Structure and optical and electrical properties of Zinc oxide based thin films

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Introduction

Thin films of Zinc oxide with different additives are widely investigated as a potential substitute to ITO.Depending on the additive, the films may exhibit either n- or p- type conductivity. This report focuses on Iridium-Zinc oxide (IrZO) and Aluminium-Zinc oxide (AZO) as candidates for p- and n-type conductors, respectively.

Experimental details and results

The films of AZO have been deposited by DC reactive magnetron sputtering from metallic (Al 98%, Zn2%) targets. The films of IrZO have been deposited by reactive sputtering from metallic mosaic targets made of Zn and Ir segments, with Zn 92-96%, Ir=4-8% surface area. The substrate was glass kept at ≈310°C temperature, the deposition was conducted at 3 mTorr working pressure and 100W sputtering power. The process was controlled by plasma optical emission spectroscopy based on Zinc emission line at 480.05 nm and Iridium emission line at 390.2 nm; an example of OES spectrum recorded upon IrZO deposition is shown in Fig.1.

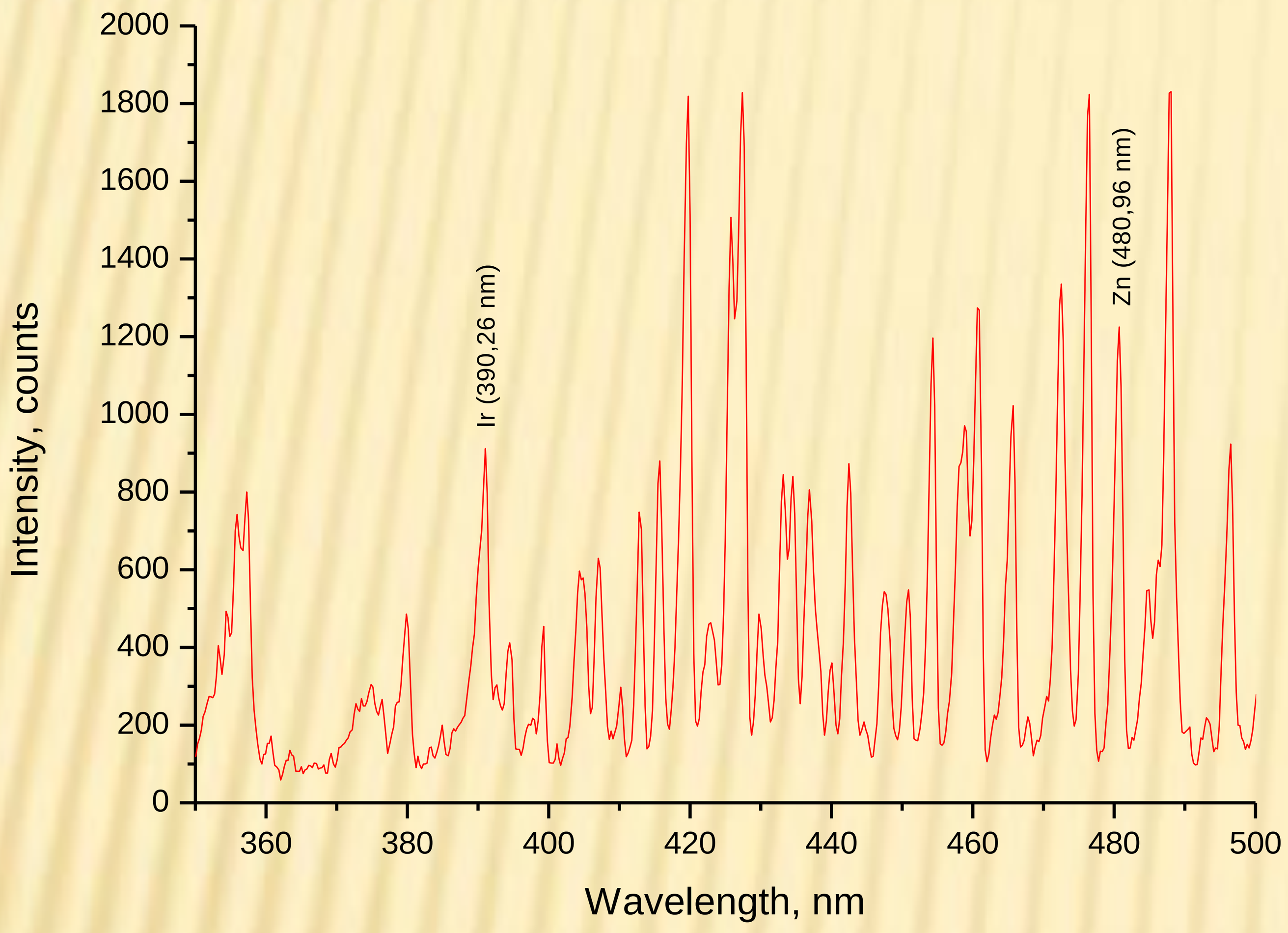

Fig.1. Plasma optical emission spectrum upon sputtering of a metallic mosaic target made of Zn and Ir segments with Zn 94%, Ir 6% surface area.

