Combinatorial pulsed laser deposition of amorphous, transparent and conductive oxides for thin film transistors

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Amorphous, transparent and conductive oxides (a-TCOs) are key components for thin film transistors (TFTs), solar cells electrodes and active displays. By controlling their stoichiometry, a-TCOs can be used as TFT channels (semiconductive behavior) or as transparent electrodes (conductive behavior). Recently, room temperature deposited amorphous indium zinc oxide (a-IZO) and indium gallium zinc oxide (a-IGZO) thin films were shown to exhibit a very good transparency in the visible range, low resistivity, and high mobility. Since the optical and electrical properties of these films depend on the In/(In+Zn) and Ga/(Ga+In+Zn) values, the measurement of these ratios as well as films thickness, density, interfacial roughness and electronic band alignment with the gate dielectric are critical parameters for future developments and applications.

Our investigations focused on the relationship between composition and properties of IZO and IGZO thin films synthesized using the Combinatorial Pulsed Laser Deposition technique. An accurate monitoring of the thin films elemental composition was performed by auto-calibrated Laser-Induced Breakdown Spectroscopy (LIBS) based on plasma modeling in view of further *in-situ* and real-time technological developments and process control in case of TCOs fabrication. The cation fractions measured by LIBS were compared to values obtained by complementary measurements using Rutherford backscattering spectrometry, energy dispersive X-ray analysis and X-ray fluorescence.

The optical properties (thickness profile and refractive index determination) of the thin films were inferred from spectroscopic ellipsometry data acquired in the visible range and optical reflectance measured from 30 cm^{-1} (4 meV) to 30 000 cm^{-1} (4 eV). Complementary investigations have been performed by fitting the measured X-ray reflectivity curves with simulated ones using a dedicated model to obtain the thickness and density of the deposited films. The room temperature electrical properties were investigated using typical four-point probe geometry and Hall measurements and compared with the values estimated from the optical reflectance data.

Key words: amorphous transparent and conductive oxides, laser induced breakdown spectroscopy, combinatorial pulsed laser deposition

Continuous spread composition IZO and IGZO thin films were synthesized using the combinatorial pulsed laser deposition technique and their stoichiometry, structure and properties were investigated to identify the best recipes for thin film transistor applications.