High-Speed Probing of Ferroelectric Capacitors: Switching Dynamics and Non-Destructive Readout

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Ferroelectric random-access memory (FeRAM) based on ferroelectric capacitors (FeCAPs) offers a promising solution for next-generation embedded memory, thanks to CMOS compatibility, low-power operation, good scalability, high endurance, and extended retention [1]. However, achieving sub-nanosecond polarization switching at low or moderate voltages remains a key challenge for embedded memory and high-speed applications [2,3]. In addition, conventional FeRAM readout methods are destructive, requiring polarization switching of the FeCAP and a write-back step, which reduces endurance and increases latency and energy consumption [4].

This talk will present experimental probing of sub-nanosecond ferroelectric polarization dynamics in HZO FeCAPs using an RF-compatible structure, as illustrated in **Fig. 1**. Importantly, we will show how low-voltage transient measurements can enable non-destructive readout (NDRO) of the ferroelectric polarization state [5]. The proposed NDRO technique, summarized in **Fig. 2**, demonstrates low energy consumption, more than 10^{13} read cycles (limited by test time), and robust operation at 125°C. We expect that this work will help establish a strong foundation for scalable FeRAM applications in non-volatile memory technology and neuromorphic hardware.

References

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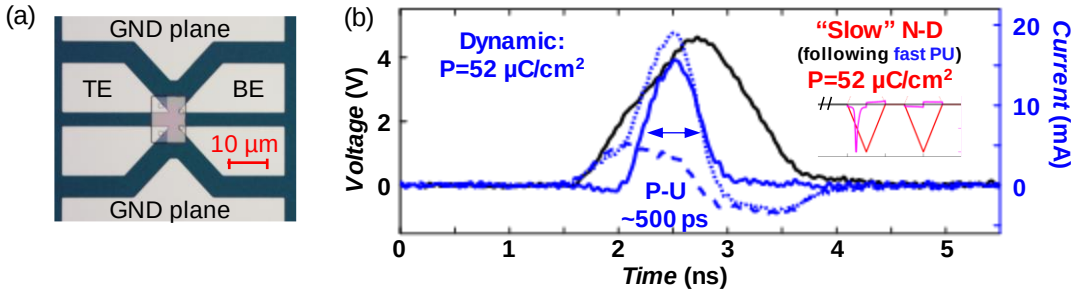

Fig. 1 – High-speed sub-ns measurements of ferroelectric polarization. (a) Top-view of RF-compatible ferroelectric capacitor. **(b)** Probing sub-ns polarization switching. Black line: measured voltage across the top electrode. Blue: transient current during different pulses, dotted, first "P" (positive) switching pulse; dashed, "U" (up) non-switching pulse; solid, the P–U difference representing the polarization current. The polarization charge obtained by integrating the dynamic (P–U) current, as well as from the subsequent slower negative–down (N–D) pulses, is 52 µC/cm² in both cases.

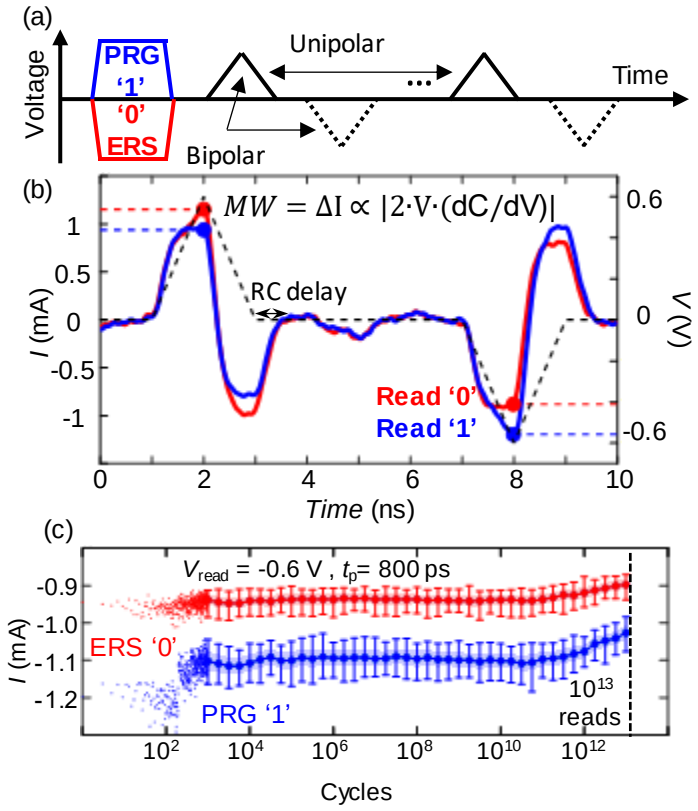

Fig. 2 – Non-destructive readout of ferroelectric capacitor by low-voltage transient current. (a) Proposed low-voltage (sub-V_C) non-destructive readout (NDRO) measurement scheme in unipolar (solid) and bipolar (solid + dashed) configurations. **(b)** Measured current waveform in bipolar configuration, showing positive and negative read pulses after PRG (blue) and ERS (red) operations. Read pulse ramp-up/down time is 800 ps, amplitude 0.6 V. The memory window (MW), proportional to 2V·dC/dV, is indicated. **(c)** Demonstration of a MW preserved after 10^{13} read cycles. Measured current peaks during negative reads of bipolar NDRO at room temperature after ERS (red) and PRG (blue) vs. number of read cycles. The first 1 k read cycles (dots) and subsequent 10^{13} cycles show Min, Max, Avg, and Std values of 1600 reads per decade. The measurement was limited by test time.