Low EOT Capacitors Utilizing ALD High-k Films from Hf- and Si-based, Metal-Organic Precursors

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The challenge of continued scaling of conventional SiO_2 gate dielectrics has led to the investigation of high-k gate dielectric materials to replace conventional SiO_2 and SiON films. The higher dielectric constants allow physically thicker films to be employed as gate dielectrics, preserving gate capacitance while limiting increases in gate leakage due to direct tunneling and reliability deficiencies of thinner films (SiO_2 below 20 Å). Metal oxides such as HfO_2 and HfSiO have been studied as promising high k alternative candidates.

Deposition techniques have been shown to affect the quality of the high k dielectric films [1]. One such technique is atomic layer deposition (ALD), which has gained acceptance as a thin film deposition technique in semiconductor device manufacturing due to its excellent thickness uniformity and ability to finely craft film compositions. Sequential pulsing of a metal containing precursor and an oxidizing source are used to deposit films in a monolayer-like fashion.

In this paper, an ALD process for HfO_2 high-k dielectric thin films using liquid, metal-organic precursors, tetrakis (ethylmethylamino)-hafnium (TEMAHf) and tetrakis (ethylmethylamino)-silicon (TEMASi), is demonstrated to provide superior Equivalent Oxide Thickness (EOT) to as low as 7.7Å while maintaining acceptable gate leakage levels. Dielectric properties of the HfO2 films as characterized by capacitor C-V and J-V measurements will be discussed. Differing pre-deposition treatments were combined with either a hafnium oxide or a hafnium silicate film, with metal gate electrode, to demonstrate the capability to provide high-k dielectric layers for 65nm node and beyond.

Reference:

1) H. Huff, et al, “Integration Challenges for High-K Gate Stack Engineering”, Extended Abstracts of IWGI 2001, Nov. 1-2, Tokyo, Japan, p 2-11.