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Supporting Information

Improving the water-resistance of MgO-based metal-insulator-metal capacitors by inserting BeO thin film grown via atomic layer deposition

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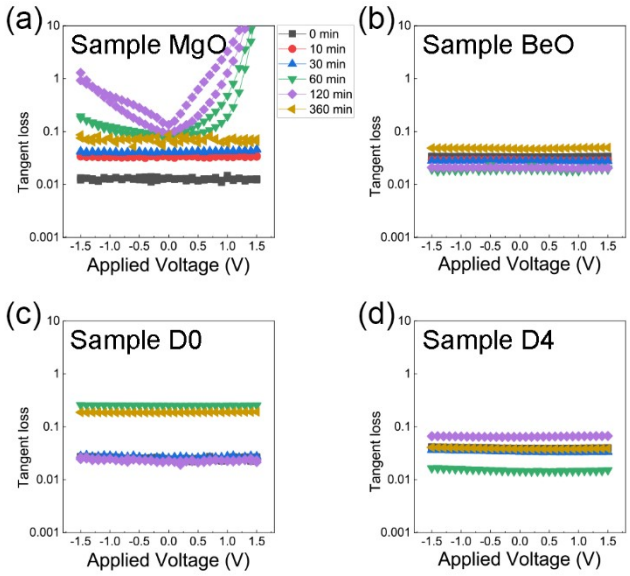

Figure. S1 Tangent loss curves of (a) single MgO, (b) single BeO, and MgO/BeO stack-based metal-insulator-metal capacitors (c) without annealing and (d) with annealing, varying with water immersion time. The physical thickness for the as-deposited single MgO film and BeO/MgO/BeO/MgO/BeO films was ~ 10–11 nm. D0 were samples without annealing while D4 were samples with annealing BeO/MgO/BeO/MgO/BeO (2/2/2/2/2 nm) stacks.

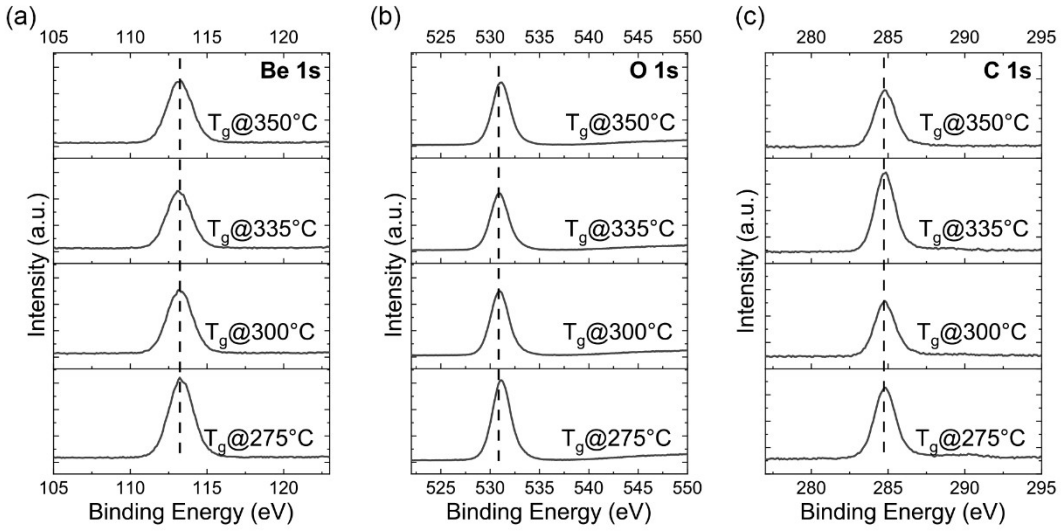

Figure S2. High-resolution X-ray photoelectron spectroscopy (XPS) scan of (a) Be 1s, (b) O 1s, and (c) C 1s for BeO films deposited by ozone-based ALD as function of grwoth temperature (T_g). The ALD cycle numbers were of 175. BeO films were deposited on top of Si substrate.

