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Low-temperature atomic layer deposition of indium oxide thin films using trimethylindium and oxygen plasma
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Indium oxide thin films were deposited on Si (100) by plasma-enhanced atomic layer deposition (PEALD) using trimethylindium (TMIn) and oxygen plasma (O2) in a low-temperature range of 80 to 200 °C. The In_2O_3 layers were characterized by in-situ spectroscopic ellipsometry (SE), ex-situ X-ray photoelectron spectroscopy (XPS) and electrical measurements. The SE data show a growth rate of 0.56 Å/cycle within the ALD window (100 to 150 °C) with a thickness inhomogeneity of $\leq$ 1.2%. In addition, the highest refractive index is 2.07 (at 632.8 nm) for the layer grown at 150 °C, and the films exhibit indirect and direct band gaps of 2.8±0.1 eV and 3.3±0.2 eV, respectively. XPS characterization indicates no carbon incorporation and a temperature-dependent off-stoichiometry of the layers. The chemical analysis of the In 3d and O 1s core levels confirms the formation of In-O bonds and suggests the additional presence of hydroxyl groups and defects. With increasing temperature, the contribution of OH groups and defects decreases whereas that of In-O bonds increases. Notably, higher growth temperatures result in an indium rich phase within the layers.

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