Growth and Characterization of Al_2O_3:HfO_2 Nanolaminate Films Deposited by Atomic Layer Deposition (ALD)

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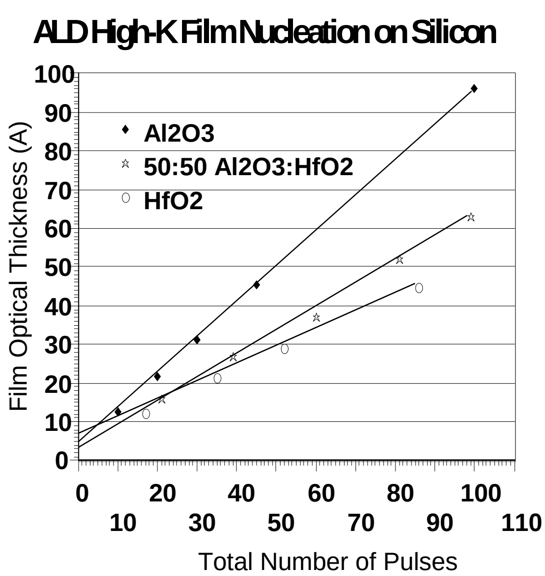
As gate dielectrics in logic and memory continue to scale, higher dielectric constant materials, such as Al_2O_3, HfO_2, ZrO_2 and others are under investigation to replace silicon dioxide. Nanolaminates of these high-K films are easily grown by Atomic Layer Deposition (ALD) and may offer potential benefits by combining the best properties of each metal oxide into one composite film.

The physical and electrical properties of Al_2O_3: HfO_2 nanolaminate films, grown by ALD, were investigated for compositional ranges from 10%-90% HfO_2 in Al_2O_3. The ALD deposition technique results in good within wafer electrical thickness uniformity (1-2%, 1 sigma). The deposition kinetics of the nanolaminates show good nucleation on SiO_2 surfaces and deposition rates intermediary between Al_2O_3 and HfO_2. The microstructure of these films, as determined by TEM cross-section, is observed to be amorphous with smooth interfaces to the bottom interfacial layer and top polysilicon. Compositional analysis, as determined by Medium-energy ion scattering (MEIS), shows that the ratio of Al_2O_3 to HfO_2 can be tuned effectively by adjusting the pulse ratio of the two films in the nanolaminate growth process.

Poly-gate capacitor results show that the nanolaminates exhibit 4-7 orders of magnitude lower leakage current than SiO_2 of the same electrical thickness, depending on the film composition. C-V measurements indicate that the flatband of these films can shift as much as 300-450 mV from thermal oxide. Hysterisis is present and charge trapping in the nanolaminates is more severe than in the individual metal oxide films.

The thermal stability of these films is also discussed.



High-K films deposited ontop of chemical oxide