The thickness of the films, as measured by Veeco Dektak 150 profilometer, was approximately 200 nm for AZO and 75 nm for IZO. With the deposition time kept constant at 10 minutes, the difference in thickness reflects the difference in the sputtering rate.

The structure of the films has been characterized by XRD. The AZO films are crystalline, the IrZO films are X-ray amorphous (Fig.2).

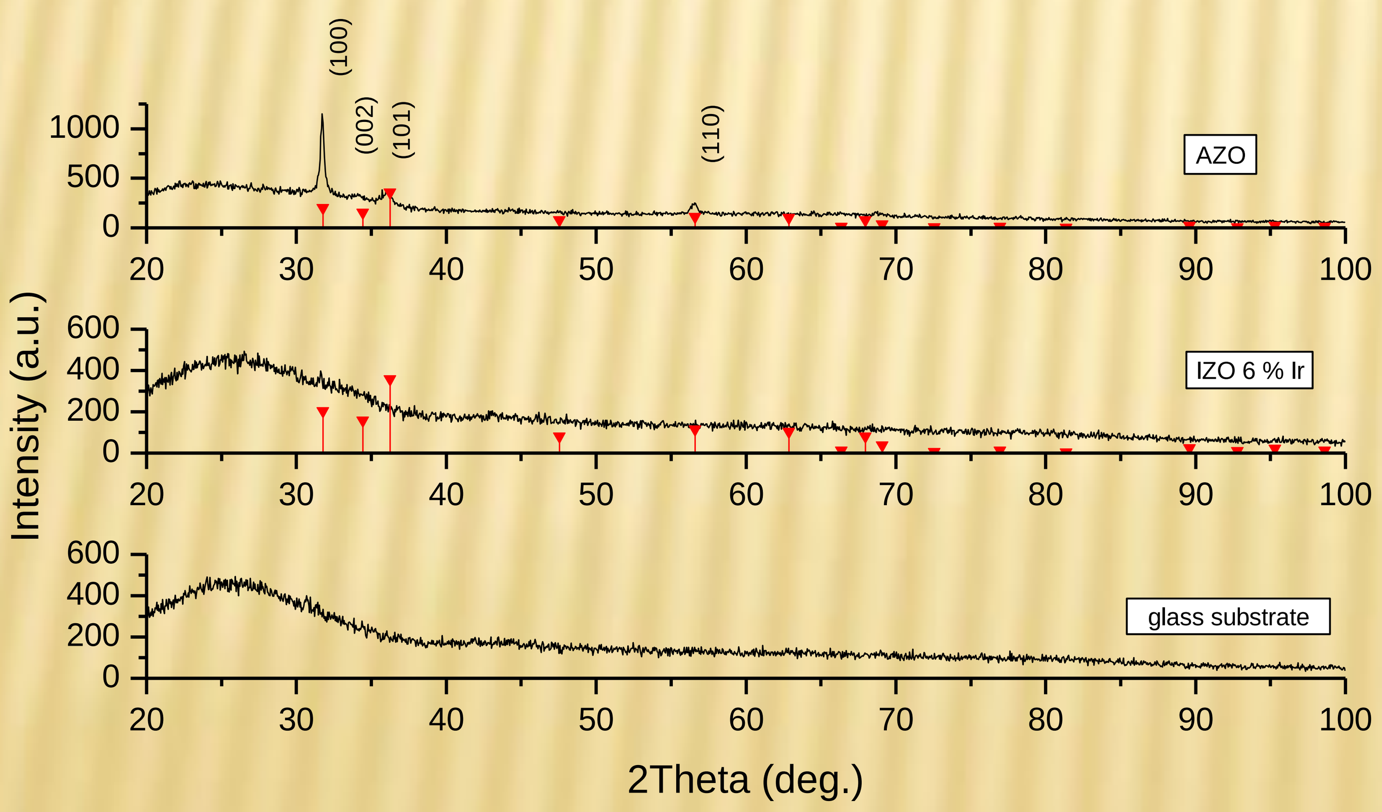

Fig.2. XRD spectra for the films of AZO (top), IrZO (middle) and a bare glass substrate (bottom).

