

Supplemental materials

Dielectrics	ZrO ₂	1:8	1:4	1:2	1:1
Zr (%)	37.0	35.6	33.2	30.7	28.3
Ta (%)	-	1.2	3.4	5.4	7.0
O (%)	60.4	60.4	60.8	61.1	62
Zr+Ta : O	1 : 1.63	1 : 1.64	1 : 1.66	1 : 1.69	1 : 1.76

Table. 1: Atomic % of Zr, Ta, and O, and stoichiometric composition, O/(Zr+Ta), in ALD ZrO₂, 1:8, 1:4, 1:2 and 1:1 Ta-doped ZrO₂ films

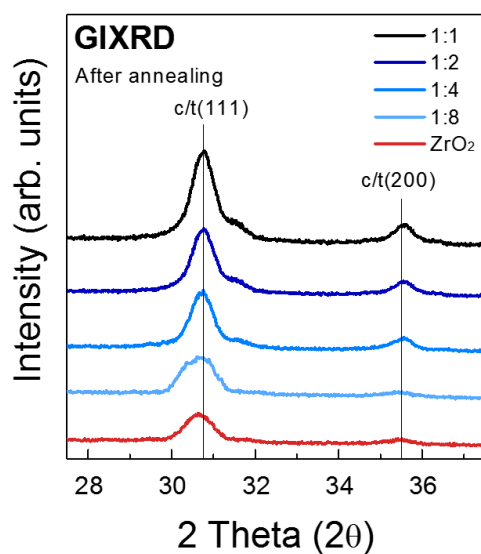


Figure. 1: XRD patterns of 10 nm ALD ZrO₂, 1:8, 1:4, 1:2 and 1:1 Ta-doped ZrO₂ films after annealing

Dielectrics	ZrO ₂	1:8	1:4	1:2	1:1
Dielectric constant	16	21	23	24	29
Leakage current density at -1 MV/cm (A/cm ²)	1.9×10^{-7}	1.4×10^{-7}	8.0×10^{-8}	7.0×10^{-8}	2.5×10^{-9}

Table 2. Summary of electrical properties of MIM capacitors using 10 nm ALD ZrO₂, 1:8, 1:4, 1:2 and 1:1 Ta-doped ZrO₂ after annealing