PCSI
Room Ballroom South - Session PCSI-WeA1
Spin Transport

Moderator: Alex Demkov, The University of Texas

2:00pm **PCSI-WeA1-1 Emergent Spintronic Functionalities in Correlated Oxide Heterostructures***, **Shinobu Ohya**,* The University of Tokyo, Japan **INVITED**

Spintronics promises low-power, multifunctional electronics in which electron spin enables both logic and memory operations. Among the various proposed devices, spin transistors are particularly attractive for non-volatile computing. Key milestones toward their practical realization include the demonstration of large spin-valve effects and the achievement of efficient spin-charge interconversion, both of which are vital for energy-efficient operation. Perovskite oxides provide a versatile materials platform owing to their nearly matched lattice constants, which allow the fabrication of high-quality all-epitaxial heterostructures essential for coherent spin control in devices. These correlated oxides exhibit emergent functionalities, such as two-dimensional transport with strong spin–orbit coupling, metal–semiconductor transitions, topological states, and spin Hall effects, thereby offering unique opportunities for spintronics applications. We first demonstrate a giant planar spin-valve effect in $(La_{0.67},Sr_{0.33})MnO_3$ (LSMO)-based spin-MOSFETs, where oxygen-vacancy engineering creates nanoscale Mott-semiconducting regions, yielding magnetoresistance ratios of ~140% [1] — over two orders of magnitude higher than those of conventional Si-based spin-MOSFETs. Second, we show highly efficient spin-to-charge conversion in the two-dimensional electron gas formed at the strongly correlated $LaTiO_{3+\delta}$ (LTO)/$SrTiO_3$ interface, achieving a record conversion efficiency (referred to as the inverse Edelstein length) of ~190 nm [2]. This performance originates from Rashba spin–orbit coupling combined with reduced spin scattering in correlated metallic LTO. Finally, in the Weyl ferromagnet $SrRuO_3$ (SRO), subtle oxygen-octahedral rotations generate spin Berry curvature that drives spin–orbit torque magnetization switching in a single-layer device [3]. Magnetization reversal occurs at current densities an order of magnitude lower than those required in conventional bilayer systems, without the need for heavy-metal layers. These studies were partly supported by Grants-in-Aid for Scientific Research, ERATO of JST, and the Spintronics Research Network of Japan (Spin-RNJ).[1] T. Endo, S. Ohya *et al*., Adv. Mater. **35**, 2300110 (2023). [2] S. Kaneta-Takada, S. Ohya *et al*., Nat. Commun. **13**, 5631 (2022).[3] H. Horiuchi, S. Ohya *et al.*, Adv. Mater. **37**, 2416091 (2025).

2:40pm **PCSI-WeA1-9 Annealing Effects on the High-Temperature Magnetic Properties of Ta/CoFeB/Ta Films***, Byeong-Kwon Ju,* ***Hyejin Son,*** *Byeongwoo Kang, Ji-Hyeon Kwon,* Korea University, Republic of Korea

Soft magnetic Cobalt–iron–boron (CoFeB) thin films have attracted significant interest for spintronic applications due to its high saturation magnetization and spin polarization. The structural and magnetic properties of CoFeB thin films are strongly influenced by sputtering power [1], post-annealing treatments [2], and variations in CoFeB layer thickness [3]. Spintronic devices operate at elevated temperatures, where thermal effects can alter magnetic damping. Since damping determines switching speed and power consumption, understanding its variation within the operating temperature range is crucial. Most experimental studies of CoFeB films have been limited to room-temperature measurements [4], which cannot provide a systematic understanding of their temperature-dependent damping.

