Supplemental

Low Temperature Ferroelectric $Hf_{0.5}Zr_{0.5}O_2$ Films deposited by thermal atomic layer deposition using high purity H_2O_2

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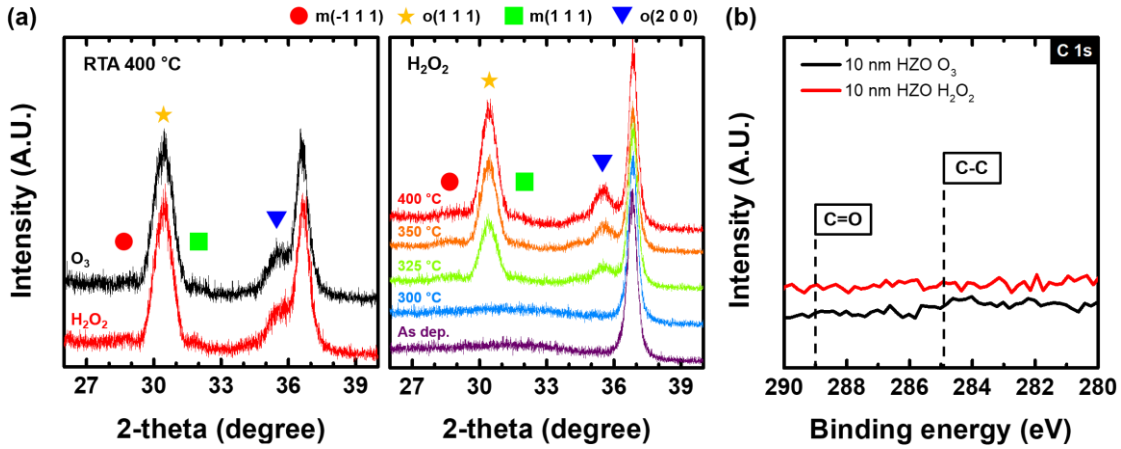

Figure 1. (a) XRD patterns of 10 nm HZO films fabricated with O_3 and H_2O_2. RTA annealing temperature varied from 300 °C to 400 °C. 400 °C annealed HZO showed similar phase configurations in both oxidants (left). From 325 °C, HZO using H_2O_2 as oxidant started to show orthorhombic phase. (b) XPS spectra of C 1s in 400 °C annealed HZO films after 6 s of surface sputtering. Both HZO using H_2O_2 and O_3, the carbon peak was not detectable, which shows that the carbon content is under the detection limit of 1 at%.

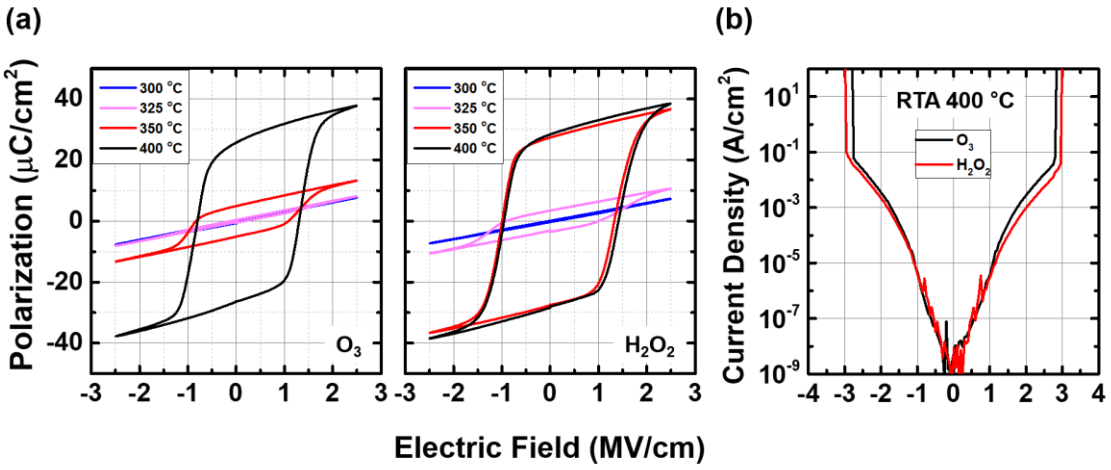

Figure 2. (a) Polarization-electric field hysteresis curves of 10 nm HZO samples fabricated with O_3 (left) and H_2O_2 (right) and varying the temperature from 300 °C to 400 °C. HZO using H_2O_2 starts to show the ferroelectric characteristics from 325 °C, and O_3 starts from 350 °C. (b) Leakage current density-electric field curves of 400 °C annealed 10 nm HZO samples using H_2O_2 and O_3 as oxidant. HZO based on H_2O_2 showed smaller leakage current and slightly higher breakdown voltage compared to O_3 case.