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Control the Crystal Growth of Al-doped ZnO Thin Film Prepared by Pulsed Laser Deposition and The Influences on Its Optical and Electrical Properties

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Transparent conducting thin film is an important layer determining the efficiency of optoelectronic devices. Materials shown the wide-range transparency together with high conductivity are of interest. Among materials providing such optical and electrical properties, metal-doped ZnO is a promising material that gain tremendous attractions. In this work, highly transparent and highly conductive thin films of Al-doped ZnO (AZO) are achieved by pulsed laser deposition (PLD). By changing the substrate temperature in the range of room temperature to 500 ^{o}C during the deposition process, the preferential growth direction of AZO crystal is controlled and, as a consequence, the surface morphology, optical and electrical properties of AZO thin film are able to be manipulated. X-ray diffractrograms as a function of substrate temperature clearly illustrate the ability to control the preferential growth direction of AZO. At the low substrate temperature, the growth along [002] direction corresponding to c-axis of hexagonal ZnO is only observed. By elevating substrate temperature, not only crystallinity of AZO thin film is further improved but also the competition of crystal growth along the [002], [001] and [101] directions are occurred due to the increase of total energy and surface mobility of adatom. The AZO films obtained by all preparation conditions exhibit an n-type semiconducting characteristics, furthermore, the carrier concentration and the carrier mobility of AZO thin films can be optimized to reach 4.10×10^{20} cm^{-3} and 7.53 cm^{2}/Vs, respectively. The excellences in both carrier concentration and mobility of AZO thin film lead to very low resistivity of 2.08×10^{-3} Ω cm. In addition, the wide optical band gap of ˜3.50 eV together with the high transparency over 85% is obtained from the AZO thin films. The exceptional optical and electrical properties of AZO thin film demonstrate that such material has enough potential to become a promising candidate using in optoelectronic applications.

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