In this study, we investigate the high-temperature magnetic properties of CoFeB thin films with different annealing conditions. Ta (5 nm)/$Co_{20}Fe_{60}B_{20}$ (35 nm)/Ta (3 nm) structures with different annealing conditions (as-deposited, 200 °C, 300 °C, and 400 °C) were measured by ferromagnetic resonance (FMR) spectroscopy at temperatures ranging from 30-160°C to extract the linewidth and resonance magnetic field for dynamic property analysis (Fig. 1). The raw FMR spectra of the 300 °C annealed sample measured at 160 °C showed a monotonic increase in both the resonance field and linewidth with increasing frequency (Fig. 1(a)). The normalized FMR spectra at a fixed frequency of 14 GHz exhibited a gradual increase in both parameters with temperature (Fig. 1(b)). Analysis of the linewidth further showed that the Gilbert damping constant α decreases in the annealed samples compared with the as-deposited film (Fig. 1(c)). The effects of annealing on the high-temperature magnetic response of symmetric Ta/CoFeB/Ta multilayers will be further discussed.

2:45pm **PCSI-WeA1-10 Magneto-Optical Detection of Orbital Hall Effect***, Kyung-Hun Ko,* Sungkyunkwan University, Republic of Korea*; Daegeun Jo, Peter Oppeneer,* Uppsala University, Sweden*; Hyun-Woo Lee,* POSTECH, Republic of Korea*;* ***Gyung-Min Choi,*** Sungkyunkwan University, Republic of Korea **INVITED**

Orbital Hall effect (OHE) refers to the generation of electron orbital angular momentum flow transverse to an external electric field. Theories predict strong OHE in various transition metals of 3d, 4d, and 5d bands [1-3]. In a weak spin-orbit coupling system of 3d metals, OHE can be dominant over spin Hall effect (SHE). To detect OHE, we measured the current-driven orbital accumulation at surfaces of 3d metals of Ti, Mn, and Cu [4-6]. Using the longitudinal magneto-optical Kerr effect (MOKE), we simultaneously detected the in-plane-polarized orbital moments driven by OHE and out-of-plane-polarized orbital moments driven by Oersted field. From the relative comparison of the in-plane and out-of-plane orbital moments, we quantified the magnitude of the OHE-driven orbital accumulation. From the thickness dependence, we distinguished the bulk contribution of OHE and interfacial contribution of orbital Rashba-Edelstein effect (OREE) and determined the orbital diffusion length.

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[4] Y.-G. Choi et al., Nature 619, 52 (2023)

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3:25pm **PCSI-WeA1-18 Anomalous Hall Effect in Co_3PdN Films***,* ***Ian Leahy,*** *Sita Dugu, Sharad Mahatara, Stephan Lany, John Mangum, Rebecca Smaha, Sage Bauers,* National Lab of the Rockies

Nitride antiperovskites offer a distinct and underexplored playground for uncovering spintronic and magnetic functionalities. Recently, we have synthesized polycrystalline and epitaxial films of phase pure (001) Co_3PdN for the first time. The magnetization behavior of epitaxial films exhibits a 'two-step' magnetization curve that is extremely sensitive to the direction of the applied magnetic field relative to high symmetry directions[1,2]. In Figure 1, we show the magnetic field dependence of the Hall resistivity for fields applied in-plane. In this planar Hall configuration, a clear step-like feature emerges which is dependent on sweep direction, field magnitude, and applied field angle relative to the a-axis. Relatively small, planar magnetic fields generate an anomalous Hall response in Co_3PdN.

By combining MOKE magnetometry and magnetotransport, we identify a rotation of the net magnetization towards the (001) axis (film growth direction) for fields applied in-plane, up to 300 K. We hypothesize that distinct domain dynamics and the magnetic free energy drives the behavior[1,2].The unique tunability of the magnetization combined with a spin-polarized DOS positions Co_3PdN as a potentially powerful spintronics platform.

References:

1 H. X. Tang, R. K. Kawakami, D. D. Awschalom, and M. L. Roukes, *Giant Planar Hall Effect in Epitaxial (Ga,Mn)As Devices*, Physical Review Letters, 90.107201 [https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.90.107201] (2003).

2 R. P. Cowburn, S. J. Gray, J. Ferré, J. A. C. Bland, and J. Miltat, *Magnetic switching and in-plane uniaxial anisotropy in ultrathin Ag/Fe/Ag(100) epitaxial films*, Jounral of Applied Physics, 78, 7210 [https://pubs.aip.org/aip/jap/article/78/12/7210/492641/Magnetic-switching-and-in-plane-uniaxial] (1995)

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