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Optical absorption spectra of Ga-doped ZnO films affected by O_2 flow rate and post-deposition thermal annealing

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Abstract – Influence of post-deposition thermal annealing on optical absorption spectra of Ga-doped ZnO (GZO) films have been studied for films deposited at different conditions of O_2 gas flow rate by an ion-plating with DC-arc discharge. Optical absorption spectra showed weak tail absorption below fundamental optical gap absorption. The GZO film deposited at low O_2 flow rate showed absorption in visible range. These absorption characteristics were affected by post-deposition annealing.

ZnO transparent conductive oxides (TCO) are one of promising candidate as transparent electrodes in flat panel display applications. Recently, we reported feasibility of Ga-doped ZnO (GZO) films as common electrodes on color filter substrates in thin film transistor liquid crystal display [1]. Optical absorption is one of important properties as common electrodes, because it influences optical property of the displays. In TCO films, optical absorption is strongly related to electrical properties and to defects in the films. In this study, we examined change of optical absorption by post-deposition thermal annealing for the GZO films deposited by an ion-plating method with different O_2 flow rate.

150 nm thick GZO films were deposited on alkali-free glass substrates (Corning 1737) by an ion-plating with DC-arc discharge. Considering heat resistance of color filter substrate composed of organic materials, substrate temperature was settled at ~110 ^oC. During the deposition, high purity O_2 gas was introduced into the deposition chamber, and the O_2 flow rate was varied from 8 to 15 sccm.

Electrical properties of GZO films depend on the O_2 flow rate [2]. As shown in fig. 1, the minimum resistivity was obtained at the O_2 flow rate of 11 sccm. The resistivity increased as postponed from the optimal O_2 flow rate. The carrier concentration monotonously decreased with increasing the O_2 flow rate. While, the Hall mobility increased up to the optimal point. Optical transmission and reflection spectra were measured by a spectrometer. Average transmittance in visible wavelength region was more than 85 % for all samples. Optical absorption spectra of as-deposited GZO films are shown in fig. 2. As main contributions, free carrier absorption in long wavelength region and fundamental optical gap absorption in UV region are observed. Weak tail absorption below the optical gap absorption is extended to the blue wavelength region as shown in inset fig.2. On the other hand, absorption in visible region appeared in the films of 8 sccm. The GZO films were annealed in air or in pure N_2 gas atmosphere at the temperature range between 200 and 450 ^oC. Electrical properties were strongly affected by the post-deposition annealing [3]. Reflecting the change in the carrier concentration and the Hall mobility, optical absorption, related to free carrier response, was strongly affected. In addition, the tail absorption was also affected by the post-deposition annealing.

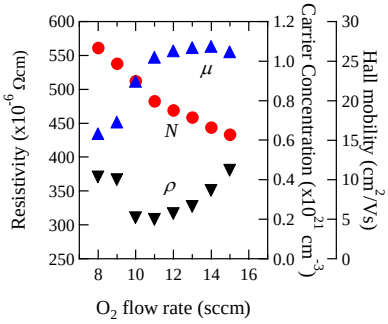

Figure 1: Dependences of electrical properties on O_2 flow rate during deposition.

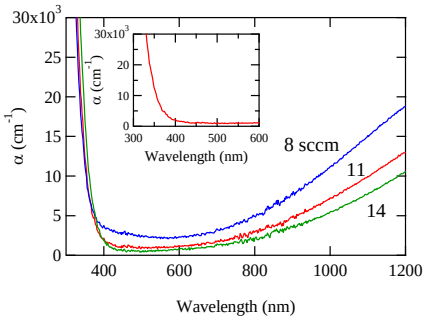

Figure 2: Optical absorption spectra of as-deposited GZO films deposited with different O_2 flow rate..

References

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