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Effect of tin concentrations on properties of indium tin oxide films deposited on PET substrate under various conditions

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ABSTRACT

This study examined the effect of the Sn concentration on the electrical and mechanical properties of ITO films. ITO films, 150–160 nm in thickness, were deposited on polyethylene terephthalate (PET) substrates by DC magnetron sputtering under various deposition conditions using one of three different high density ITO targets (10 wt%, 7 wt% and 5 wt% SnO_2) without substrate heating. Deposition was carried out under the following conditions: DC power; total gas pressure; distance between target and substrate; and O_2 or H_2 addition ratio. The lowest resistivity of 3.19×10^{-4} Ω cm and relatively small change in resistance in dynamic stress mode was obtained for the film deposited from an ITO target doped with 7wt% SnO_2. These results can be explained by the effect of the kinetic energy of sputtered atoms (In, Sn, O) and the bombardment of high energy particles (Ar^0, O^-) arriving at the film surface during deposition.

1. Introduction

Indium tin oxide (ITO) films are a representative transparent conducting oxide (TCO) that are generally used as transparent electrodes in flat panel displays (FPDs), such as liquid crystal displays (LCDs), plasma display panels (PDPs) and organic light emitting diodes (OLEDs), on account of their high conductivity and transmittance in the visible light region [1–3]. The Sn concentration in ITO films is generally up to 10 at%. ITO films are commonly deposited by DC magnetron sputtering using ITO ceramic targets with SnO_2 concentrations ranging from 5 to 10 wt% [4]. With the recent demand for portable and flexible displays, ITO films should be deposited on polymer substrates at low temperatures. In addition, their electrical properties and surface morphology should have low resistivity and smooth surface [5]. In particular, the durability and reliability of ITO films under the condition of mechanical dynamic bending stress is the key point in applications to flexible displays. However, there are no reports of the mechanical durability of ITO films deposited on flexible substrates under mechanical dynamic stress in relation to the Sn concentrations.

As an extension to our previous work [6], this study examined the effect of the Sn concentration on the mechanical properties of ITO films. ITO films with a thickness of 150–160 nm were deposited on polyethylene terephthalate (PET) substrates by DC magnetron sputtering under a variety of deposition conditions using high density ITO targets containing various concentrations of SnO_2 without substrate heating. Deposition was carried out under various conditions, such as sputtering power, total gas pressure (P_{tot}), distance between the target and substrate (T–S) and the O_2 or H_2 addition ratio.

2. Experimental

ITO films with a thickness of 150–160 nm were deposited on hard coated PET (50 × 50 mm size, 125 μm thickness, Omega-Whayeon Co. Ltd.) by DC magnetron sputtering (Multi-sputtering system-a, Dae Ki Hi – Tech Co. Ltd.) without substrate heating using ITO targets (target A: doped with 10 wt% SnO_2, target B: doped with 7 wt% SnO_2, target C: doped with 5 wt% SnO_2). Deposition was carried out at various sputtering powers (30–100 W), P_{tot} (0.3–2.0 Pa), T–S (50–80 mm), and O_2 or H_2 addition ratios (0–0.6%). All the targets were pre-sputtered for 10 min to observe plasma stability and to obtain high reproducibility of the films prior to deposition. The stability of the discharge for each target was monitored using a micro arcing counter (SPL-1, SJPOWER).

