Division of Materials Chemistry
– Nanospintronics –

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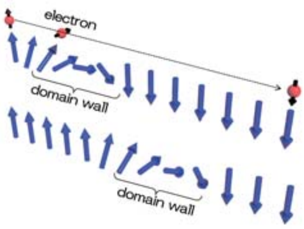
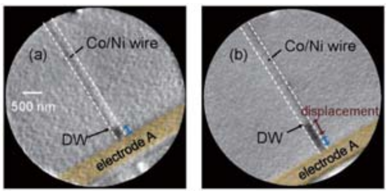
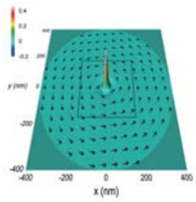
Scope of Research

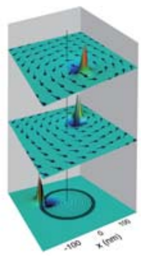
The conventional electronics utilizes only the "charge" of electrons, while the traditional magnetic devices use only "spin" degree of freedom of electrons. Aiming at the complete control of both charge and spin in single solid-state devices, an emerging field called *spintronics* is rapidly developing 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

Tanabe, K.; Matsumoto, R.; Ohe, J.; Murakami, S.; Moriyama, T.; Chiba, D.; Kobayashi, K.; Ono, T., Real-time Observation of Snell's Law for Spin Waves in Thin Ferromagnetic Films, *Applied Physics Express*, **7,** [053001-1]-[053001-4] (2014).

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Tanabe, K.; Chiba, D.; Ohe, J.; Kasai, S.; Kohno, H.; Barnes, S. E.; Maekawa, S.; Kobayashi, K.; Ono, T., Spin-motive Force Due to a Gyrating Magnetic Vortex, *Nature Communications*, **3,** 845 (2012).

Im, M-Y.; Fischer, P.; Yamada, K.; Sato, T.; Kasai, S.; Nakatani, Y.; Ono, T., Symmetry Breaking in the Formation of Magnetic Vortex States in a Permalloy Nanodisk, *Nature Communications*, **3,** 983-988 (2012).

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Kim, K.-J.; Hiramatsu, R.; Koyama, T.; Ueda, K.; Yoshimura, Y.; Chiba, D.; Kobayashi, K.; Nakatani, Y.; Fukami, S.; Yamanouchi, M.; Ohno, H.; Kohno, H.; Tatara, G.; Ono, T., Two-barrier Stability That Allows Low-power Operation in Current-induced Domain-wall Motion, *Nature Communications*, **4,** 2011 (2013).

Two-barrier Stability That Allows Low Power Operation in Current-induced Domain Wall Motion

Energy barriers appear in diverse systems and its determination has long been a debatable issue because it determines the thermal stability of devices as well as the threshold force triggering their dynamics. In general, there is a severe dilemma between the thermal stability of bit data and the operation power of devices, because larger energy barrier for higher thermal stability inevitably leads to larger magnetic field (or current) for operation. Here we show that this is not the case for the current-induced magnetic domain wall motion induced by the adiabatic spin transfer torque. By quantifying domain wall depinning energy barriers by magnetic field and current, we have found that there exist two different pinning barriers, extrinsic and intrinsic energy barriers, which govern the thermal stability and threshold current, respectively. This unique two-barrier system allows the low power operation with high thermal stability, which is impossible in conventional single-barrier systems.

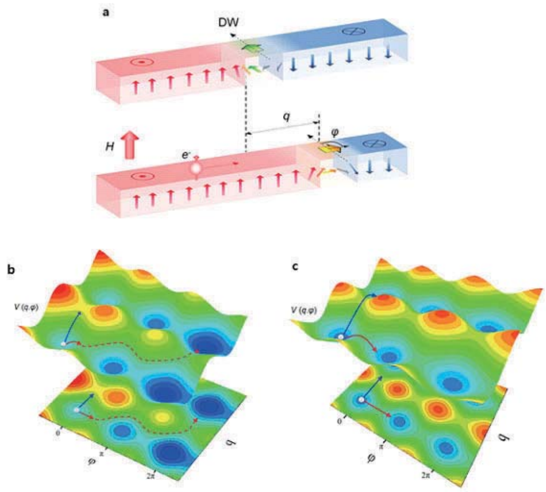

Figure 1. Schematic illustration of DW motion and energy landscape. (a) A magnetic DW in a nanowire and its collective coordinates, the position q and the tilting angle φ. (b,c) Energy landscape for the DW motion in the presence (b) and absence (c) of d.c. current.

Real-time Observation of Snell's Law for Spin Waves in Thin Ferromagnetic Films

Magnon, a quasiparticle of the spin wave, can potentially be used for information processing and storage technology. We report the real-time observation of spin-wave propagation across a step inserted between two ferromagnetic films with different thicknesses. Because the dispersion relation of the spin wave depends on the thickness of the film, the step works as a junction to affect the spin wave propagation. When the spin wave transmits through the junction, the wavenumber undergoes modulation as per Snell's law, which states that the refraction index is proportional to the wavenumber. From the viewpoint of "magnonics", the present achievement opens up new possibilities of controlling the wavenumber of spin waves.

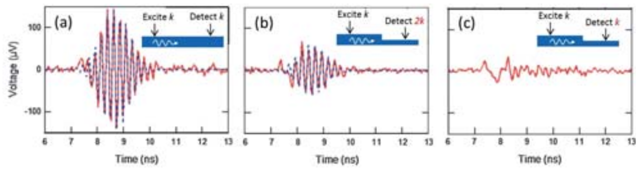

Figure 2. Time-domain wave packet transmission measurements for (a) film with no thickness difference (b) and (c) film with a thickness step at which the film thickness becomes a half. One can see the wavevector k is doubled when the wave is transmitted through the step.