Polarization modulated Capacitance in FTJs

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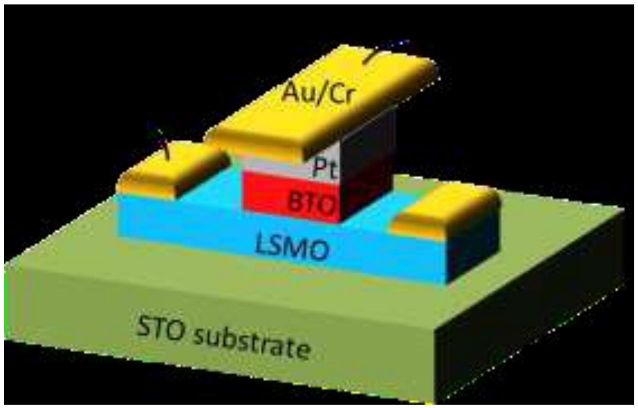
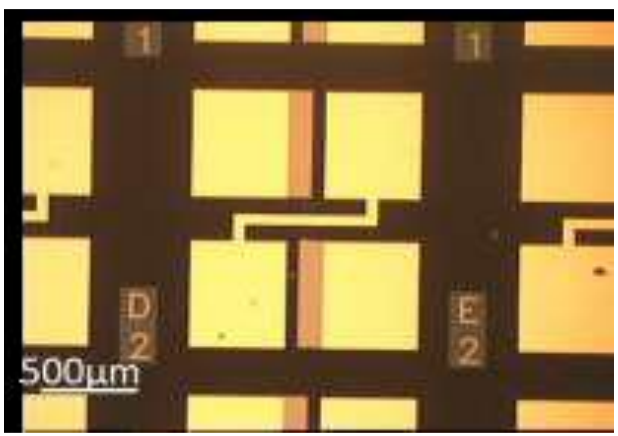
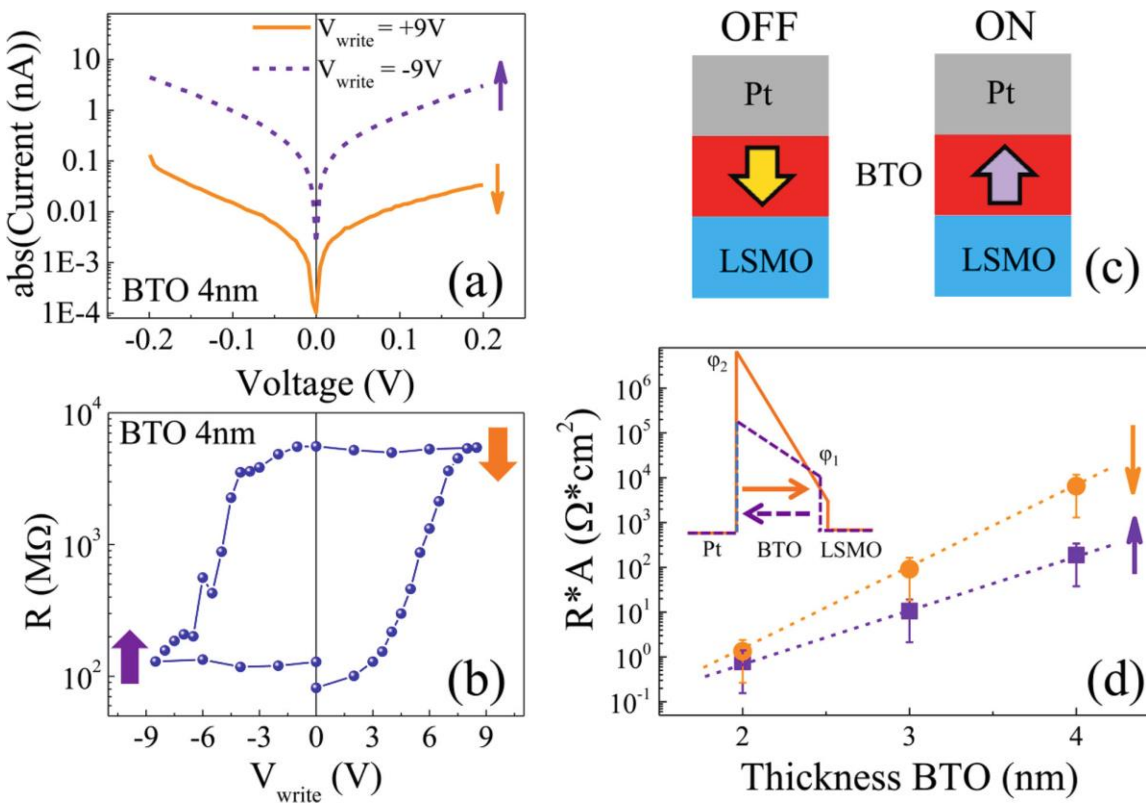
TER in Pt/BTO/LSMO FTJ