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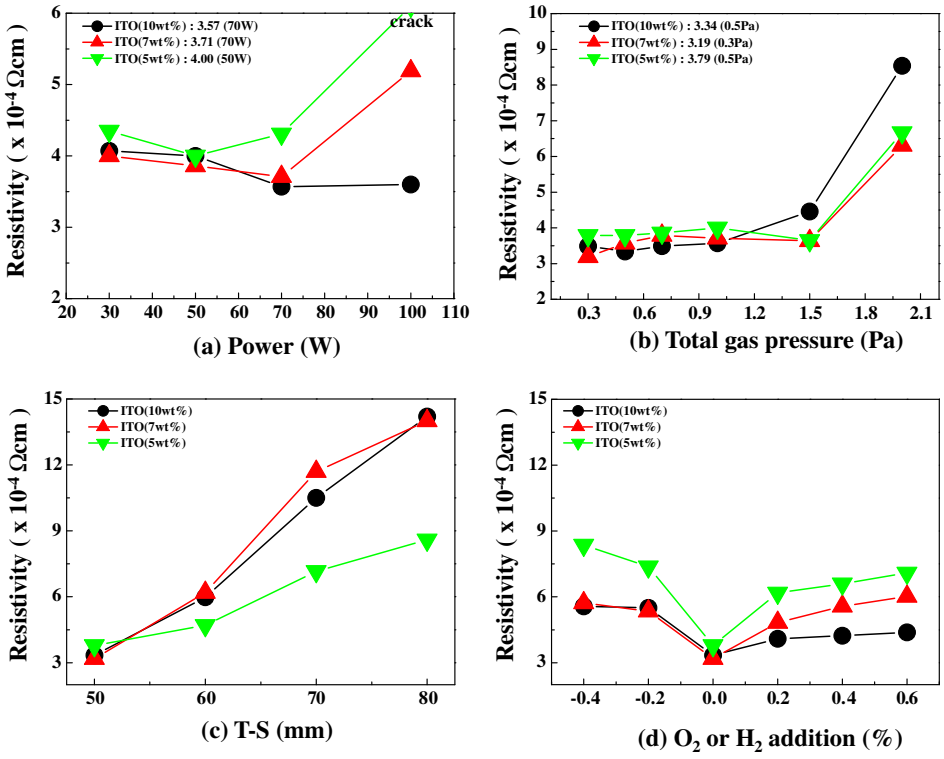

Fig. 1. Resistivity of the ITO films deposited on PET substrate under various (a) sputtering powers, (b) P_{tot}, (c) T–S and (d) H_2 and O_2 gas ratios.

The thickness and deposition rate of the films were determined using a surface profiler (Dektak3, VEECO). The electrical properties of the ITO films were measured using a 4-point probe method. The surface morphology of the films was analyzed by atomic force

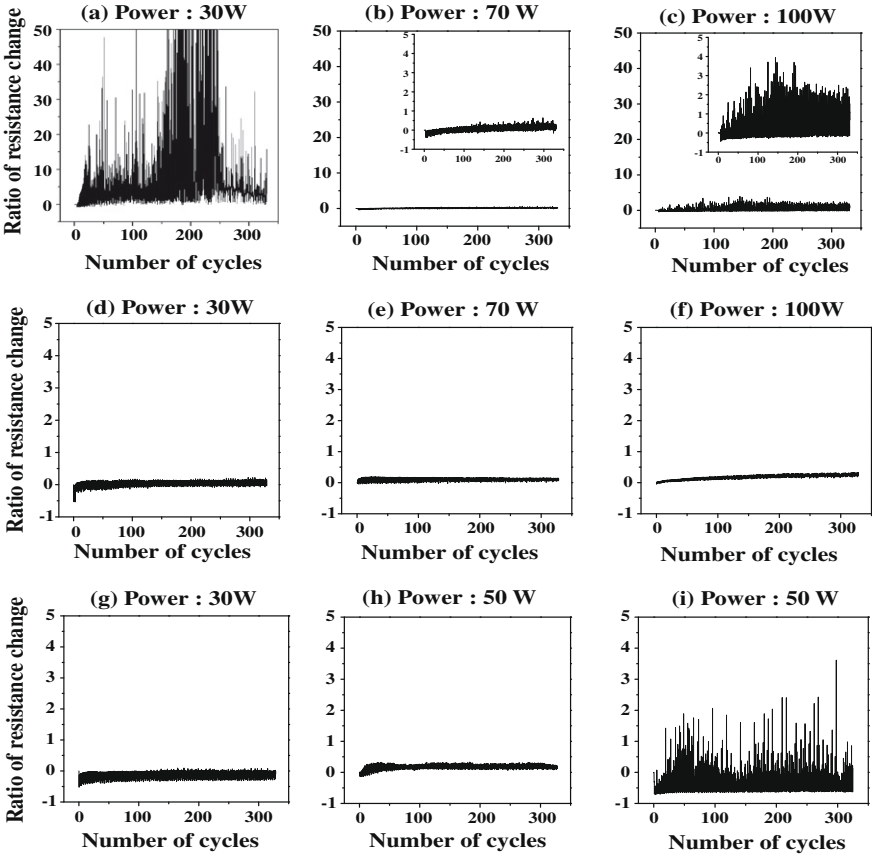

Fig. 2. Change in the resistance of ITO films under cyclic mode deposited using (a–c) target A, (d–f) target B and (g–i) target C under various sputtering powers.