Atomic Layer Deposition of $ZrSiO_4$ and $HfSiO_4$ Thin Films using a newly designed DNS-Zr and DNS-Hf bimetallic precursors for high-performance logic devices

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Future scaling of complementary metal-oxide semiconductor (CMOS) technology requires high *k* dielectrics with metal gate electrodes to obtain higher gate capacitances and low gate leakage current. Of various candidates for gate dielectrics, Zr or Hf based silicates ($ZrSiO_4$ and $HfSiO_4$) prepared by atomic layer deposition (ALD) have received great attention for this application due to its high dielectric constant, low leakage current, and their thermodynamic stability with Si. However, such ALD-$ZrSiO_4$ and $HfSiO_4$ dielectrics have been generally prepared by alternating ALD-ZrO_2 (or HfO_2) and SiO_2 using multiple ALD precursors, which increased the process complexity and occasionally resulted in the fluctuation of electrical performance due to the composition inhomogeneity between Zr (or Hf) and Si within the gate dielectric films.

Herein, therefore, we demonstrated a reliable ALD process of $ZrSiO_4$ and $HfSiO_4$ dielectrics using newly designed bimetallic precursors, DNS-Zr and DNS-Hf. H_2O and O_3 was applied as suitable reactants for those bimetallic precursors. Our bimetallic precursor for $ZrSiO_4$ and $HfSiO_4$ enables a simple and reliable ALD process for depositing stoichiometric $ZrSiO_4$ and $HfSiO_4$ compounds on Si substrate. And, the detailed growth characteristics of both dielectrics are systemically investigated. Also, their electrical performance including current-voltage (I-V) and capacitance-voltage (C-V) was carefully evaluated. The result indicated that our bimetallic precursor based ALD-$ZrSiO_4$ and $HfSiO_4$ processes can be potentially used as future gate dielectrics of high performance of logic devices.