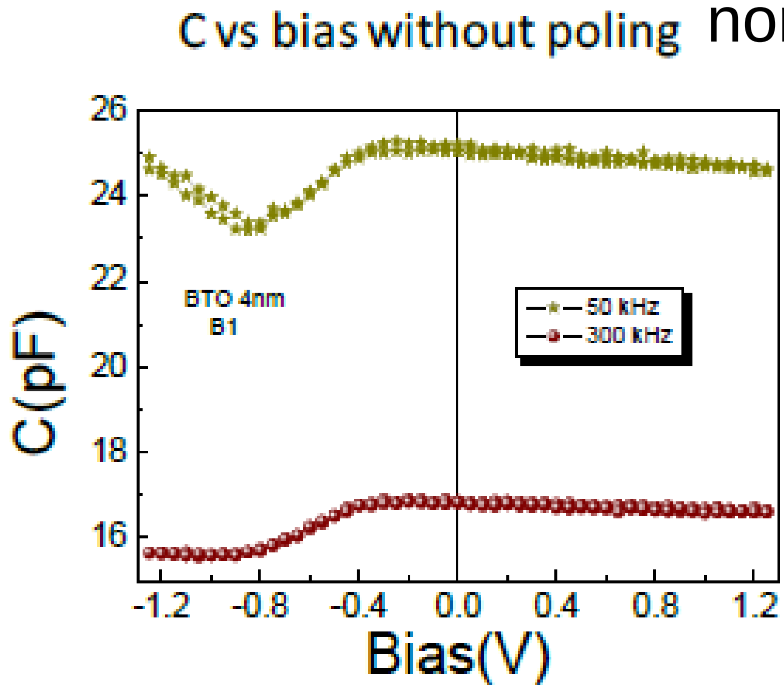


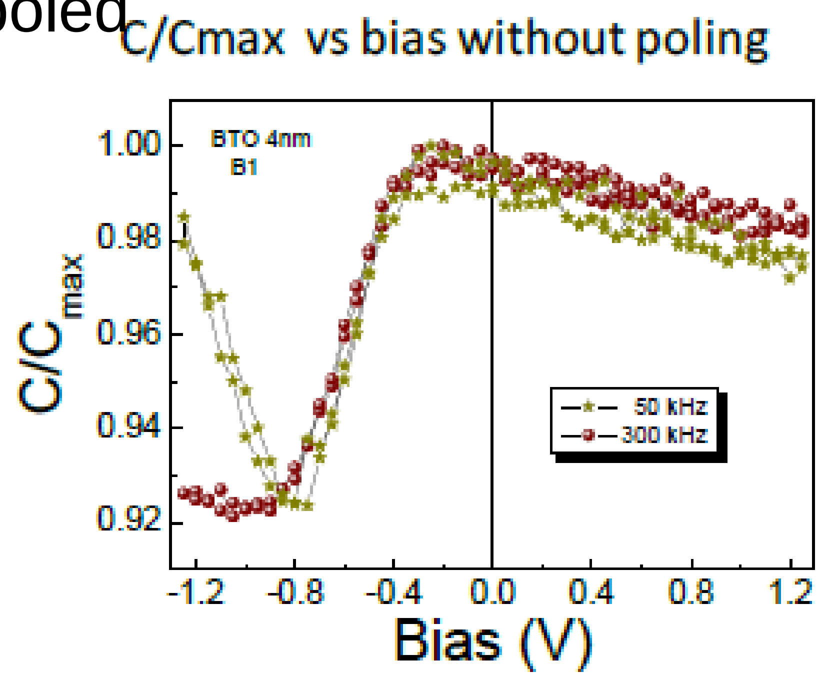
- Maximum TER~300 (4nm BTO)

