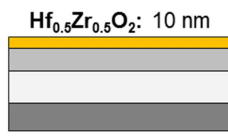
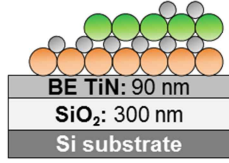


MIM capacitor fabrication

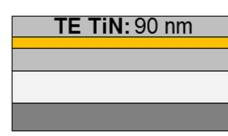
ALD process

- ① TDMA-Hf ② O₃ or H₂O ③ TDMA-Zr ④ O₃ or H₂O ...
~0.2 nm/cycle x 50 cycles = 10 nm



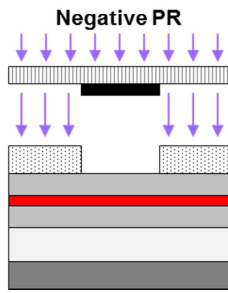
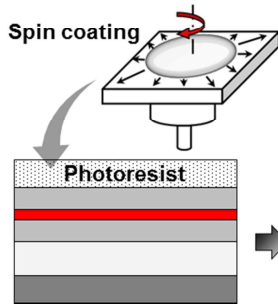
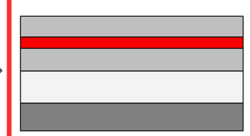
Sputtering

- Thickness
: TE TiN = BE TiN



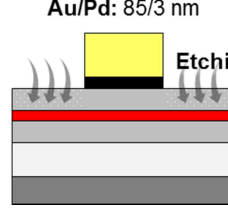
RTA process (PMA)

- For 60 s at 300-500°C
- In N₂ atmosphere



E-beam evaporator

- Sequential deposition



MIM capacitor

Diameter: 50-100 μm

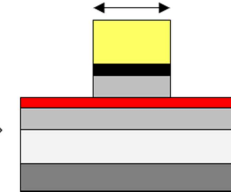
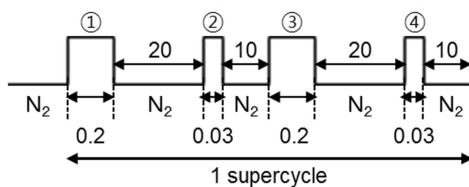


Figure 1. Schematic illustration of the procedure used to fabricate the ozone- and water-based HZO samples.

ALD process

ALD process

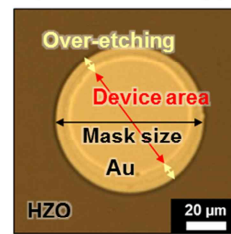
- ① TDMA-Hf ② O₃ or H₂O ③ TDMA-Zr ④ O₃ or H₂O ...



~0.2 nm/supercycle x 50 supercycles = 10 nm

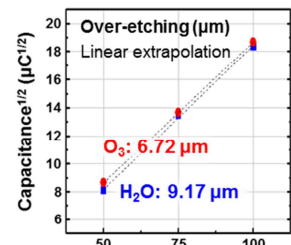
Over-etching calculation

Optical microscopy



After wet-etching

Annealed at 400°C



Over-etching (μm)
Linear extrapolation
O₃: 6.72 μm
H₂O: 9.17 μm

Figure 2. ALD process for the deposition of the ozone- and water-based HZO films and the over-etching values of the ozone- and water-based HZO samples used in this work. These values are estimated by linear extrapolation of the square root of capacitance versus the device diameter and included in all the electrical results.

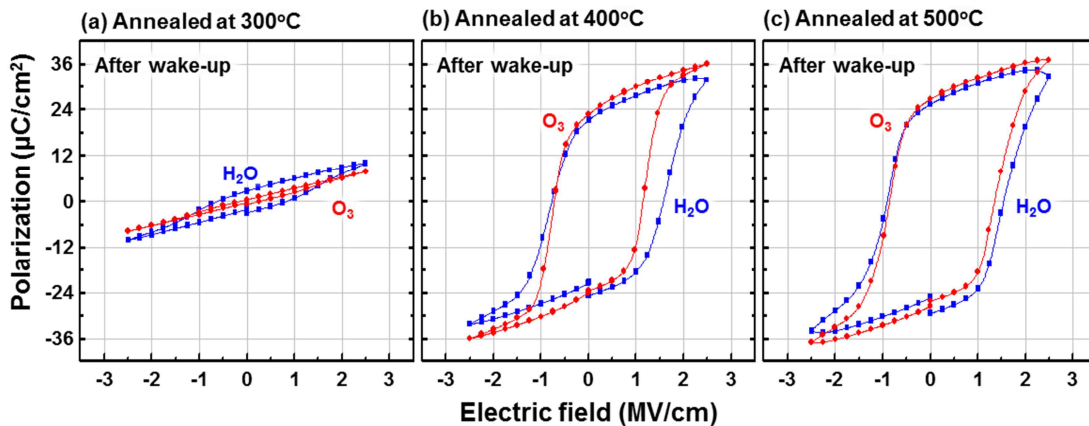


Figure 3. Polarization-electric field hysteresis curves of the ozone- and water-based HZO samples after wake-up field cycling.