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Probing Magnetic Configurations in Buried Cobalt/Copper Multilayered Nanowires[1]

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Multilayered magnetic nanowires have been a model system for heterostructured junctions that exhibit a host of fascinating perpendicular spin transport phenomena, such as giant and tunneling magnetoresistance (MR), and spin-transfer torque effects. Due to the extremely small physical dimensions the magnetic components in these nanowires or junctions often exhibit complex magnetization reversal behaviors, which are difficult to probe by magnetic imaging since the entities are buried deep inside a matrix. Conventional hysteresis loop measurement alone cannot reliably distinguish the reversal mechanisms either. In this work we have captured magnetic and MR "fingerprints" of Co nanodiscs in Co/Cu multilayered nanowires as they undergo a single domain to vortex state transition, using a first-order reversal curve (FORC) method [1]. The nanowires have been electrochemically deposited into nanoporous polycarbonate membranes. In 50 nm diameter $[Co(5nm)/Cu(8nm)]_{400}$ nanowires, a 10% MR effect is observed at 300 K. In 200 nm diameter nanowires, the magnetic configurations can be tuned by adjusting the Co nanodisc aspect ratio. Nanowires with thinnest Co exhibit single domain behavior. Those with thicker Co exhibit vortex states, where the irreversible nucleation and annihilation of the vortices are manifested as butterfly-like features in the FORC distributions, similar to those observed in arrays of Fe nanodots [2]. They also show a superposition of giant and anisotropic magnetoresistance, which corresponds to the specific magnetic configurations of the Co nanodiscs.

[1] J. E. Davies, *et al*, Phys. Rev. B **70,** 224434 (2004); Appl. Phys. Lett. **86,** 262503 (2005); Phys. Rev. B **77**, 014421 (2008).
[2] R. K. Dumas, *et al,* Phys. Rev. B **75**, 134405 (2007); Appl. Phys. Lett. **91**, 202501 (2007).

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