Supporting Information

Hafnium-doped zirconia ferroelectric thin films with excellent endurance at high polarization

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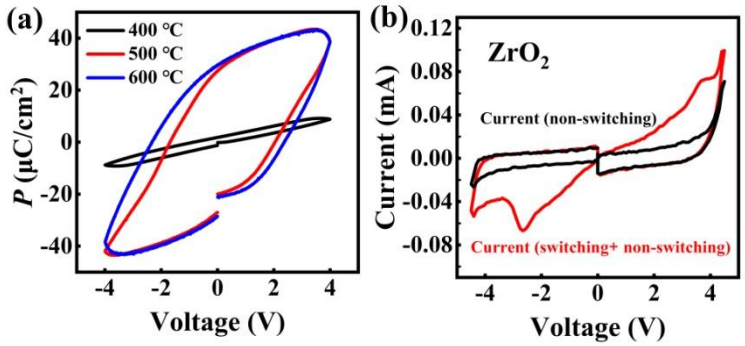

Fig. S1 (a) Pristine *P*-*V* hysteresis loops of W/ZrO_2/W capacitors annealed at different temperatures. **(b)** The corresponding overall (switching plus non-switching) current and non-switching (capacitive and leakage) current curves of ZrO_2 annealed at 600 °C for the PUND result presented in Fig. 2a.

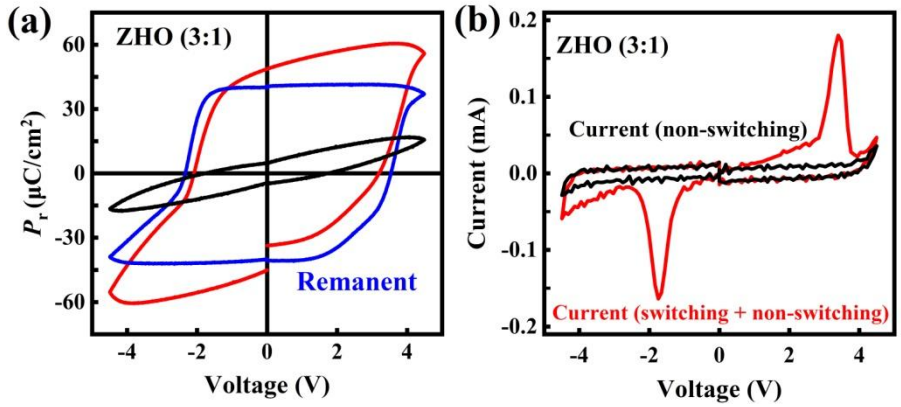

Fig. S2 PUND measurement results of 100 μm-sized W/ZHO (3:1)/W capacitor. **(a)** Polarization hysteresis curves (remanent switching Pr hysteresis curve in blue color: subtracting non-switching curve in black color from overall measured polarization curve in red color; **(b)** The overall and the non-switching (capacitive and leakage) current-voltage curves.

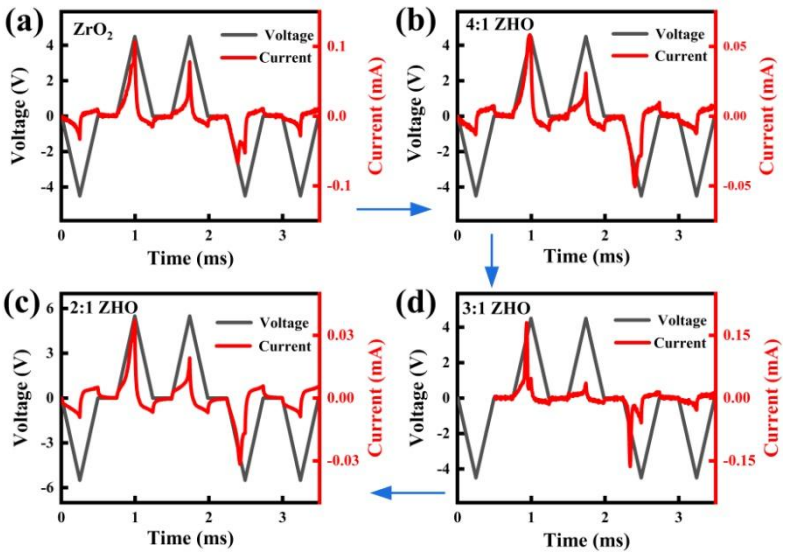

Fig. S3 Voltage waveforms applied in PUND tests and the corresponding current response of W/ZHO/W devices with 10 nm-thick ZHO thin films with different Zr:Hf ratios. **(a)** ZrO_2, **(b)** 4:1 ZHO, **(c)** 2:1 ZHO, **(d)** 3:1 ZHO.

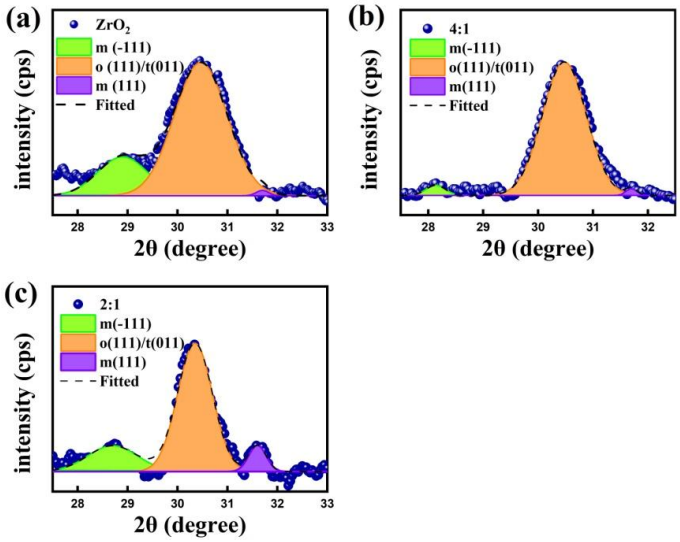

Fig. S4 Gaussian fitting results of the GIXRD spectra of annealed thin films. **(a)** ZrO_2, **(b)** 4:1 ZHO, **(c)** 2:1 ZHO.

