ON PHYSICAL PROPERTIES OF UNDOPED, Al AND In DOPED ZINC OXIDE FILMS DEPOSITED ON PET SUBSTRATES BY PULSED LASER DEPOSITION

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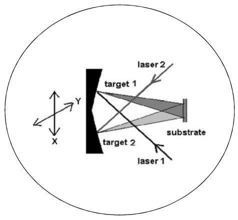
Abstract

ZnO is a semiconducting material with a band gap of 3,3 eV and is widely used for solar cells and LED devices. Undoped and aluminum- and indium-doped zinc oxide films were deposited on flexible PET substrates by Reactive Pulsed Laser Deposition (R-PLD). The morphological and structural characteristics of the obtained structures were investigated by AFM, SEM and XRD respectively. The transmittance spectra were recorded in the wavelength range 300-1200 nm and the electrical conductivity was measured. The samples appeared as granular and polycrystalline with high transparency and had a good electrical conductivity. The crystallinity of the undoped ZnO films improved with increasing pressure of the reactive oxygen gas. Doping of ZnO with Al or In modified the energy band gap of the material. The possibility for the application of such structures for the development of flexible photovoltaic cells will be discussed.

Experimental parameters

Schematic of PLD setup



Vacuum chamber

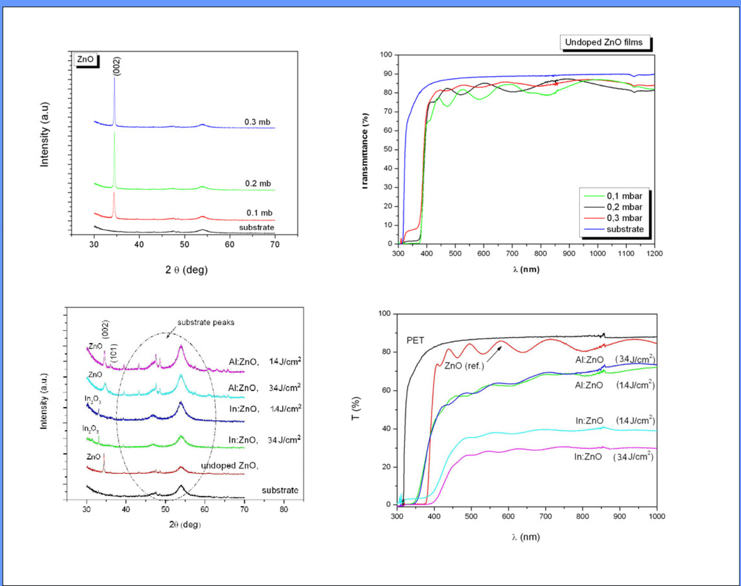
Undoped ZnO

ZnO thin films were deposited on PET substrates (heated at 120 °C) by an 248 nm excimer laser at oxygen pressures 0.1mb, 0.2mb, 0.3mb.

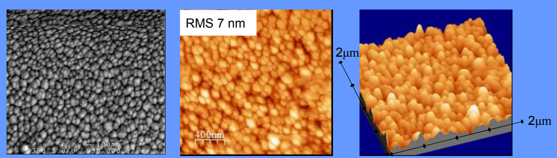
• Doped ZnO with Al or In

The 248nm excimer laser was applied for the ablation of the ceramic ZnO target and simultaneously a 355nm Nd:YAG laser for the ablation of the metallic In or Al target. The repetition rate for both lasers was 10 Hz. The fluence of the second laser used for the ablation of the dopants varied and thus their concentration in the ZnO matrix film could be controlled. The substrate was heated at 120°C and the deposition occurred in oxygen atmosphere at 0.3mb for 1,5 h.

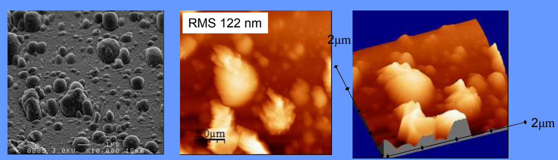
Results and discussion



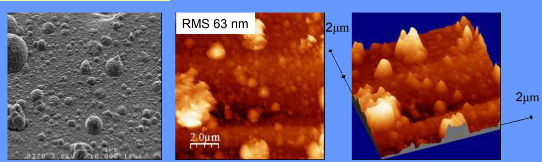
ZnO



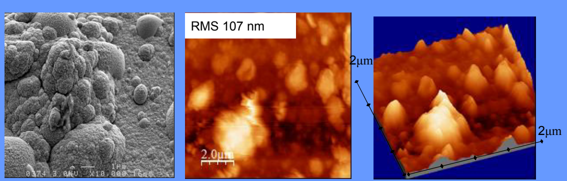
In:ZnO 1.4 J/cm²



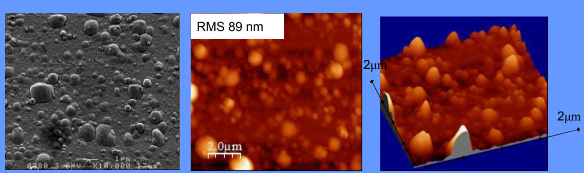
Al:ZnO 1.4 J/cm²



In:ZnO 3.4 J/cm²



Al:ZnO 3.4 J/cm²



The ZnO thin film deposited at 0.3mb had an improved crystallinity (as could be seen from XRD diffractograms), less particulates and it was the most transparent sample. Consequently this pressure was chosen for the deposition of the doped samples.
Al:ZnO films are more transparent and more conductive than In:ZnO films because of the less and smaller metal particulates. In is ablated more easily than Al and obviously 1.4 J/cm² and 3.4 J/cm² is a too high fluence for this material. The particulates act as light scattering centers and impede the current through the material.
The doping of ZnO with Al caused an increase of band gap as the transmittance reaches the zero at lower wavelength. On the other hand, doping with In caused a decrease of band gap as the transmittance reaches the zero at higher wavelength.
Al:ZnO and In:ZnO samples with the less Nd:YAG laser fluence had less particulates and thus they were more conductive.

Conclusion

The R-PLD method allows the growth of semiconducting thin films with good quality on flexible substrates at low temperature. Laser fluence control is crucial for the properties of the materials. The doped In:ZnO thin films seem to be inappropriate for photovoltaic applications due to their low transparency and low conductivity induced by the big particulates. These effects are less pronounced for doped Al-ZnO thin films