Functional topological antiferromagnet

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Topological antiferromagnets Mn_3X (X=Sn and Ge) exhibit distinctive magnetoelectric, thermoelectric, and optical responses. Their magnitudes reach almost the same as ferromagnetic metals. Our recent study demonstrated that a novel type of contribution to the SHE (magnetic SHE, MSHE) and the inverse SHE (MISHE) absent in nonmagnetic materials could be dominant in the antiferromagnets, Mn_3X [1].

In this talk, we will introduce the magnetic spin Hall effects (MSHE), particularly angular-dependent spin densities appearing on the surface of a focused ion beam fabricated Mn_3Sn single crystal thin slab. We will discuss the new functionality, giant magnetic field-like spin-orbit torque (SOT), originated from the MSHE [2]. We will also discuss the electrical nucleation, displacement, and detection of antiferromagnetic domain walls (AFDWs) consisting of the CMOPs. We will show some of our recent MOKE measurements for Mn_3Ge to discuss the magnetic domain structures [3, 4]. Our findings could provide a guiding principle for engineering the AFDW structure in topological antiferromagnetic materials.

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Spin-torque control, magnetoresistance, and dynamics of octupole polarization in a topological antiferromagnet Mn_3Sn

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Dzyaloshinskii-Moriya interaction induces a ferroic ordering of octupole polarization to the non-collinear antiferromagnetic spin structure in Mn_3Sn. The octupole polarization possesses the same symmetry as the spin polarization and induces a large Berry curvature owing to magnetic Weyl points in momentum space. Recently, we have developed epitaxial thin films of Mn_3Sn by molecular beam epitaxy and realized several spintronic phenomena.

In this talk, we show that the octupole polarization is fully switched by spin-transfer torque induced by the spin Hall effect [1]. Moreover, the octupole polarization induces magnetoresistance in an all-antiferromagnetic tunnel junction consisting of Mn_3Sn/MgO/Mn_3Sn [2]. We also show the exchange-enhanced ultrafast damping of the octupole polarization [3]. We believe that these are the key to constructing novel spintronic devices using the topological antiferromagnet.

This work has been done in collaboration with Nakatsuji, Otani, and Arita groups of The University of Tokyo, and Mizukami group of Tohoku University.

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Development of spin shift register using ferrimagnet with antiferromagnetic spin ordering

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There is a strong demand for ultra-high-speed, low-energy-consumption magnetic information storage or processing based on spintronics technology. Deterministic All-Optical magnetization Switching (AOS) at room temperature by femto-pulse (FWHM ~40fs) laser irradiation is possible in ferrimagnets with antiparallel coupled sublattice magnetization, ex. heavy rare-earth transition metal alloy such as GdFeCo. High-speed domain wall motion over 1km/s has also been confirmed originated from the angular momentum compensation phenomenon in GdFeCo. In this talk, I will introduce the resent progress of the development of all-optical spin shift register that integrate opto-magnetic domain formation by AOS and current driven domain wall motion.