Electrodeposition of High-Haze Textured Zinc Oxide Films

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Hexagonal wurtzite zinc oxide (ZnO) is an *n*-type semiconductor with a wide bandgap energy of 3.3 eV and a large exciton binding energy of 59 meV, affording high visible transparency and room-temperature UV emission. Due to these valuable characteristics, ZnO has attracted increasing attention in the field of solar cells and UV-emitting diodes. In general, the surface structure, including atomic arrangement and shape, of polycrystalline films is mainly determined by the preferred growth orientation and exposed crystal faces. Since various properties such as, interfacial states, optical transmission, and catalytic activities depend on the surface structure, the control of preferred growth orientation and exposed crystal faces is a crucial challenge.

Electrodeposition is a powerful technique to grow relatively large crystal grains with a regular polyhedral faces due to a mild growth condition in aqueous solution (< 90°C in the ambient atmosphere). Since the development of ZnO electrodeposition technique by Izaki et al.[1] and Lincot et al.[2] in 1996, a variety of structures, such as nano-wires, nano-rods, nano-cauliflower, and nano-plates, has been prepared.

In the present study, we have prepared pyramidal-textured ZnO films with a [0001] preferred growth orientation and {101} exposed crystal faces by electrodeposition (Fig. 1a). The pyramidal-textured surface is a well-known structure in the field of crystalline and thin-film Si solar cells,[3] because such a structure is highly effective in light scattering as shown in Fig. 1b, leading an improvement in photovoltaic conversion efficiency. Thus, we have also examined the optical scattering performance by measuring haze values. Haze is generally defined as the ratio of diffused transmittance, *T*d, to total optical transmittance, *T*t, and higher haze values means that the scatter component is more dominant than the vertical one.

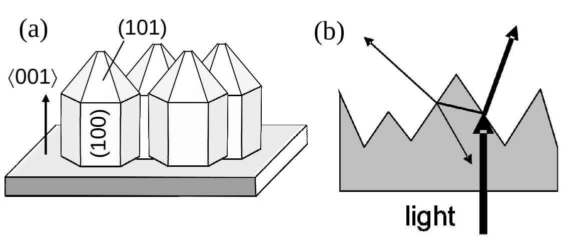

Figure 1. Schematics of (a) a ZnO film with a pyramidal textured surface and (b) a light scattering effect.

Figure 2 shows an FE-SEM image of a pyramidal-textured ZnO film electrodeposited on an FTO glass substrate from a $Zn(NO_3)_2$ aqueous solution. The film is an aggregate of hexagonal columnar ZnO grains ~400 nm in diameter with a regular pointed tip. As mentioned above, the pointed tip is composed of {101} faces, which has a plane angle of 62° to the (001) plane. Haze was evaluated in the visible light region (380−780 nm) using an integrating sphere, revealing that the ZnO film has a haze value as high as 52%, which is about four times higher than that of a bare FTO substrate.

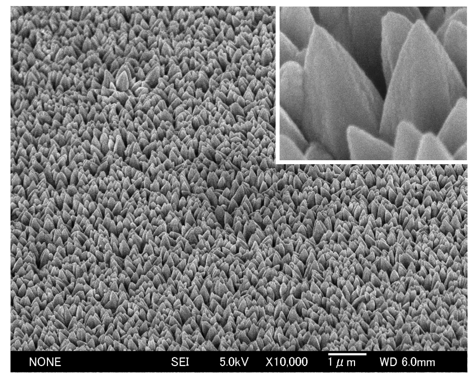

Figure 2. FE-SEM image of a pyramidal-textured ZnO film electrodeposited from an aqueous solution.

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References

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