Supplemental Document

The thicknesses and refractive index of high-k films were measured using spectroscopic ellipsometry (Elli-SE(UV)-FM8, Ellipso Technology). We used X-ray photoelectron spectroscopy (XPS, AXIS SUPRA+, KRATOS) to investigate the presence of Carbon. The top electrode, ITO 100 nm, of the MIS capacitor was deposited by RF sputtering. Subsequently, the MIS capacitor was fabricated using a lift-off process. C-V measurements of the MIS capacitors were conducted using a semiconductor parameter analyzer (4200-SCS, Keithley). the interface trap density was calculated using the conductance method.

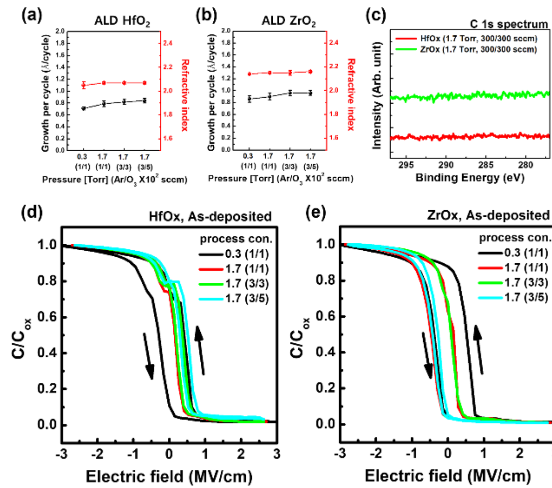

Figure 1. GPC and RI values with modulated ALD process pressures for (a) HfO_2 and (b) ZrO_2. (c) C content measured by XPS under modulated process conditions. C–V characteristics of MIS devices for high-k dielectrics with different process pressures: (d) HfO_2 and (e) ZrO_2.

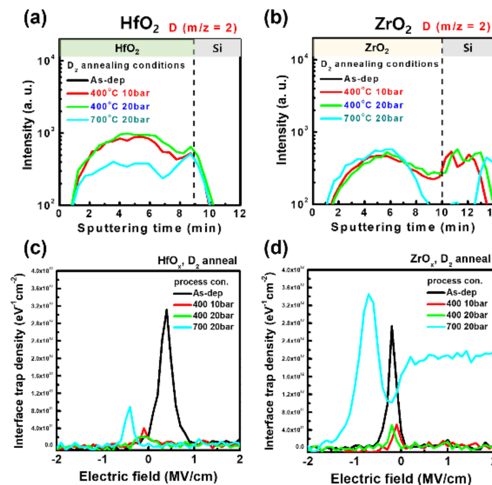

Figure 2. D-SIMS depth profiles of D_2 atoms across the insulator/Si interface before and after HPDA. D_2 profiles for (a) HfO_2, and (b) ZrO_2 on Si interfaces. Calculated interface trap density using the conductance method for MIS devices with (c) HfO_2, and (d) ZrO_2 films after HPDA.