Greta Radaelli, et al, Adv Mater, 27, 2602 (2015)

Frequency dependence of capacitance

nonprepoled





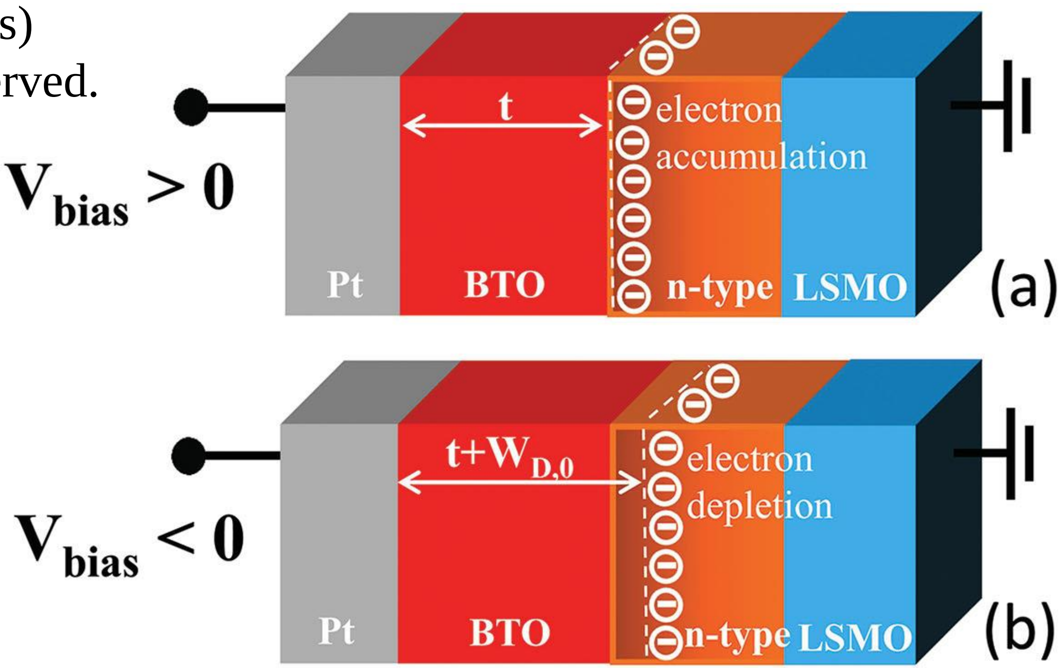
In an ideal M/I/M capacitor, the capacitance ($C = \varepsilon A/t$; A, t, and ε are the capacitor area, thickness, and relative permittivity, respectively) should be expected to be basically insensitive to frequency and independent of the bias voltage or, in case of a voltage dependent permittivity, the capacitance should follow the $\varepsilon(V)$ dependence.

The reduction of capacitance in the C (V < 0) curve is associated to the formation of a depletion layer of thickness W at the I/n type interface, whose capacitance is in series with that of the insulating layer, thus causing a reduction of the total capacitance.

