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Study of aluminium oxide thin films deposited by plasma-enhanced atomic layer deposition from tri-methyl-aluminium and dioxygen precursors: investigation of interfacial and structural properties

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Abstract:

Aluminium oxide (Al_2O_3) films were deposited on silicon substrates using plasma-enhanced atomic layer deposition (PE-ALD) technique with tri-methyl-aluminium TMA ($Al(CH_3)_3$) and dioxygen (O_2) as precursors. PE-ALD experiments were performed in order to (i) investigate the interfacial properties between the silicon substrate and the alumina layer, and (ii) understand the impact of growth and crystallization phenomena on the Al_2O_3 films properties (structural, optical, mechanical, dielectric and etch). The formation of oxide-based transition layers, either silicon oxide SiO_2 and/or aluminosilicate Al_xSi_yO, was evidenced for the TMA/O_2 PE-ALD process. Based on these results, it appears that no substrate-enhanced growth occurs at the early stages of the growth process, as assumed in previous reports. Thus, constant growth rate (0.08 nm per cycle) and refractive index (1.64 at a 450 nm wavelength) were obtained for the Al_2O_3 layer deposited at 300°C. Finally, thermal annealing experiments were performed on these films, evidencing the influences of atomic structural rearrangement and crystallization on the Al_2O_3 film main characteristics: interface steepness, atomic structure, refractive index, residual stress, dielectric constant and etch rate.

Keywords: plasma-enhanced atomic layer deposition, PE-ALD, thin film, alumina, aluminium oxide, Al_2O_3, interfacial properties, physical properties