Comparisons between TiO_2/Al_2O_3 nanolaminates grown by thermal and plasma enhanced atomic layer deposition: growth mechanism and material properties

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Nanolaminate coatings can offer significant improvements to traditional single-layer materials. An interesting class of nanolaminate materials is one based on alternatively ordered thin films of transition metal oxides with nanoscale thickness [1]. Using the TiO_2/Al_2O_3 nanolaminate concept of our previous work [1], it is possible to obtain at high temperature a 'stable amorphous film' which is very attractive for applications in microelectronics and optics. It is known that amorphous films of certain materials 'crystallize' during the various processing steps (deposition, metallization and lift-off) required for manufacturing a device. This crystallization modifies the fundamental properties of the film, which makes it suitable for the application. Herein, the thermal atomic layer deposition (ALD) and plasma enhanced atomic layer deposition (PEALD) of TiO_2/Al_2O_3 nanolaminates on silicon(100) and glass substrates were studied in order to discuss the growth mechanism and material properties of the films. We use the nanolaminate concept where each TiO_2/Al_2O_3 nanolaminate incorporates a certain number of Al_2O_3 partial-monolayers (between 10 to 90) during 2700 total reaction cycles of TiO_2 under temperature of 250 ºC [1]. TiO_2/Al_2O_3 films were deposited by a TFS-200 ALD system from Beneq. TMA and TTIP were used as metallic precursors, while H_2O or O_2 plasma were used as ligand. The growth mechanisms and fundamental properties of the TiO_2/Al_2O_3 nanolaminates were inferred from measurements of the film thickness, chemical composition, microstructure and morphology. In addition, some optical and mechanical characteristics were determined and correlated with fundamental properties. Results evidenced that the model proposed for thermal ALD TiO_2/Al_2O_3 nanolaminate is valid for PEALD, however it was necessary a higher number of Al_2O_3 layers for stop the TiO_2 crystallinity. This allows obtaining a nanolaminate with improved properties in comparison with thermal ALD, as for example higher transmittance, lower refractive index (near the value of 3.2 eV), low resistivity, and higher hardness and young modulus. These properties are interesting for sensing application, such as UV detection.

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