Growth of AZO thin films from pressed-sintered powder targets under subatmospheric conditions

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Aluminum-doped zinc oxide (AZO) transparent thin films continue to be of great interest due to their potential in several industrially significant applications. However, to realize the high throughput of AZO thin film production, the deposition process should be simple, fast, and inexpensive. In this work, the deposition of AZO thin films using a custom-built magnetron sputtering system operated at around 9.5 Pa with a base pressure of 5 Pa is presented. The target was made from zinc oxide (ZnO) and aluminum oxide (Al_2O_3) powders with predetermined ratios. The 3.2 cm diameter disk target was prepared by mixing, pressing, calcining, and sintering the powders. A 13.56 MHz radio frequency (RF) power supply was used to ignite the plasma and sputter the target material leading to the growth of AZO films on precleaned glass substrates. The characteristics of the films were compared to AZO films deposited at the same operating pressure but with a base pressure of 0.007 Pa. UV-Vis transmittance spectra of the deposited AZO thin films showed a transparency range of around 94-95% at 500 nm of the visible light region. A red shift on the absorption edge from 348 to 359 nm was observed for a lower base pressure which indicates a change in the optical band gap. The calculated optical band gap of the films are 3.19 and 3.37 eV for base pressures of 0.007 and 5 Pa, respectively. X-ray diffractograms revealed a dominant peak around 34.2° which corresponds to the (002) plane of the hexagonal wurtzite structure of ZnO. Other diffraction peaks were observed at 47.5°, 62.8°, and 68.1° which correspond to (102), (103), and (112), respectively. An improved crystallinity was observed for the film deposited at a higher base pressure based on the (002) peak intensity. Using the Scherrer equation, the estimated crystallite sizes are 4.14 and 5.25 nm for base pressures of 0.007 and 5 Pa, respectively. Energy-dispersive X-ray (EDX) spectral data confirmed the presence of Zn, Al, and O. A higher atomic concentration of all the elements was observed for the sample deposited at higher base pressure. The Al concentrations were found to be 0.59 and 0.64 at% with Al/Zn ratio for samples deposited at base pressures 0.007 and 5 Pa, respectively. In addition, no unwanted impurities were observed from the EDX spectra. This signifies that AZO thin films can be grown without using high vacuum systems. This study demonstrated that a facile preparation process using subatmospheric conditions can produce highly crystalline AZO films.