Division of Materials Chemistry
– Nanospintronics –

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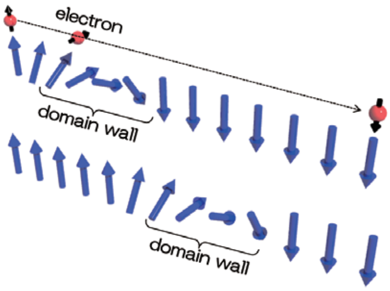
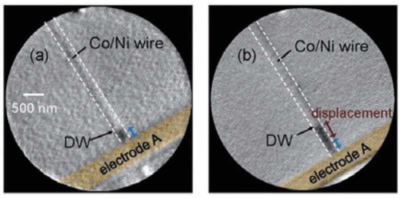
Scope of Research

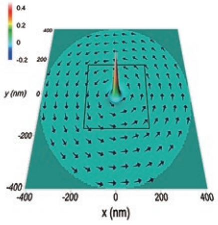
The conventional electronics utilizes only the "charge" of electrons, while the traditional magnetic devices use only "spin" degree of freedom of electrons. Aiming at the complete control of both charge and spin in single solid-state devices, an emerging field called *spintronics* is rapidly developing and impacting on information technologies. By combining the atomic-layer deposition with nanofabrication, we focus on the development of spin properties of various materials and the control of quantum effects in mesoscopic systems for novel spintronics devices.

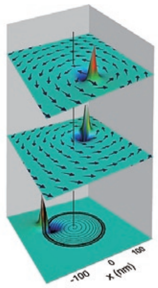
KEYWORDS

Spintronics
Quantum Transport
Nano-fabrication
Artificial Materials









Selected Publications

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Enhancement in Switching Speed of Magnetic Domain Wall by Voltage Application

Controlling the displacement of a magnetic domain wall is potentially useful for information processing in magnetic non-volatile memories and logic devices. A magnetic domain wall can be moved by applying an external magnetic field and/or electric current, and its velocity depends on their magnitudes. We showed that the applying an electric field could change the velocity of a magnetic domain wall significantly. A field-effect device, consisting of a top-gate electrode, a dielectric insulator layer, and a wire-shaped ferromagnetic Co thin layer with perpendicular magnetization, was used to observe it in a finite magnetic field (Figure 1). We found that the application of the electric fields can change the magnetic domain wall velocity by more than an order of magnitude (Figure 2). This significant change is due to electrical modulation of the energy barrier for the magnetic domain wall motion. We think that the concept presented here will be useful in reducing the energy consumption of magnetic recording media and logic devices.

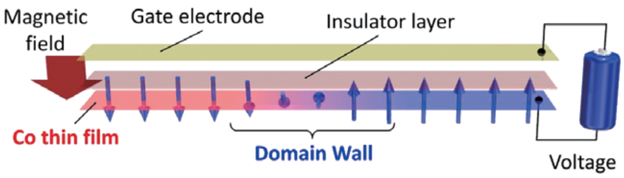

Figure 1. Schematic illustration of the device structure. The device consists of a Co microwire, an insulator layer, and a gate electrode on top. The magnetic domain wall was prepared in the wire to investigate the speed of it under applying voltage.

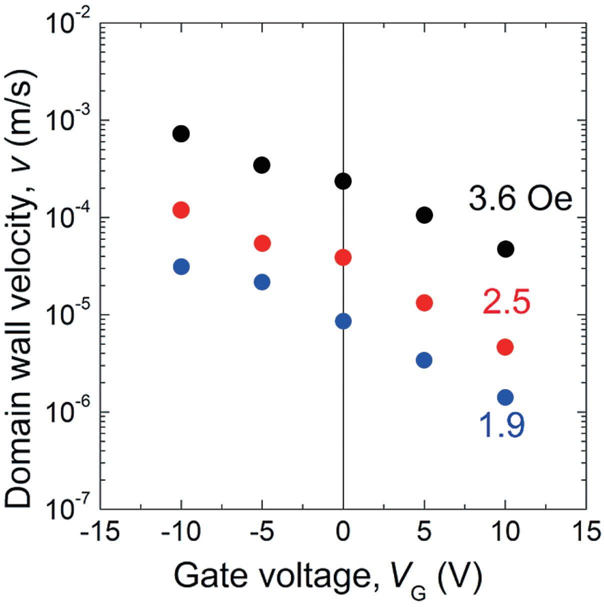

Figure 2. Applied voltage dependence of the domain wall speed.

Spin-motive Force Due to a Gyrating Magnetic Vortex

A change of magnetic flux through a circuit induces an electromotive force. By analogy, a recently predicted force that results from the motion of non-uniform spin structures has been termed the spin-motive force (Figure 3). Although recent experiments seem to confirm its presence, a direct signature of the spin-motive force has remained elusive. We report the observation of a real-time spin-motive force produced by the gyration of a magnetic vortex core (Figure 4). We find a good agreement between the experimental results, theory and micromagnetic simulations, which taken as a whole provide strong evidence in favour of a spin-motive force.

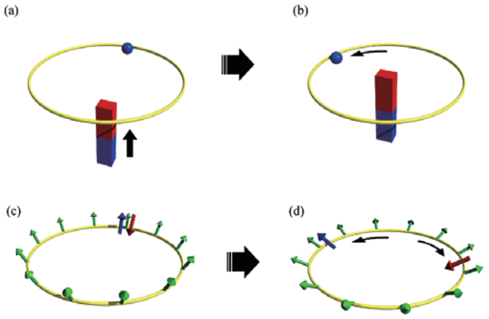

Figure 3. (a-b) A change of magnetic flux through a closed circuit induces an electromotive force which drives an electron flow (c-d) A motion of non-uniform spin structures induces the spin-motive force which drives a spin current flow.

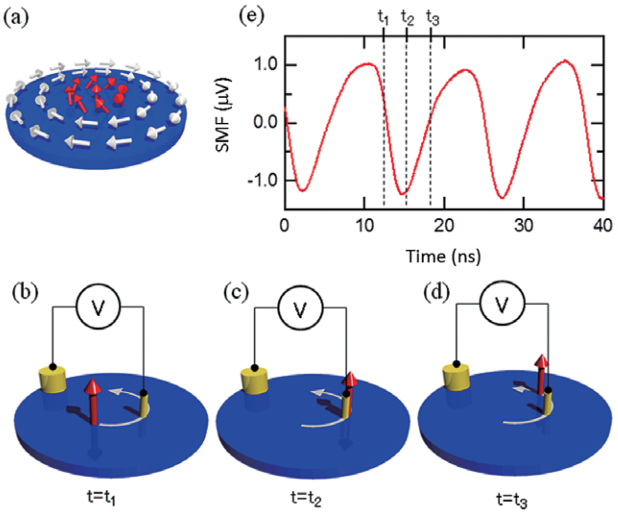

Figure 4. (a) A vortex state in a micron-size magnetic disk. (b)-(d) Illustrations of the time domain measurements in a gyrating vortex core at a time t. The vortex core is indicated by the red arrow. (e) Experimentally observed spin motive force (SMF) as a function of time.