Ultrathin ALD films and nanolaminates based on Al_2O_3, ZrO_2 and ZnO

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The atomic layer deposition (ALD) technique gives the possibility of depositing conformal functional coatings with a controlled chemical composition - single-component, multi-component and also multi-layer structures such as nanolaminates - used in various fields of technology to modify surface properties. Ultra-thin metal oxides can be used, e.g. as anti-corrosion coatings, functional coatings of polymeric materials, or as coatings on electrode/electrolyte interfaces in all-solid-state battery (ASSB) structures. We experimentally tested the ALD growth and properties of ultrathin (up to about 20 nm) Al_2O_3, ZrO_2 and ZnO coatings in the form of individual layers and nanolaminates (Al_2O_3/ZrO_2, Al_2O_3/ZnO). We used a thermal ALD mode in the temperature range of 100-300°C, on various substrates (silicon, gallium arsenide) and with the use of various oxygen precursors (water, ozone). The precursors of Al, Zr and Zn were, respectively: trimethylaluminum, tetrakis(ethylmethylamino)-zirconium(IV) and diethylzinc. We used a number of material characterization methods and proved the possibility of controlling the thickness and refractive index of the layers (by spectroscopic ellipsometry), structure composition (by X-ray photoelectron spectroscopy, energy-dispersive X-ray spectroscopy), coating tightness and electrical properties (by conductive atomic force microscopy-tunneling AFM), surface topography (by tapping mode AFM).

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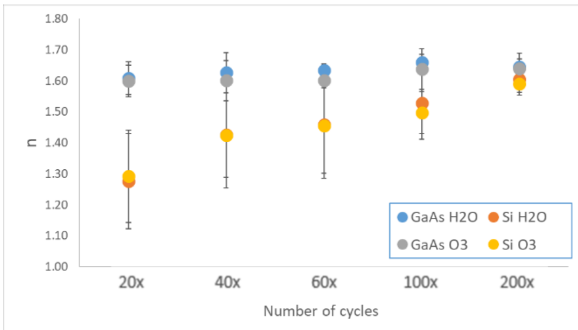

Fig. 1. Refractive index (@650 nm), for ultrathin Al_2O_3 on GaAs and Si deposited using different oxygen precursors.

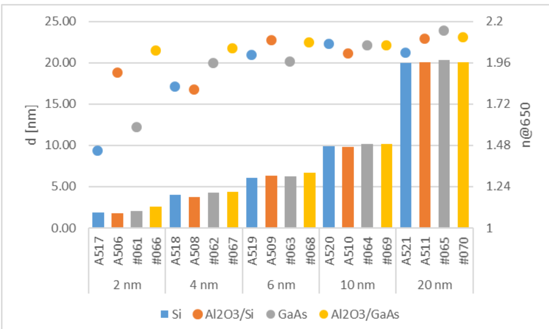

Fig. 2. Thickness and refractive index (@650 nm), for ultrathin ZrO_2 on GaAs, Si, Al_2O_3/GaAs, Al_2O_3/Si.

(a) (b)

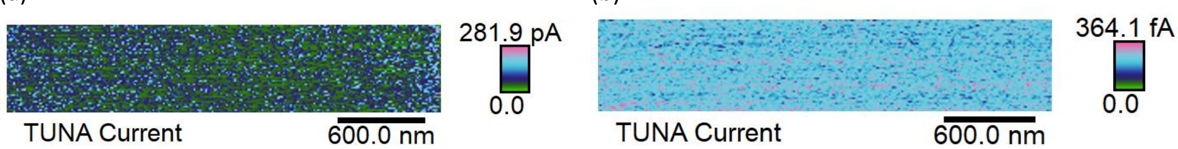

Fig. 3. Tunneling AFM, for the Si (n+) substrate (a) and the decrease in electrical conductivity by three orders of magnitude after coating with a layer of 2 nm Al_2O_3 (b).