View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Ghent University Academic Bibliography

Cost-reducing PE-ALD processes for pure and doped SiO_2 thin films

Geert Rampelberg[1], Véronique Cremers[1], Andreas Werbrouck[1], Jolien Dendooven[1], Christophe Detavernier[1]

1 Department of Solid State Sciences, COCOON group, Ghent University, Gent, Belgium

(Christophe.Detavernier@UGent.be)

Plasma-enhanced atomic layer deposition (PE-ALD) of SiO_2 has evolved tremendously during the past decade, mainly driven by the need for well-controlled conformal layers for spacer defined double patterning in microelectronics. For this application, dedicated Si precursors have been developed, focusing on high growth per ALD cycle and low-temperature ALD. The cost of these novel precursors is however high compared to traditional high volume manufacturing (HVM) silicon compounds used for chemical vapor deposition and plasma polymerization, such as (3-Aminopropyl)triethoxysilane (APTES), tetraethyl orthosilicate (TEOS) and hexamethyldisilazane (HMDS). Certainly when coating large area substrates such as foils, nano- and micron-sized particles and porous materials, precursor cost can become a major fraction of the total process cost, motivating research into cheaper HVM precursors for SiO_2 ALD for these applications.

In this work, we compare the PE-ALD growth characteristics of bis(diethylamino)silane (BDEAS) and the three aforementioned lower-cost Si precursors for deposition of pure SiO_2 films. Although all four precursors enable deposition, the growth rate decreases from around 1 Å/c for BDEAS down to 0.2 Å/c for TEOS (Figure 1). While BDEAS and APTES based processes show excellent to medium conformality, TEOS and HMDS are not at all able to deposit SiO_2 inside a trench structure (Figure 2). Growth enhancement was observed when adding TiO_2 subcycles to the deposition process, using the HVM and low-cost titanium tetraisopropoxide (TTIP) precursor (Figure 1). These $Ti_xSi_{(1-x)}O_2$ films, with tunable dielectric properties, are furthermore characterized by drastically improved conformality (Figure 2). In addition, pure SiO_2 coatings have been deposited on micron sized polymer particles using different room-temperature PE-ALD processes to improve the flowability.

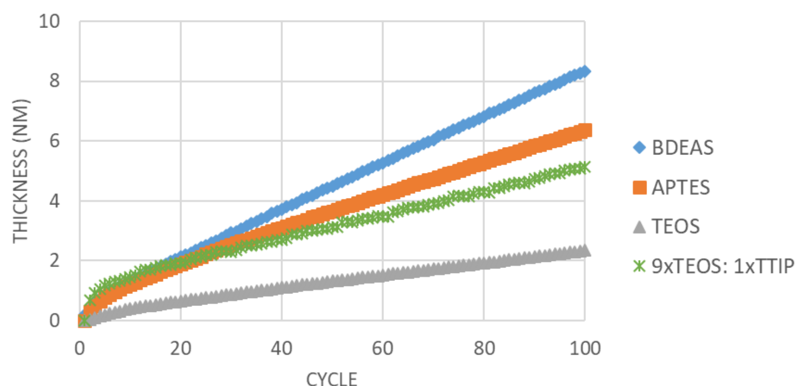

Figure 1. Linearity curves for PE-ALD of SiO_2 from BDEAS, APTES, TEOS and TEOS+TTIP (9:1 ratio).

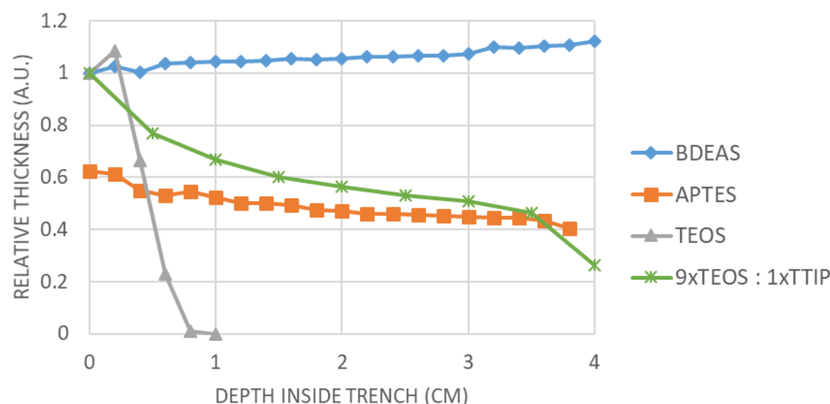

Figure 2. Conformality inside a macroscopic trench for pure and doped SiO_2 from BDEAS, APTES, TEOS and TEOS+TTIP (9:1 ratio).