Characterization of multi-domain ferroelectric ZrO_2 thin films for negative capacitance and inductive responses

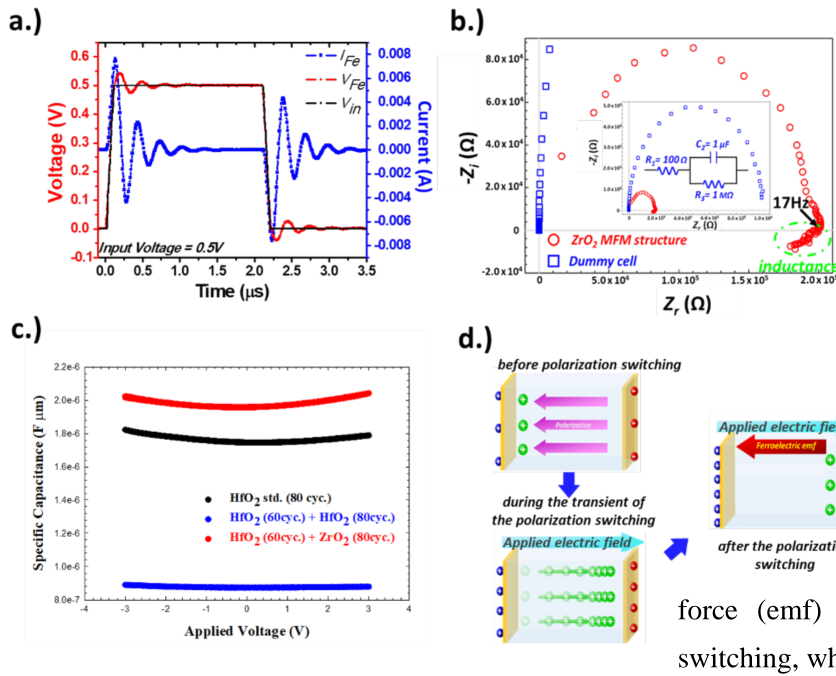

Figure 1. Experimental observations and schematic illustration of the ferroelectric inductance. (a) Transient voltage and current responses of the as-deposited nano-*f*-ZrO_2 MFM structure under the excitation of a voltage pulse. (b) Impedance Nyquist plot of the as-deposited nano-*f*-ZrO_2 and standard dummy cell. (c) CV characteristic of the standard HfO_2, MFMIM and MIMIM structure. (MIMIM: HfO_2+ HfO_2；MFMIM: nano-*f*-ZrO_2 + HfO_2) (d) Schematic diagram of the effective ferroelectric induced electromotive force (emf) originating from the ferroelectric polarization switching, which the behavior was similar with the Lenz's law.

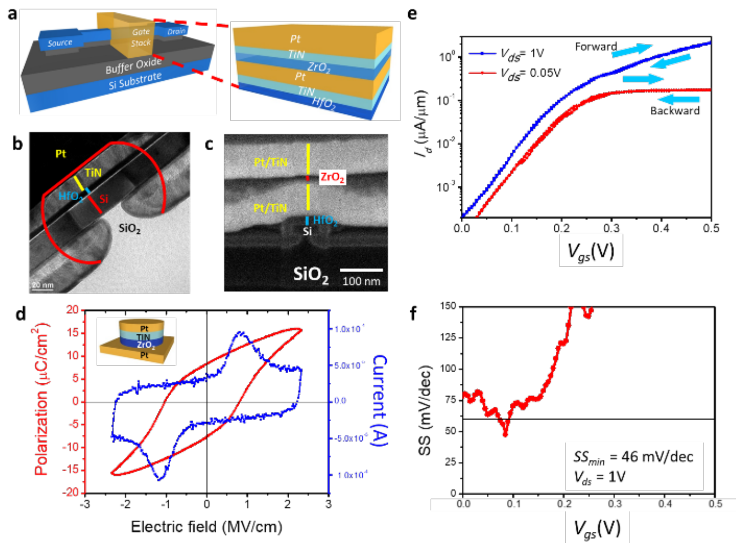

Figure 2. (a-c) Negative-capacitance Si junctionless transistor (NC-JLT) and the gate stack. (a) The schematic diagram of the NC-JLT. (b) and (c) are the cross-sectional TEM and SEM images of the Si channel and gate stack. (d) Ferroelectric characteristics of the as-deposited ZrO2 MFM structure (The schematic diagram of the MFM structure has been demonstrated as inset.). (e-f) Electrical characteristics of the NC-JLT. (e) The forward and backward Id-Vgs curves at Vds=0.05V and 1V, respectively. (f) The subthreshold swing (SS) as a function of Vgs at a large drain voltage of Vds=1V, revealing sub-60 mV/dec SS with a minimum value of 46 mV/dec.