Oxide-Interface-Based Quantum Wires

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Introduction – In $SrTiO_3/LaAlO_3$ superconductivity is observed while various probes discover the presence of magnetism. These two orders are considered to be mutually excluded. None of the reported experiments has yet been able to determine the full nature of the magnetic ground state of the interface.

Experimental – We have fabricated for the first time nano-wires (as narrow as 50nm) made of the $SrTiO_3/LaAlO_3$ interface using a unique fabrication method, which does not require high resolution lithography equipment. The samples were cooled down in a dilution refrigerator (SCM1) and were studied in high magnetic fields applied at various orientations relative to the nano-wire.

Results and Discussion

The wires exhibit superconductivity below 300mK. High magnetic fields were used to characterize the wires using quantum resistance oscillations. In addition, at low magnetic fields a hysteretic behavior was observed in the magnetoresistance indicating of a ferromagnetic order coexisting with the superconducting one in the same sample and within the same temperature-magnetic field domain. The hysteretic properties of the ferromagnetic interface are reminiscent of the Giant Magneto-Resistance effect (GMR) indicating that at zero field the spins in the sample are anti –parallel to each other. This is the high resistance state. At higher magnetic field they align resulting in a lower resistance. From the angular dependence it was found that the magnetic anisotropy axes of the interface are perpendicular to all crystal axes and to the interface itself. The temperature dependence of the effect clearly indicate a Curie temperature of Tcurie=952±20 mk, the same order of magnitude as the superconducting transition temperature, allowing them to coexist. The fast switching between the high and low resistance states suggests a pinning energy for the various magnetic states rendering this interface a platform for spin-transport experiments.

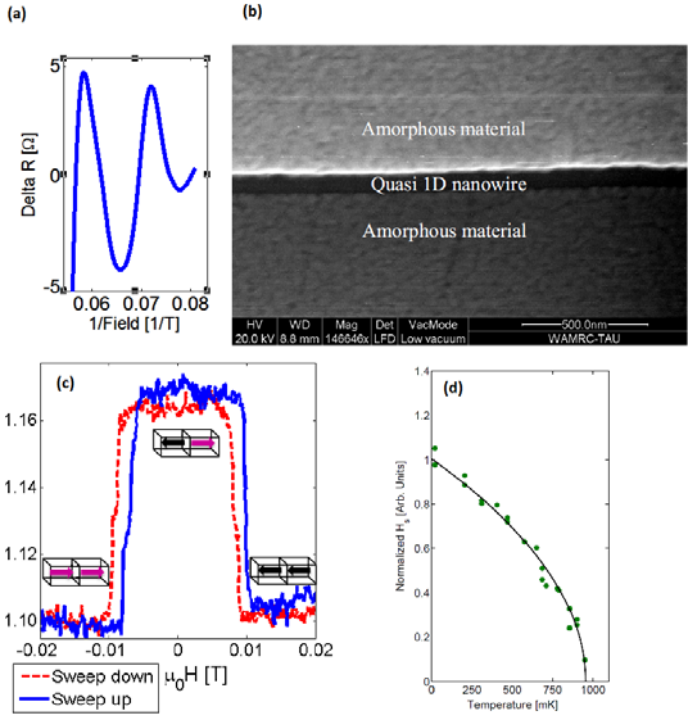

Fig.1 (a) Quantum oscillations used to characterize the sample (b)Scanning electron micrograph of the device. (c) The magnetic effect discovered at low temperatures. (d) Measurement of the Curie temperature and a mean field fit to the data.

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References

[1] Ron, A., et al. "Anomalous Magnetic Ground State in an $LaAlO_3/SrTiO_3$ Interface Probed by Transport through Nanowires." *Physical Review Letters* 113.21 (2014): 216801.