Universal dielectric breakdown and synaptic behavior in Mott insulators

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Abstract

One of today's most exciting research frontier and challenge 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 V2-xCrxO3, NiS2-xSex and GaTa4Se8, 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 demonstratesthat the Mott electric breakdown can be associated to a dynamically directed avalanche.

Refs:

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