Aluminum-doped indium saving indium-tin oxide thin films sputtered on preheated substrates

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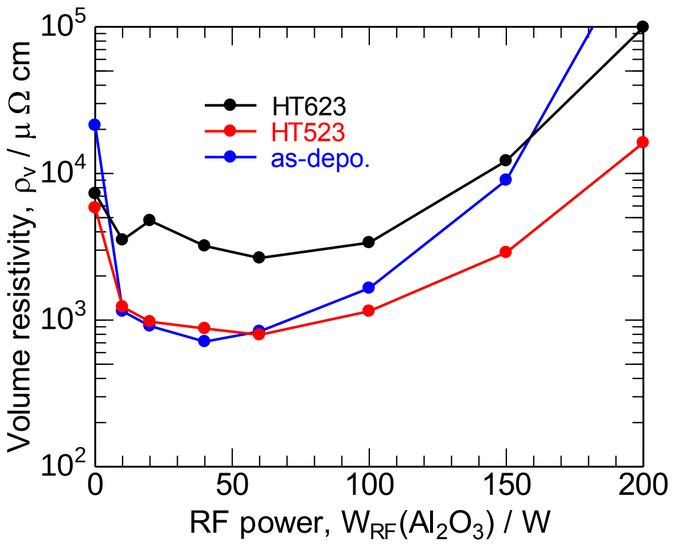
Introduction

Indium-tin oxide (ITO) thin films have been widely used in a variety of electronic and optoelectronic applications because of the high transmission in the visible region and the low resistivity. However high demand for ITO thin films for industry and limited natural source of indium provoked its high price. Thus, indium-saving ITO thin films attracted attention of investigators [1-5] since these films are cost-effective and their electrical and optical properties are comparable with those of conventional ITO (In_2O_3-10 mass% SnO_2). Aluminum-doped ITO thin films were produced by co-sputtering method onto glass substrates preheated at 523 K (ITO50:Al2O3 (PHS)) in order to improve optical and electrical properties of ITO thin films with reduced from 90 mass% to 50 mass% indium oxide usage in the target.

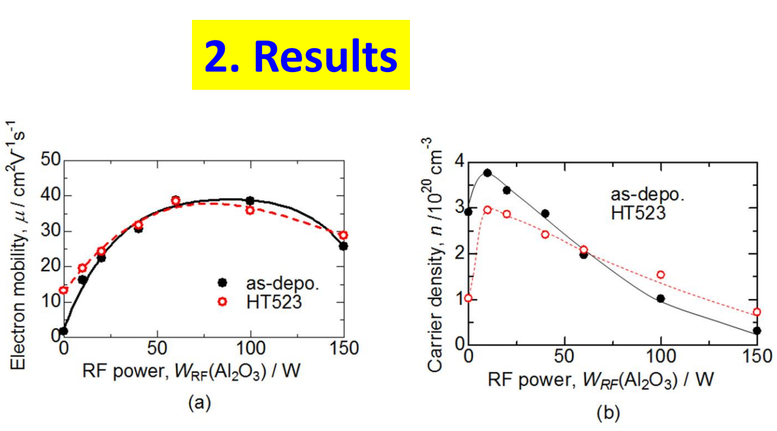
1. Experimental methods

Aluminum-doped ITO50 (ITO50:Al_2O_3) thin films were prepared by using a commercial sputtering system (ULVAC, CS-200). ITO50 (Mitsui Mining & Smelting, In_2O_3-48.9 mass% SnO_2) and Al_2O_3 (Kojundo Chemical Laboratory, 99.99 mass%) targets were co-sputtered. The aluminum-doped ITO50 thin films were sputtered onto glass substrates (Corning EAGLE 2000, surface: 50 mm×50 mm, thickness: 0.7 mm) preheated at 523 K (PHS) under the rotation of the substrate holder in order to obtain a homogeneous deposition. The DC plasma power for ITO50 target was kept at 100 W and the RF plasma power for Al_2O_3 target was altered 0-200 W. The argon flow rate was kept constant at Q(Ar) = 50 sccm while oxygen flow rate $Q(O_2)$ was fixed at 0.1 sccm, and the deposition time was fixed at 30 min. The deposited films were heat-treated (HT) in air at 523-823 K for 60 min and cooled at room temperature. The obtained thin films were characterized by means of four-point probe, Ultraviolet-Visible-Infrared spectroscopy, X-ray diffraction and X-ray photoelectron spectroscopy.

