleaned in organic solvents before anodization, if necessary. A coiled Pt wire was used as a cathode. Figure 1 shows the schematic diagram of the cell. The diameter of beaker is about 6 cm. distance between sample and counter electrode is about 3 cm.

3. Results and Discussion

At either the room temperature or the low temperature (about 0 to 10 ^{o}C), the transparent ZnO films were not obtained first. Then we have reconsidered deposition conditions and found that the key issue is surface cleanness of the substrates. The transparent ZnO films have grown on the surface of the polished Zn plates with diamond paste for 5 min at least .



(a) Anodized film (Transparent)

(b) Anodized film (White)

(c) Anodized film (Black)

(d) Zn plate (Substrate)

Fig.2 Appearances of the films and the substrate.

Figure 2 (a), (b) and (c) show the appearances of

anodized Zn plates. The appearance of the Zn plate substrate before anodization is also shown in Fig. 2 (d) for comparison. The plates shown in Fig. 2 (a) and (b) were anodized at 20 V in 0.1 mol/l solution and the film (c) 5 V and 0.1 mol/l. From the figures, we can find that the color of the anodized film (a) is different from that of any of the white film (b), the black film (c) and the Zn plate substrate (d). This indicates that the transparent film has grown on the plate. The films shown in Fig. 2 (a) and (b) were prepared on same conditions except surface cleanness. The Zn plate substrate shown in Fig. 2 (a) was polished better than that in Fig. 2 (b). When the Zn plates were not polished sufficiently, only white or black films were obtained, depending on deposition conditions, as shown in Fig. 2 (b) and (c), even if the Zn plates were anodized on the same conditions as the transparent film grew.

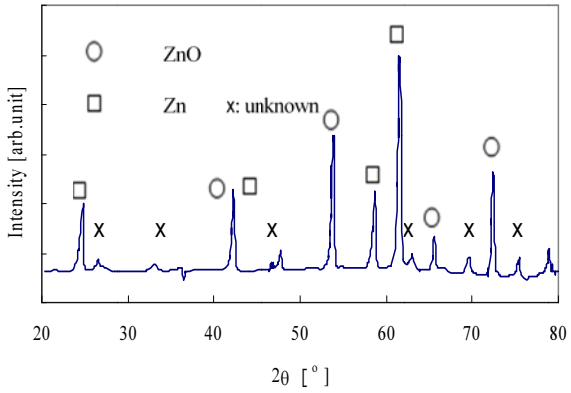


Fig. 3 XRD pattern for the transparent film.

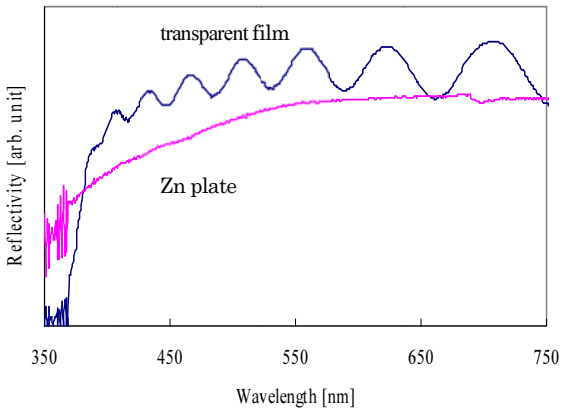


Fig.4 Reflectivity spectrum for the transparent film and the Zn plate

We have confirmed ZnO growth by XRD and reflectivity spectrum measurements. Some peaks attributed to ZnO are detected, as shown in Fig. 3. The reflectivity spectrum for the transparent film begins to rise at about 370 nm, which almost corresponds to ZnO bandgap, as shown in Fig. 4. On the other hand, the Zn plate reflects the light whose wavelength is less than 370 nm. Figure 5 shows XPS depthprofile of the transparent film. The depthprofile is found to be uniform except the vicinity of the surface. The figure also shows the thickness of about 0.5 μm is obtained for 10 min anodization.

4. Conclusion

We have concluded that the transparent ZnO films are prepared on the sufficiently-polished Zn plates by anodization at room temperature at 20 V in 0.1 mol/l NaOH electrolyte.

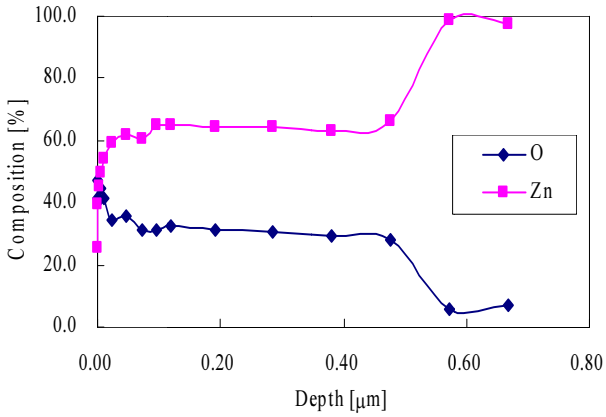


Fig. 5 XPS depth-profile for the transparent film.

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