Depletion layer in n-BTO

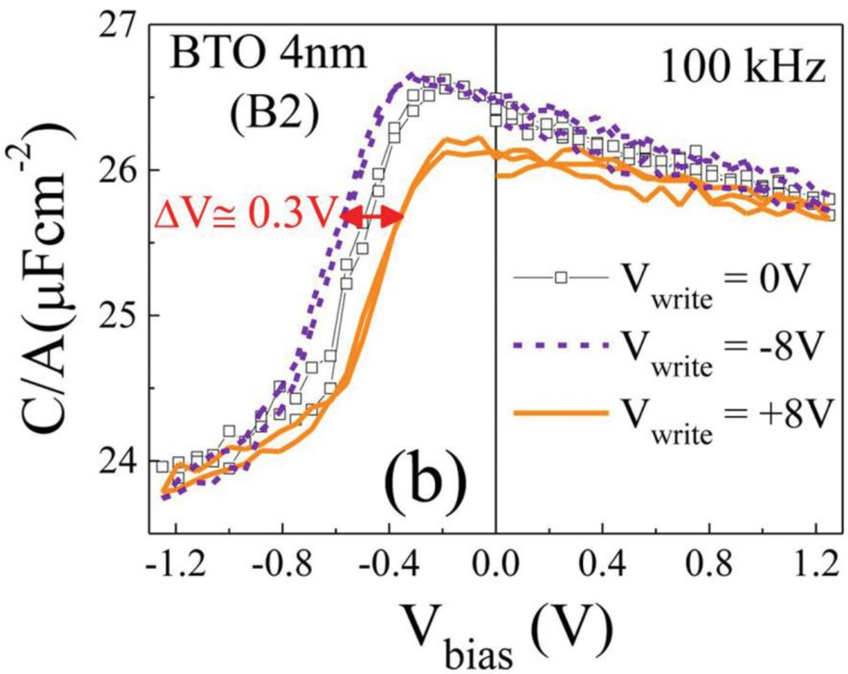
Upon negative biasing of the metal in M/I/n-type structure, a charge depleted region is formed in the n-type semiconductor that widens the effective width of the dielectric layer, which is then given by $t + W_D$, and reduces the capacitance. When $C(V_{bias})$ measurements are performed at even larger negative V_{bias}, strong inversion occurs in the semiconductor where minority carriers (holes in the present case) are accumulated at the insulator/semiconductor interface; in this situation, the effective width of the dielectric is given again by that of the insulator and thus the capacitance increases further recovering its initial value. Of course, if the minority carrier concentration cannot follow the frequency of the driving field for the measurement (the ac-field used in capacitancemeasurements)
the capacitance recovery will not be observed.

Therefore, when measurements are performed at relatively large frequency, a small C should be observed at $V_{bias} < 0$, while recovering a larger C is possible if a lower measuring frequency is used.

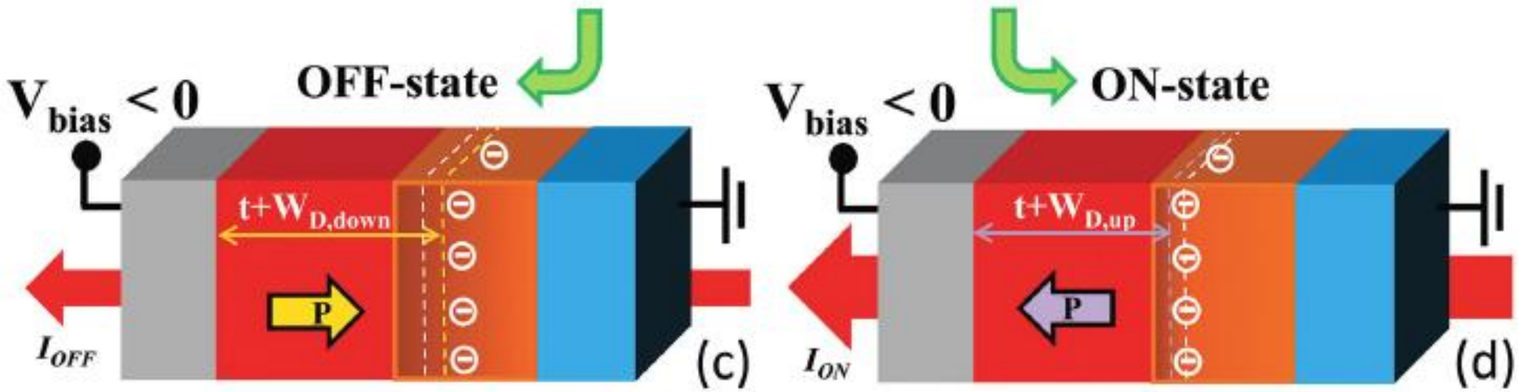


metal(Pt)/insulator(BTO)/n-type-BTO/metal(LSMO)