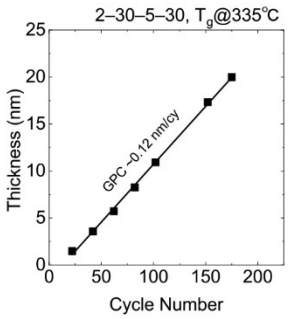

Figure S3. . Diethyl beryllium as precursor and ozone as oxygen source Film thickness as a function of ALD cycle number of ozone-based process at growth temperature (T_g) of 335°C. BeO films were deposited on top of Si substrate.

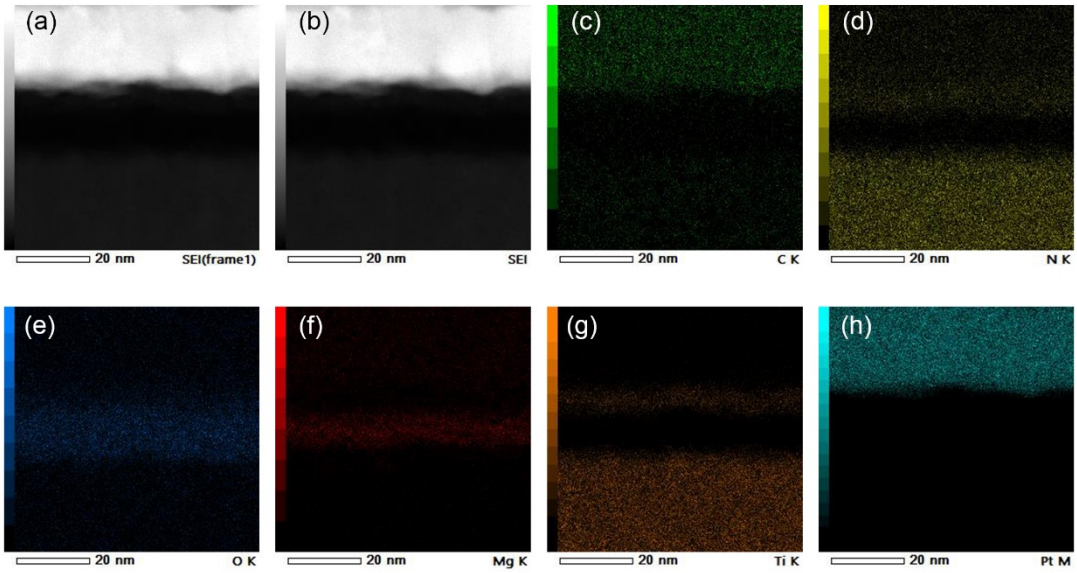

Figure S4. Secondary electron image (SEI) of (a) before and (b) after mapping. (c–h) Elemental mapping by energy-dispersive X-ray spectroscopy in scanning transmission electron microscopy mode. The adopted sample fabricated via focus ion beam method was top-TiN/BeO/MgO/BeO/MgO/BeO/bottom-TiN (sample D0, without water immersion). The physical thickness of BeO/MgO/BeO/MgO/BeO films was ~ 10 nm.

Table S1. Atomic ratio calculated from XPS scan of samples BeO in Figure S2.

Atomic Ratio	275°C	300°C	335°C	350°C
Be	43.9	44.3	42.6	44.7
O	46.9	47.1	44.7	46.7
C	9.2	8.6	12.7	8.7
Be/O	0.936	0.941	0.951	0.957

Table S2. Atomic ratio calculated from XPS scan of samples MgO, D0, D4 in Figure 6.

Atomic Ratio	MgO-0	D0	D4
Mg/Be	-	0.13	0.08
Mg/O	1.41	0.14	0.1
Be/O	-	1.15	1.21
Metal/O	-	1.29	1.3