Atomic layer deposition of novel multifunctional nanostructures

A major challenge facing the silicon micro- and nano-electronics industry is the requirement to replace the SiO_2 gate of transistors with high dielectric constant (k) nanostructures in future processes. The use of high-k materials is essential to reduce overall power dissipation and leakage currents in future devices. The current lack of understanding of process – structure – functionality relationships of high-k/semiconductor nanostructures and interfaces during and after deposition as well as during post-deposition thermal treatments are primary obstacles to the successful incorporation of high-ḳ nanostructured materials into mainstream micro- and nano-electronic processes.[1-4]

The proposed project will focus on atomic layer deposition (ALD) of $HfAlO_x$ using tetrakis-diethylamino hafnium and tris-diethylamino aluminum as metal precursors and ozone as oxidizer. ALD temperature windows of these two precursors are found to overlap between 200 and 275 ^oC which is critical for ALD of composite $HfAlO_x$ films. The film composition will be studied with the number of cycles of alternating alumina and hafnia. Structure - properties relationships of the resulting $HfAlO_x$ films will also be studied.

We will also investigate the effectiveness of atomic layer deposited (ALD) aluminum oxide barrier layer in controlling the interfacial reaction between ALD HfO_2 film and Si substrate.[5] The HfO_2 is observed to form silicate and silicide at its interface with Si during 5 min post deposition annealing in Ar at 800 and 1000 ^oC. Variable thickness Al_2O_3 barrier layers will be grown in order to study interfacial reactions between HfO_2 and Si during annealing at 600 - 1000 ^oC. Chemical analytical techniques as well as electron microscopy will be used in these studies. And lastly, incorporation of rare earth elements into the composite oxide film using similar techniques is to be examined in future work as a means to further enhance desired properties.

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