MAR10-2009-020038

Abstract for an Invited Paper
for the MAR10 Meeting of
the American Physical Society

Electric field driven transition in magnetite[1]

SUNGBAE LEE, Physics Dept., The University of Houston

Magnetite, Fe_3O_4, is a strongly electronically correlated system and thus exhibits remarkable electrical and magnetic properties, including the Verwey transition at $T_V \sim$122 K, which has attracted much attention since its 1939 discovery. Fe_3O_4 has recently revealed a new effect. By performing experiments at the nanoscale, we have discovered a novel *electric-field* driven transition (EFT) in magnetite below T_V, from high- to low-resistance states driven by high electric field. The EFT is detected both in Fe_3O_4 nanoparticles and thin films, is hysteretic in voltage under continuous biasing, and is not caused by self- heating (S. Lee *et. al.*, Nature Mater. 7, 130 (2008)). In this work we report on a thorough investigation of this new EFT. First, we unveil the origin of hysteresis observed in $I - V$ curves. By applying voltage in a *pulsed* manner with controlled parameters we unambiguously demonstrate that while the transition is field-driven, hysteresis results from Joule heating in the low-resistance state. A simple relaxation-time thermal model captures the essentials of the hysteresis mechanism (A. Fursina *et al.*, Phys. Rev. B 79, 245131 (2009)). Second, by doing multilead electrical measurements, we quantitatively separate the contributions of the Fe_3O_4 channel and each electrode interfaces and explore the contact effects upon testing several different contact metals. On the onset of the transition, contact resistances at *both* source and drain electrodes and the resistance of Fe_3O_4 channel decrease abruptly. This behavior is consistent with a theoretically predicted transition mechanism of charge gap closure by electric field. Finally, we report recent measurements of the distribution of switching voltages and its evolution with temperature. These studies demonstrate that nanoscale, nonequilibrium probes can reveal much about the underlying physics of strongly correlated materials.

[1]Recent work done primarily by A. Fursina, in collaboration with D. Natelson, R. G. S. Sofin, and I. V. Shvets. Financial support includes US Dept. of Energy Grant No. DE-FG02-06ER46337, the David and Lucille Packard Foundation, and the Research Corp.