Electrical resistivity of the films, as determined using a 2 point method with aluminium contacts is shown in Fig. 3. In both cases, the resistivity passes through a minimum as a function of the oxygen flow during the deposition. The lowest resistivity, 2.3×10^{-3} Ω×cm, for AZO films is achieved at 1.2 sccm oxygen flow. The lowest resistivity for IrZO films is 25×10^{-3} Ω×cm at 2.5 sccm oxygen flow. One of the reasons for the higher resistivity of IrZO most likely is the amorphous structure of the films.

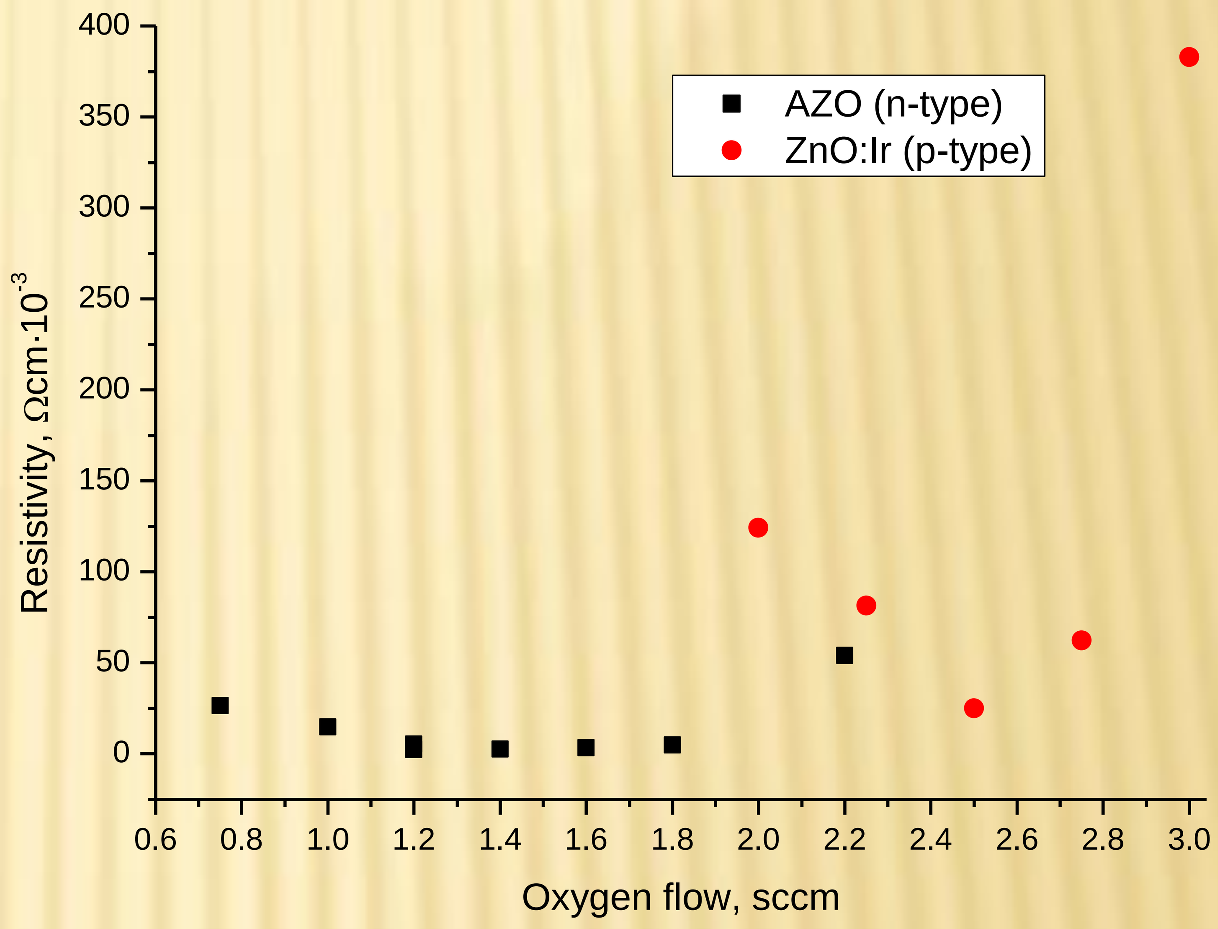

Fig.3. Resistivity of AZO and IrZO films as a function of oxygen flow in the sputtering atmosphere.

