Low-temperature plasma-enhanced atomic layer deposition of indium oxide

Ali Mahmoodinezhad,[1] Carlos Morales,[1] Franziska Naumann,[2] Paul Plate,[2] Robert Meyer,[2] Christoph Janowitz,[1] Karsten Henkel,[1] Małgorzata Kot,[1] and Jan Ingo Flege[1]

[1]Applied Physics and Semiconductor Spectroscopy, Brandenburg University of Technology Cottbus–Senftenberg, K.-Zuse-Str. 1, 03046 Cottbus, Germany
[2]SENTECH Instruments GmbH, Schwarzschildstraße 2, 12489 Berlin, Germany

Indium oxide (In_xO_y) thin films were successfully grown by plasma-enhanced atomic layer deposition (PEALD) using trimethylindium (TMIn) and oxygen plasma (O_2) at low temperatures of 80 to 200 °C. The films were investigated by spectroscopic ellipsometry (SE), X-ray photoelectron spectroscopy (XPS), and electrical measurements. The in-situ SE data confirmed a self-saturated growth mechanism with a growth rate of 0.56 Å per cycle within the ALD window (100 to 150 °C) resulting in a well-defined film thickness with an excellent homogeneity of ≥ 98.8% across 4 inch substrates. We found that the refractive index of the layers increases from 2.04 at 80 °C to 2.07 at 150 °C, and it abruptly decreased to 2.02 at 200 °C. Besides, the In_xO_y layers show indirect and direct transitions in the optical band gap with values of 2.8 ± 0.1 eV and 3.3 ± 0.2 eV, respectively. According to XPS, the PEALD-In_xO_y thin films are free of carbon below the surface; also, they exhibit a temperature-dependent indium-rich off-stoichiometry that increases with temperature. Correspondingly, at temperatures ≥ 150 °C, the electrical conductivity of the layers is higher. In addition, a detailed XPS analysis revealed the presence of hydroxyl groups and defect states whose concentrations decrease with rising deposition temperature. Based on the obtained results, we deem our indium oxide thin films to be suitable for high-performance optoelectronic and photovoltaic devices.

Topic: AA17: ALD Applications Poster Session