Beyond Dual Energy Landscape Landau Switches

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Negative capacitance switches, capable of operation below the thermionic limit of 60 mV per decade, can facilitate operation below 0.2V supply voltage to reduce the power consumption of future CMOS technology nodes. CMOS scaling received a significant boost from the discovery of ferroelectric properties of HfO_2 in 2012 - as a gate dielectric already in manufacturing, it makes it easier to design its Negative Capacitance effects into future technology nodes. Ferroelectrics demonstrate spontaneous electric polarisation that consists of a sudden switching of many electric dipoles with electric field. Their two-well energy profile causes an internal amplification of applied gate voltage that results in low operating voltages.

More recently, we have observed steep switching in synaptic Tantalum oxide/ZnO thin film transistors that extends our understanding of the theory of "steep switching" beyond dual-well Landau theory. The boost in performance of these transistors is explained by the formation and depletion of sheet charge as a result of the motion of mobile oxide ions in the insulator in response to a slowly varying electric field. A high density of such oxide charge at the interface results in a boost in the density of electrons in the channel, leading to a higher drain current. This dynamic variation of density results in a body factor "m" of less than unity, thereby achieving sub-60 mV of switching capability.