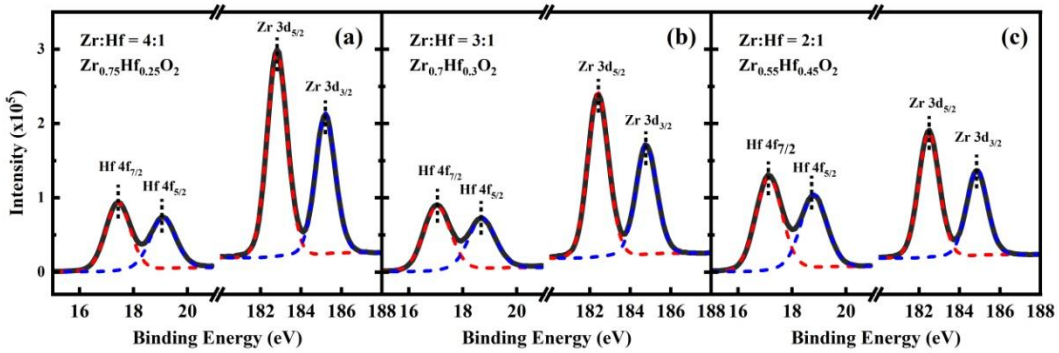

Fig. S5 XPS spectra of annealed ZHO films with different Zr:Hf cycle ratios. **(a)** 4:1, **(b)** 3:1, **(c)** 2:1. The corresponding actual compositions are calculated based on the ratio of Zr 3d/Hf 4f.

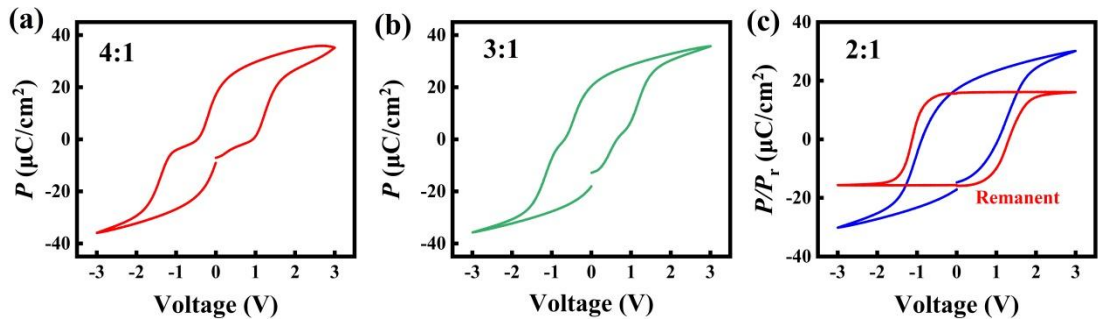

Fig. S6 Ferroelectric characteristics of PMA-treated W/ZHO/W devices. **(a)** Pristine P-V hysteresis loop of 4:1 ZHO. **(b)** Pristine P-V hysteresis loop of 3:1 ZHO. **(c)** Hysteresis loops of pristine P-V (in blue) and PUND-measured remanent P_r-V (in red) for 2:1 ZHO films.

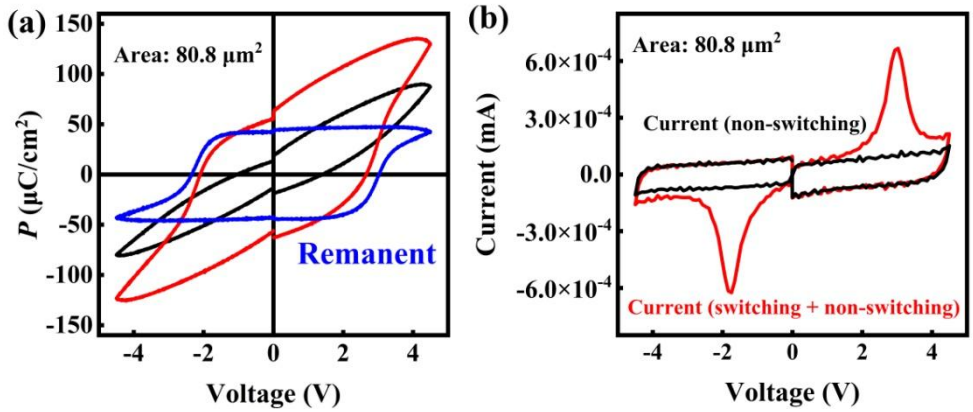

Fig. S7 PUND measurement results of a W/ZHO (3:1)/W capacitor in array. **(a)** Polarization hysteresis curves. Remanent switching P_r hysteresis curve in blue was extracted by subtracting non-switching curve in black from overall polarization curve in red. **(b)** The overall and the non-switching (capacitive and leakage) current-voltage curves.