Ultra thin $Zr_xSi_{1-x}O_2$ with compositional gradation grown on Si (100) using $Zr(N(C_2H_5)_2)_4$ and $Si(OC_4H_9)_4$

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$Zr_xSi_{1-x}O_2$ films were deposited by MOCVD using $Zr(N(C_2H_5)_2)_4$ and $Si(OC_4H_9)_4$. Composition (x) of a 4 nm thick $Zr_xSi_{1-x}O_2$ was investigated by Zr 3d, Si 2p, and O 1s XPS depth profiles. The Zr/(Zr+ Si) ratio gradationally changed from ~0.1 at the silicate film surface to ~0.67 at the $Zr_xSi_{1-x}O_2$-Si interface during Ar^+ sputtering. These results were analyzed by binding energy shifts, which are consistent with the predictions of model calculations based on the relative atomic electronativities. An atomically flat interface with no sub-SiO2 interfacial layers was observed. Carbon contamination was less than 0.1 atomic % (below detection limits). The dielectric constants were approximately 9 for both Zr-silicate films as-deposited and annealed at 500 °C in oxygen ambient. When annealed in oxygen ambient, the flat band approached the ideal value in C-V curve. The leakage current density of the Zr-silicate films as-deposited and annealed at 500 °C was ~5×10^{-4} A/cm^2 and ~3×10^{-8} A/cm^2, respectively, at a bias of 1.0 V.