Optical transmittance is considerably higher for the AZO films than for the IrZO films (Fig. 4).

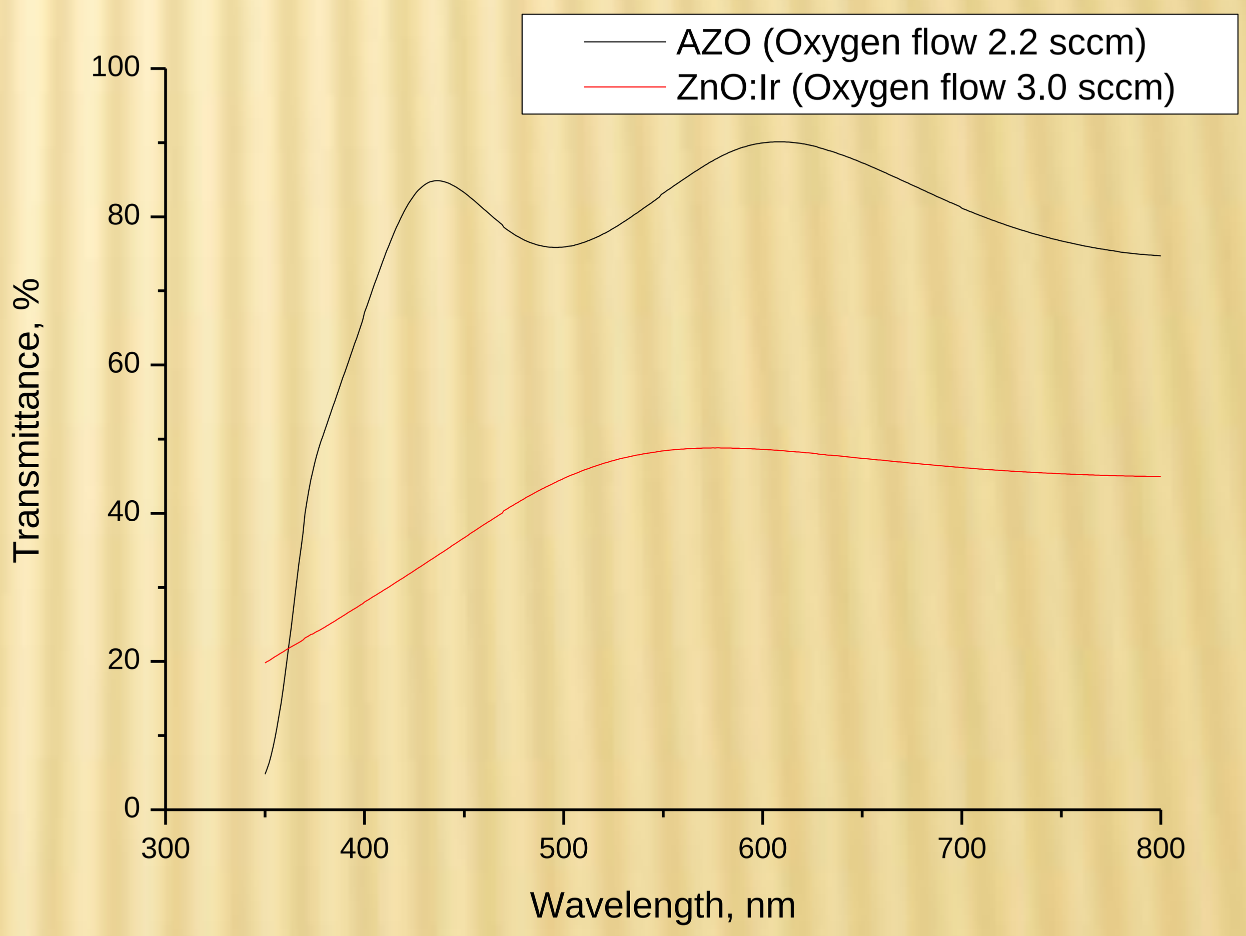

Fig.4. Optical transmittance spectra for AZO and IrZO films

Summary

Films of n-type Aluminium-Zinc oxide and p-type Iridium-Zinc oxide have been deposited by DC reactive magnetron sputtering from metallic targets with the process control based on plasma optical emission spectroscopy. With the resistivity for both types of films passing through a minimum as a function of oxygen flow in the sputtering atmosphere, the resistivity for IrZO films is approximately 10 times higher than for AZO films. One of the likely reasons for the higher resistivity of IrZO is the amorphous structure of these films, compared to the nanocrystalline films of AZO.

Acknowledgements

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