

Universal dielectric breakdown and synaptic behavior in Mott insulators

Marcelo J. Rozenberg
CNRS & LPS, Université Paris-Sud, Orsay

One of today's most exciting research frontiers and challenges in condensed matter physics is known as Mottronics, whose goal is to incorporate strong correlation effects into the realm of electronics.

In fact, taming the Mott metal-insulator transition, which is driven by strong electronic correlation effects, holds the promise of a commutation speed set by a quantum transition, and with negligible power dissipation. In this context, one possible route to control the Mott transition is to electrostatically dope the systems using strong dielectrics, in FET-like devices.

Another possibility is through resistive switching, that is, to induce the transition by strong electric pulsing. This action brings the correlated system far from equilibrium, rendering the exact treatment of the problem a difficult challenge. Here we show that existing theoretical predictions of the off-equilibrium many-body problem err by orders of magnitudes, when compared to experiments that we performed on three prototypical narrow gap Mott systems $V_{2-x}Cr_xO_3$, $NiS_{2-x}Se_x$ and $GaTa_4Se_8$, and which also demonstrate a striking universality of dielectric breakdown in Mott insulators.

We then introduce and numerically study a model based on key theoretically known physical features of the Mott phenomenon in the Hubbard model. We find that our model predictions are in very good agreement with the observed universal dielectric breakdown and with a non-trivial time-delay electric pulsing experiment, which show synaptic-like behavior.

Our study demonstrates that the Mott electric breakdown can be associated to a dynamically directed avalanche.

[1] V Guiot et al. Nat Com

<http://www.nature.com/ncomms/journal/v4/n4/full/ncomms2735.html>

[2] P Stoliar et al. Adv. Mat. : Universal Electric-Field-Driven Resistive Transition in Narrow Mott insulators. Advanced Materials, Volume 25, Issue 23, pages 3222-3226, June 18, 2013