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Negative Capacitance transients in a ferroelectric capacitor ASIF KHAN, KOROK CHATTERJEE, BRIAN WANG, STEVEN DRAPCHO, LONG YOU, CLAUDY SERRAO, SAIDUR BAKAUL, RAMAMOORTHY RAMESH, SAYEEF SALAHUDDIN, Univerity of California, Berkeley — The Boltzmann distribution of electrons poses a fundamental barrier to lowering energy dissipation in conventional electronics, often termed as Boltzmann Tyranny [1,2]. Negative capacitance in ferroelectric materials, which stems from the stored energy of phase transition, could provide a solution, but a direct measurement of negative capacitance has so far been elusive. Here we demonstrate the negative differential capacitance in a thin, single crystalline ferroelectric film, by constructing a simple R-C network and monitoring the voltage dynamics across the ferroelectric capacitor6. When a voltage pulse is applied, the voltage across the ferroelectric capacitor is found to be decreasing with time–in exactly the opposite direction to which voltage for a regular capacitor should change. The results are analyzed on the basis of the Landau-Khalatnikov equation, which shows that as the ferroelectric polarization switches its direction, it passes through the unstable negative capacitance region resulting in the characteristic "negative capacitance transients." Analysis of this "inductance"-like behavior from a capacitor allows us to calculate the value of the negative capacitance directly and presents an unprecedented insight into the intrinsic energy profile of the ferroelectric material.

[1] Salahuddin et al. Nano Lett. 8, 40 (2008).
[2] Zhirnov et al. Nature Nanotechnology 3, 77 (2008).
[3] Khan et al. Nature Materials (in press).

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