Division of Materials Chemistry
– Nanospintronics –

http://www.scl.kyoto-u.ac.jp/~ono/onolab/public_html/english/index_e.html

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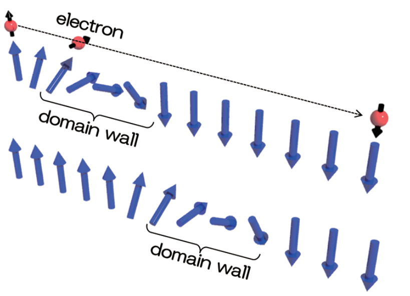
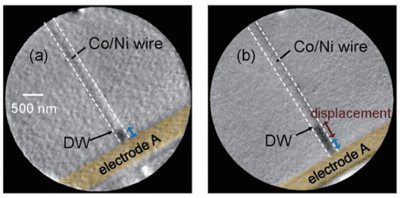
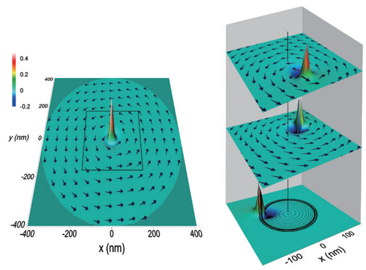
Scope of Research

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, a new field called *spintronics* is rapidly developing and impacting on information technology. 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

Yamaguchi, A.; Ono, T.; Nasu, S.; Miyake, K.; Mibu, K.; Shinjo, T., Real-space Observation of Current-Driven Domain Wall Motion in Submicron Magnetic Wires, *Phys. Rev. Lett.*, **92,** [077205-1]-[077205-4] (2004).

Kasai, S.; Nakatani, Y.; Kobayashi, K.; Kohno, H.; Ono, T., Current-driven Resonant Excitation of Magnetic Vortex, *Phys. Rev. Lett.*, **97,** [107204-1]-[107204-4] (2006).

Yamada, K.; Kasai, S.; Nakatani, Y.; Kobayashi, K.; Kohno, H.; Thiaville, A.; Ono, T., Electrical Switching of the Vortex Core in a Magnetic Disk, *Nature Materials*, **6,** 269-273 (2007).

Delmo, M. P.; Yamamoto, S.; Kasai, S.; Ono, T.; Kobayashi, K., Large Positive Magnetoresistive Effect in Silicon Induced by the Space-Charge Effect, *Nature*, **457,** 1112-1115 (2009).

Yamauchi, Y.; Sekiguchi, K.; Chida, K.; Arakawa, T.; Nakamura, S.; Kobayashi, K.; Ono, T.; Fujii, T.; Sakano, R., Evolution of the Kondo Effect in a Quantum Dot Probed by Shot Noise, *Phys. Rev. Lett.*, **106,** [176601-1]-[176601-4] (2011).

Koyama, T.; Chiba, D.; Ueda, K.; Kondou, K.; Tanigawa, H.; Fukami, S.; Suzuki, T.; Ohshima, N.; Ishiwata, N.; Nakatani, Y.; Kobayashi, K.; Ono, T., Observation of the Intrinsic Pinning of a Magnetic Domain Wall in a Ferromagnetic Nanowire, *Nature Materials*, **10,** 194-197 (2011).

Chiba, D.; Fukami, S.; Shimamura, K.; Ishiwata, N.; Kobayashi, K.; Ono, T., Electrical Control of the Ferromagnetic Phase Transition in Cobalt at Room Temperature, *Nature Materials*, **10,** 853-856 (2011).

