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Transparent conductive IZO films deposited by reactive sputtering from metallic targets

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InZnO (IZO) is an amorphous TCO with interesting properties such as low electrical resistivity, high electron mobility, optical transparency in the visible and near-infrared spectrum range and low surface roughness. Due to its amorphous character, it can be deposited at Room Temperature (RT), which makes IZO an ideal material for flexible devices and a candidate for replacement of the ITO/glass combination. The primary source of carriers in IZO is the native defect doping via oxygen vacancies in the amorphous phase. Precise control of the oxygen gas amount during sputter deposition is required to optimize the oxygen vacancy concentration and hence the carrier density. The conductivity of the IZO films can be changed from electrically insulating to conductive by varying the oxygen concentration in the argon sputtering gas (less than 5%). The optimum oxygen content to maximize the conductivity is also dependant on the In to Zn ratio. In order to achieve reproducible results in both conductivity and transparency, it is crucial to obtain a stable and precise deposition process. In this paper, we show the use of a feedback control of the reactive gas to stabilise the surface composition of the metallic targets by adjusting the reactive oxygen flow in response to the plasma conditions. A co-sputtering arrangement with two rectangular magnetrons (40 x 10 cm2) with individual In and Zn targets is used. A closed loop reactive gas controller is used to monitor the plasma emission lines and adjust the oxygen flow in order to stabilize the sputtering process. As changes occur in the plasma, the optical sensor monitors the variations of the intensity of the emission lines providing an input to the fast process control that automatically actuates the mass flow controller to adjust the oxygen flow. The balance of metal and oxygen atoms is maintained at the optimum level for obtaining high deposition rates and accurate control of the film stoichiometry, which is crucial for obtaining high optical transparency and electrical conductivity of the IZO films. IZO films with electrical resistivity in the 10-4Ohm.cm range and average optical transparencies of 85% were achieved.

Keywords
TCO