Nitrided hafnium silicates for gate dielectrics

CHANG-GONG WANG, MOHITH VERGHESE, ERIC SHERO, GLEN WILK, ASM America, Inc., JAN WILLEM MAES, W. DEWEERD, IMEC, R. OPILA, University of Delaware, J. MORAIS, Instituto de Fisica — Nitrided hafnium silicate (HfSiON) gate dielectric films deposited by atomic layer chemical vapor deposition (ALCVD\textsuperscript{TM}) show excellent capacitor and transistor characteristics with both poly-Si and metal gates, which are directly correlated with local physical and chemical properties. A wide range of compositions are demonstrated, with Si/(Hf+Si) percentages from 0 to 75\% and uniformly distributed N levels up to 30 at. \%. XPS is used to distinguish the local bonding arrangements of N to Hf, Si and O. The distribution and depth profile of these N bonds is directly attributable to the observed electrical and physical properties of these films as measured by TOF-SIMS, TEM, EELS, nuclear reaction analysis and angle-resolved XPS. Using poly-silicon gate electrodes with chemical or thermal oxide underlayers, EOT values down to 1.3nm with substantial leakage reduction vs. SiO\textsubscript{2} have been achieved using stacks with ultrathin HfSiON. Hysteresis and midgap interface density (Dit) are less than 10mV and 5X10\textsuperscript{10}cm\textsuperscript{-2}eV\textsuperscript{-1}, respectively. Transistors (gate length of 110nm) with these ALD HfSiON films display excellent \(V_T\) stability and channel electron mobility \(> 90\%\) of SiO\textsubscript{2} at high \(E_{eff}\). Detailed analysis on silicate compositions, the distribution of nitrogen in the interface layers, and corresponding impact on device performance will be presented.

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