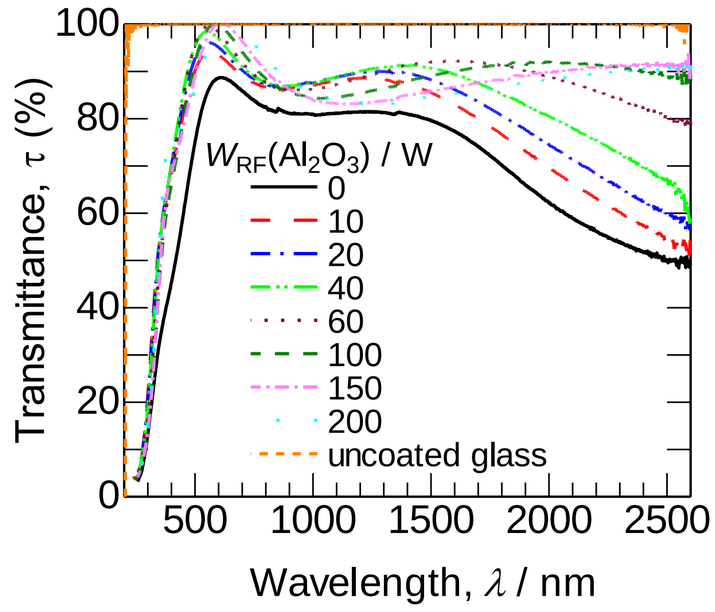
2. Results



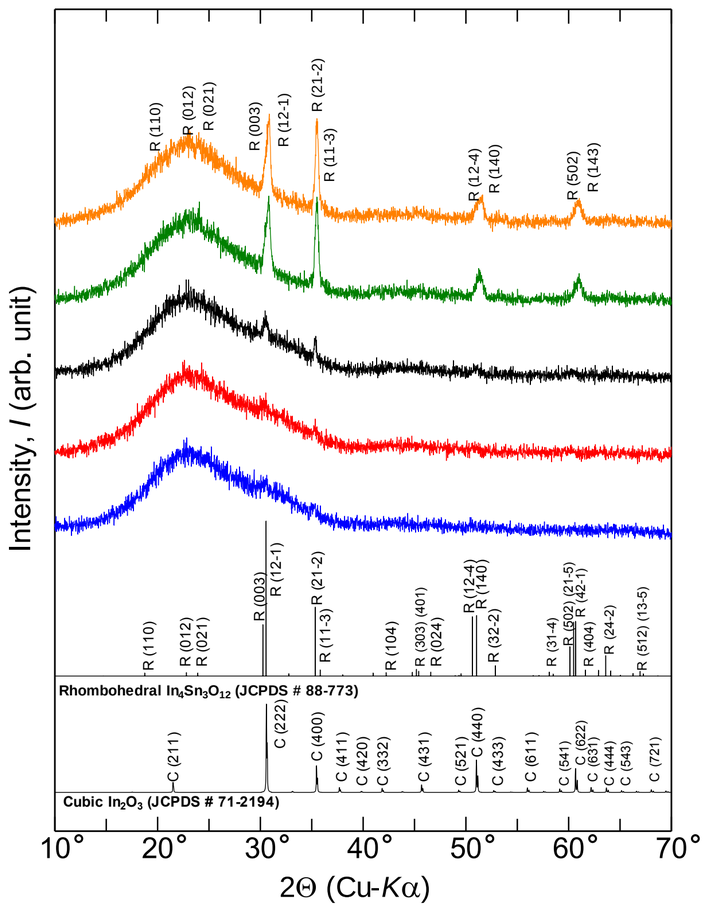
Effect of RF power of Al_2O_3 target and heat treatment temperature on volume resistivity of the ITO50:Al_2O_3 (PHS) thin films



The electron mobility (a) and the carrier density (b) of the as-deposited and HT523 ITO50:Al_2O_3 (PHS) thin films deposited at Q(Ar)/$Q(O_2)$ = 50 sccm/0.1 sccm depending on RF power of Al_2O_3 target



Effect of RF power of Al_2O_3 target on transmittance of ITO50:Al_2O_3 (PHS) thin films



XRD results for as-deposited and heat-treated at 523-823 K ITO50:Al_2O_3 (PHS) thin films

Conclusions

Transmittance of the ITO50:Al_2O_3 (PHS) thin films was improved significantly at fixed oxygen flow rate $Q(O_2)$=0.1 sccm when a high radio frequency power increased. It was observed since aluminum oxide is an additional source of oxygen during filling of oxygen vacancies.

It was shown that optimum radio frequency power was W_{RF} (Al_2O_3)=40 W. The volume resistivity of the as-deposited ITO50:Al_2O_3 (PHS) thin films sputtered under such conditions was 713 μΩ cm. Further increase of W_{RF} (Al_2O_3) conduces to increase of volume resistivity. This may be connected with dying out of doping effect of aluminum oxide.

Introducing of Al_2O_3 to the ITO50 thin films did not alter the ITO structure.

Acknowledgments

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