Oral Session B1 (Wednesday, February 14)

Chair: Kyung-Jin Lee, KAIST

Keynote Talk

9: 00 - 9 : 40

Shunsuke Fukami

Research Institute of Electrical Communication, Tohoku University

Electrical control of noncollinear antiferromagnetic Mn_3Sn

Dynamics of collective spin structures induced by various electrical means has been of paramount interest in magnetics and spintronics fields, and many interesting phenomena have been revealed, leading to various opportunities of applications. Non-collinear antiferromagnet with chiral-spin structure is an attractive system showing intriguing properties that were believed to be inherent to ferromagnets such as the anomalous Hall effect [1]. Here I discuss physics and functionalities of Mn_3Sn, a representative room-temperature noncollinear antiferromagnetic system. First, I will show an epitaxial thin-film growth technique that is necessary to explore the device functionalities [2] and show basic magneto-transport properties [2,3]. Then, I will show the characteristic response of the chiral-spin structure of Mn_3Sn epitaxial heterostructures under a spin-orbit torque generated by an electric current [4]. If time allows, I will also present our studies on the domain structure [6] and thermal stability [7] of Mn_3Sn thin film and nanodot.

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Oral Session B1 (Wednesday, February 14)

Chair: Kyung-Jin Lee, KAIST

Contributed Oral

9: 40 - 10 : 00

Electrical manipulation and detection of topological antiferromagnetic state in Mn_3Sn-based epitaxial heterostructures

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Antiferromagnetic materials have garnered significant attention for their favorable properties in device applications, including negligible stray/demagnetizing fields and ultrafast spin dynamics [1]. The non-collinear antiferromagnet (AFM) Mn_3Sn [2], a prominent example of time-reversal symmetry-breaking AFMs, is a magnetic Weyl semimetal with unique AF ordering hosting cluster magnetic octupoles, leading to large transverse responses [2,3]. The research targets are shifting fundamental studies using bulk samples to exploring spintronic properties using thin films. This presentation focuses on our recent studies involving heterointerfaces based on Mn_3Sn. We have successfully manipulated the chiral AF order in bilayer films composed of polycrystalline Mn_3Sn and heavy metals, demonstrating the potential for spin-orbit torque (SOT) [4]. This research extends to heterostructures comprising epitaxial Mn_3Sn and heavy metals [5,6], where we have achieved SOT-induced perpendicular magnetic recording for the first time in AFMs [6], leveraging high-quality Mn_3Sn layers fabricated by MBE methods. These samples exhibit large Hall conductivity of ~40 $\Omega^{-1}cm^{-1}$ comparable to that obtained in the bulk single crystals, and the fabrication of Mn_3Sn/MgO/Mn_3Sn stacks has also enabled the observation of the tunnel magnetoresistance effect at room temperature [7]. These results offer promising avenues for the development of AF spintronics.

References

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Oral Session B1 (Wednesday, February 14)

Chair: Kyung-Jin Lee, KAIST

Keynote Talk

10: 00 - 10 : 40

Stuart Parkin

Max Planck Institute of Microstructure Physics

The Josephson diode effect

We discuss a non-reciprocal Josephson diode effect in Josephson junctions, both lateral and vertical, formed from superconducting electrodes (Nb, $NbSe_2$) separated by several 2D van der Waals metals, $NiTe_2$ [1] , WTe_2 [2] , and $PtTe_2$ [3] , as well as platinum that is magnetically proximitized via a magnetic insulator [4] . Each of these materials becomes superconducting by proximity to the conventional superconducting electrodes. The superconductivity can be sustained over long distances of, in some cases, up to ~1 micron. The critical supercurrent densities for current flowing in opposite directions are distinct and can vary by up to 40% or more. For the van der Waals metals the non-reciprocity is only observed in the presence of a small magnetic field oriented perpendicular to the supercurrent, whereas for the Pt based junctions the diode effect is observed in zero field. For vertical Josephson junctions formed from WTe_2 we show that the non-reciprocity depends on the orientation of the magnetic field with respect to the crystal structure of the WTe_2, thereby proving the intrinsic origin of the Josephson diode effect. Such an effect could have important applications as a novel magnetic field detector at cryogenic temperatures, for example, to "read" magnetic domain walls in a cryogenic racetrack memory.

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