NANO HIGHLIGHT
Domain Dynamics in Nanometer-Scale Magnetic Structures

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Magnetic domain walls separate regions of opposing electron spin direction in a ferromagnet. An external magnetic field or spin-polarized electric current [1] can be used to manipulate the position of a domain wall and control the spin configuration in a magnetic structure. The speed of this process depends on the velocity of domain-wall propagation, which is a function of the applied-field strength or current density and of the (nanometer scale) dynamic spin configuration within a domain wall. This research seeks fundamental understanding of mechanisms governing domain-wall motion by measuring wall propagation velocities under the influence of applied field and electric current, and by calculating the time evolution of the electron spin configurations during wall motion. One important result [2] of the research is illustrated in Figure 1: a transition to a dynamic spin configuration within the wall at a critical breakdown field, H_w, is accompanied by a decrease in domain-wall velocity (region of negative differential mobility – the slope of the velocity vs. applied field plot) followed by a region of positive but substantially-reduced mobility.

The research objectives offer broad technological relevance to applications based on engineered magnetic materials and device structures where high-speed spin dynamics plays a central role: microwave, radar, and telecommunications devices; new logic and memory device architectures based on magnetic response (spintronics); high-density magnetic-based information storage (hard disk materials, read/write heads, and head shielding); and military applications (stealth technology).

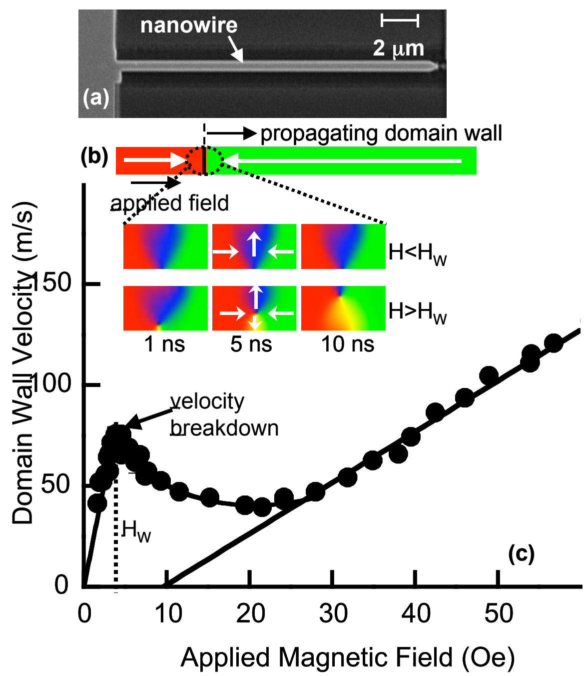

Figure. 1. (a) Ferromagnetic nanowire measuring 600 nm wide by 20 nm thick. (b) Snapshots of the calculated spin configurations within a domain wall at three different times, as the wall moves under an applied field. At low fields (top row), the wall spin structure is unchanged as it moves. Above a critical field H_W, (bottom row) a "vortex" appears in the wall and moves across the wall with time, slowing the wall substantially. **(c)** Measured velocity versus field for a domain wall in the nanowire shown in (a), showing a "breakdown" in the capacity of the field to "push" the wall once the wall structure becomes unstable, in agreement with calculations.

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[1] M. Tsoi, R. E. Fontana, and S. S. P. Parkin, "Magnetic domain wall motion triggered by an electric current," *Appl. Phys. Lett.* **83,** 2617 (2003).
[2] G. S. D. Beach, C. Nistor, C. Knutson, M. Tsoi, and J. L. Erskine, "Dynamics of field-driven domain wall propagation in ferromagnetic nanowires," *Nature Mater.* **4**, 741 (2005)