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Electrically-driven phase transition in magnetite nanostructures

D. NATELSON, S. LEE, Department of Physics and Astronomy, Rice University, A. FURSINA, J.T. MAYO, C.T. YAVUZ, V.L. COLVIN, Department of Chemistry, Rice University, R.M.S. SOFIN, I.V. SHVETS, CRANN, School of Physics, Trinity College, Dublin, IE — In 1939 Verwey found that bulk magnetite undergoes a first-order transition at $T_V \approx$120 K from a high temperature conducting phase to a low-temperature insulating phase. High-T conduction occurs via the fluctuating valences of the octahedral iron atoms, and the transition comes from the interplay of charge ordering and structural distortion upon cooling. The Verwey transition mechanism and charge ordering remain highly controversial. We will present data on magnetite nanocrystals and single-crystal thin films demonstrating an electrically driven phase transition below the Verwey temperature. We find sharp conductance switching that is hysteretic in source-drain voltage, and show that this transition is not due to local heating, but instead is due to the breakdown of the correlated insulating state when driven out of equilibrium by electrical bias. Scaling of switching voltage with electrode spacing in thin film samples shows that the switching is driven by a critical temperature-dependent electric field. Further studies of this newly observed transition and its low-temperature conducting phase should shed light on how charge ordering and vibrational degrees of freedom determine the ground state of this important compound.

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