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# Multi-Deposition Technology of Highly Transparent Conductive ZnO Thin Films on Polymer Substrates to Control Residual Stress in the Films

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The fabrication using conventional mass-production line and field test of 20 inch thin-film-transistor liquid-crystal-display panels (TFT-LCDPs) utilizing highly transparent ZnO-based common electrodes deposited on RGBY-color filters (CFs) was successfully achieved for the first time in the world [1)]. The brightness of the LCD TV mounted the ZnO electrodes (Fig. 1) was found to be 5% higher than that of the conventional LCD TV utilizing ITO-based electrodes. The key point to note is the reduction of deposition temperature (<180-200 ºC) because of the CFs with low heat resistance and high coefficient of thermal expansion compared with those of the ZnO films. Since the ZnO films can be deposited on the substrates at low temperatures, the new product will be applicable to heat-susceptible substrates such as polymer-based ones. Polymer-based substrates have been a subject of increasing interest because of their favorable properties, such as relative flexibility, light weight and impact resistance, for flexible electro-optical devices.

In this talk, we will discuss the characteristics of Ga-doped ZnO (GZO) films prepared on polymer[2-5)], especially, polyester substrates[6,7)] (Fig. 2). The key point to note here is the reduction of residual stresses in the GZO films, to develop multi-deposition technology to achieve the flexible substrates with highly transparent conductive GZO films[7)]. The GZO films were deposited using ion plating with DC arc discharge. No intentional heating was applied to the substrate. Very little difference was found between the electrical resistivity values of the GZO films on the glass substrate and those of the GZO films on the polyester substrates[2-7)]. The resistivity of the 100-nm-thick GZO films deposited on glass or polyester substrates was about $5.0 \times 10^{-4}$ Ωcm[2-7)]. The mechanical bending properties of the GZO films deposited on the polyester substrates were evaluated by analyzing the change ratio of sheet resistance before and after the bending test as a parameter of bending diameter, including two different types of the compressive and tensile directions of the GZO films. The results of the bending test of GZO films deposited on polyester substrates shows three regimes of resistance increase: 1) no change in resistance (bending diameter 30nm or more); 2) a gradual linear increase in resistance, possibly due to cracking of the GZO films (bending diameter from 15 to 20 mm); and 3) a catastrophic failure, attributed to severe crack formation across the entire sample width (bending diameter less than 15 mm). [6,7)]

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Fig. 1. Display of 20-inchi TFT LCD TV with highly transparent ZnO-based common electrodes/RGBY CFs.

Fig. 2. GZO films/buffer layers/ polyester substrates.

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