Electrical Properties of In_2O_3 and ITO Thin Films Prepared by Solution Process using $In(acac)_3$ Precursor

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Introduction: Indium tin oxide (ITO) is widely used transparent conductive oxide. It was demonstrated that fine patterns can be fabricated for indium oxide (In_2O_3) and ITO by direct nanoimprint process using indium acetylacetonate ($In(acac)_3$) based source solution [1]. In this work, electrical properties of solution processed In_2O_3 and ITO films were studied using $In(acac)_3$ based source solutions. Sn precursors used in this work were tin acetylacetonate ($Sn(acac)_2$) and tin chloride ($SnCl_2$) while propionic acid (PrA) was used as a solvent. To the best of our knowledge, no other research group has used these precursors. A few researchers [2] have used $InCl_3$ and $SnCl_2$ to from ITO films. In our case, $In(acac)_3$ with $SnCl_2$ or $Sn(acac)_2$ were used as precursors.

Experimental Procedure: First, source solutions were prepared by dissolving $In(acac)_3$ in PrA for In_2O_3, $In(acac)_3$ and $SnCl_2$ or $Sn(acac)_2$ in PrA for ITO film formation. Then, they were filtered and spin-coated on SiO_2(200nm)/Si substrate, after which the sample was heated on a hot-plate in air, which resulted in gel films. Next, the gel films were annealed in rapid thermal annealing (RTA) in O_2 by varying the annealing time at 600°C in O_2. Electrical properties (mobility and carrier concentration) were studied by Hall measurements using van der Pauw configuration.

Results and Discussion: Figure 1 shows the Hall mobility of In_2O_3 and ITO films prepared with $SnCl_2$ and $Sn(acac)_2$ precursors. Relatively large mobility of 45 cm^2/Vs was obtained for In_2O_3 and the mobility decreases with Sn content, which is similar to the previous publications. It is interesting to note that the Hall mobility of ITO via $SnCl_2$ is lower than that of $Sn(acac)_2$, which may be due to the incorporation of Cl in the films and the details are now under study. Figure 2 shows the resistivity of ITO films. A resistivity of 2.5×10^{-3} Ω.cm was obtained when the Sn content is 1%, which is comparable or larger than that of the films prepared by spay and dip coating methods [2, 3]. This is due to relatively small carrier concentration (1×10^{20} cm^{-3}) of the films fabricated in this work, because we employed O_2 annealing.

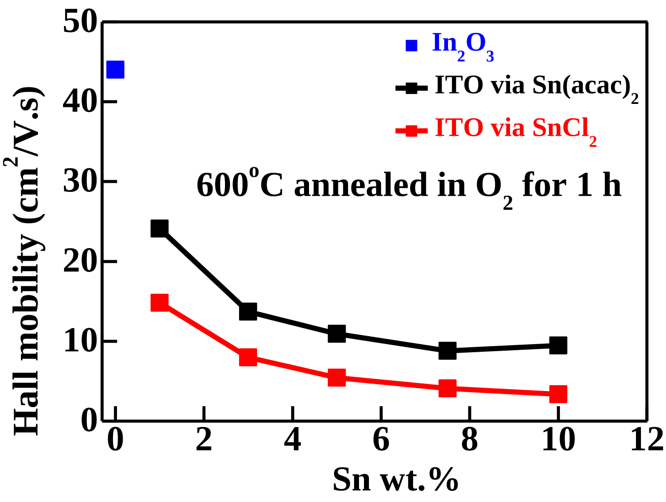

Fig. 1: Hall mobility dependence on Sn wt.% for ITO films.

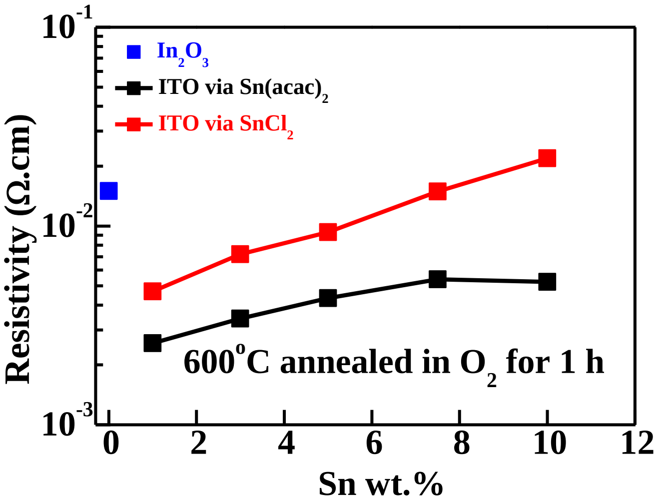

Fig. 2: Resistivity of ITO films.

References:
1. T. Kaneda et al., *J. Mater. Chem. C* **2** (2014) 40
2. Y. Sawada et al., *MRS-J* **34** (2009) 225.
3. Y. Seki et al., *MRS-J*, **34** (2009) 253.