Electrical Control of Ferromagnetic Phase Transition

Electrical control of magnetic properties is crucial for device applications in the field of spintronics. Our team has demonstrated the room-temperature electrical control of the ferromagnetic phase transition in cobalt, a representative of the transition-metal ferromagnet family. Solid-state field effect devices, consisting of an ultra-thin cobalt film covered by a dielectric layer and a gate-electrode on top of that, were fabricated (Figure 1). We found that the ferromagnetic state of the film could be turned on and off isothermally and reversed simply by applying gate voltage between the cobalt layer and the gate electrode at room temperature. The shift of the Curie temperature was found to be up to 12 Kelvin by applying gate voltage of ±10 V. The result is a significant development for future low-power magnetic devices. For example, it could be used for building a "field-effect magnet"; where the magnet can be easily switched-off to become a non-magnet electrically, and for building a non-dissipative magnetic force generator without an electric current. In addition, the demonstrated electric field effect of the two dimensional ferromagnet opens up a new way to explore and control magnetism in relation to the dimensionality.

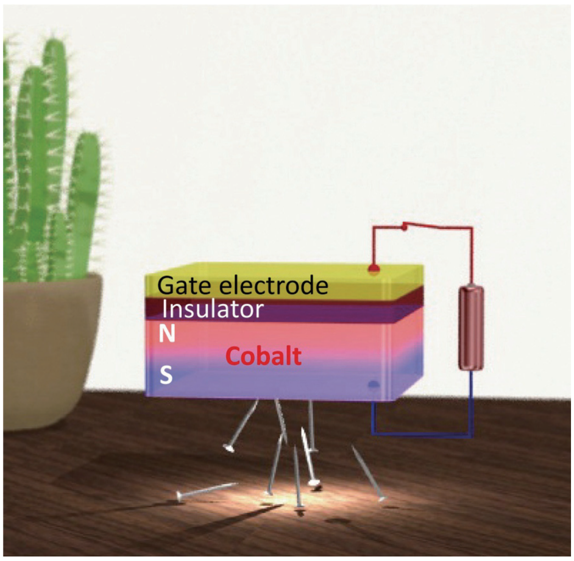


Figure 1. Ferromagnetic phase transition of a metal ferromagnet of Cobalt (Co) was induced by applying a gate voltage (V_G) at room temperature. The device for the transport measurements consists of a metal gate (Au/Cr), an insulator layer (HfO_2), and an ultra-thin Co layer.

Scattered by the Kondo Cloud

The Kondo effect is one of the most fundamental many-body phenomena in condensed matter physics. Conventionally, the Kondo effect is detected through the characteristic temperature dependence of the resistance or the magnetization of the system. Such properties tell us how a local spin interacts with continuum to form a correlated ground state, namely "Kondo cloud", in lowering the temperature. However, the Kondo effect in an artificial atom or quantum dot (QD) fabricated on the semiconductor surface offers a new attractive stage to address Kondo physics in a way otherwise impossible. We showed that the shot noise at the Kondo QD successfully signals the evolution of the Kondo correlation due to the electron scattering via the Kondo cloud. When the Kondo correlation evolves, the electron scattering that involves several electrons starts to occur. This enhances the shot noise in the Kondo QD more than that in the noninteracting case. Such an experiment can be viewed as "collision experiments" on a chip and will shed new light on Kondo physics.

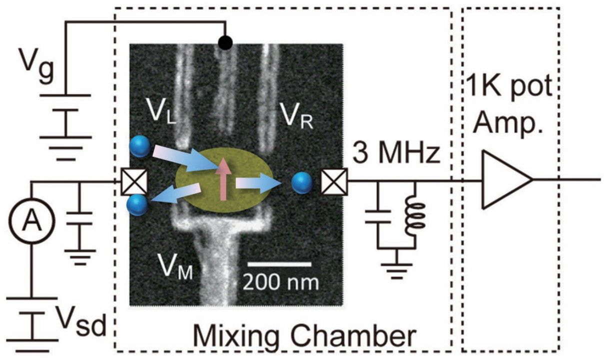


Figure 2. The scanning electron microscope image of the artificial atom (yellow) with a measurement schematic. The single spin inside the atom (indicated by the arrow) causes the Kondo effect. We measure the electron scattering by the Kondo state.