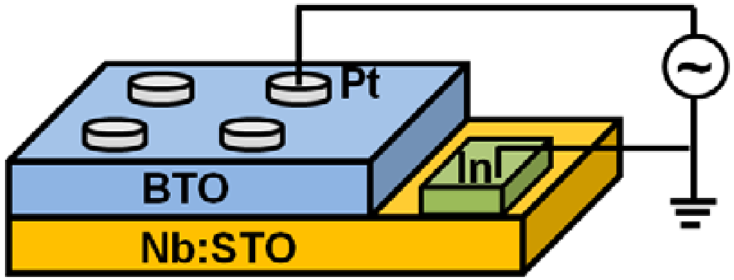
Polarization dependent capacitance



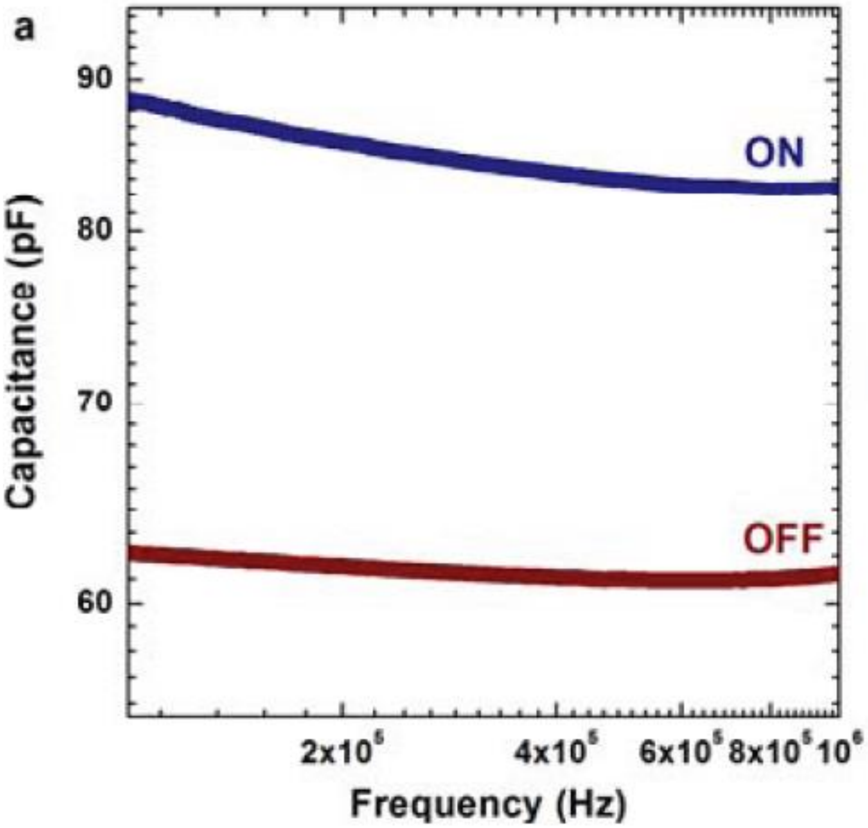
The capacitance in the depletion region depends on the polarization state of BTO. This observation would indicate that the extension of W_D varies with polarization and $C(V_{bias}, P_{up}) > C_0(V_{bias}) > C(V_{bias}, P_{down})$, where C_0 is the capacitance measured in the nonprepoled state. No polarization dependence of the capacitance is visible in the accumulation state: $C(V_{bias}, P_{up}) \approx C(V_{bias}, P_{down})$.



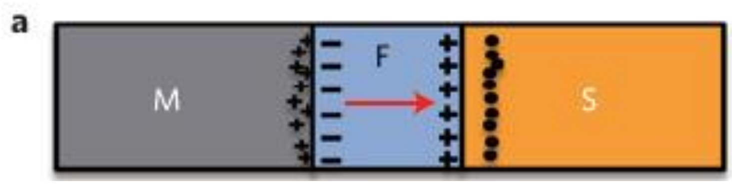
Similar structure and results

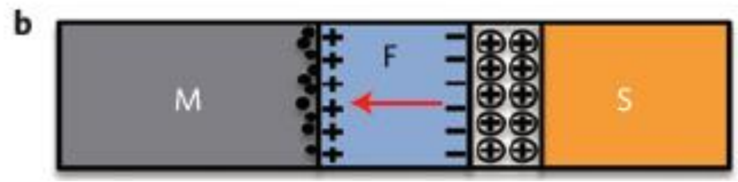


Z. Wen, et al, Nat Mater, 12, 617 (2013)



The capacitance of the OFF state is indeed smaller than that of the ON state. At 1 MHz, the measured capacitances are 82.7 and 62.4 pF for the ON and OFF states, respectively





Thank you!