Magnetic Interfaces and Nanostructures
Room 318 - Session MI1-MoA

Advanced Magnetic Materials in Low Dimensional Structures II

Moderators: Prof. Dr. Markus Donath, Muenster University, Germany, **Dr. Valeria Lauter**, Oak Ridge National Laboratory

1:30pm **MI1-MoA-1 Observation of Mirror-Odd and Mirror-Even Spin Texture in Ultra-Thin Epitaxially-Strained RuO_2 Films**, *Ming Yi,* Rice University*; **Yichen Zhang**,* Caltech **INVITED**

Recently, rutile RuO_2 has attracted renewed interest due to expectations of prominent altermagnetic spin-splitting. However, accumulating experimental evidence suggests that in its bulk and thick-film forms, RuO_2 does not display any form of magnetic ordering. Despite this, the spin structure of RuO_2 remains largely unexplored in the ultra-thin limit, where substrate-imposed epitaxial strain can be substantial. Here, we employ spin-resolved angle-resolved photoemission spectroscopy, supported by ab-initio calculations, to reveal the electronic structure of 2.7~nm-thick epitaxial RuO_2 heterostructures. We observe an unconventional spin texture characterized by the coexistence of mirror-even and mirror-odd momentum-dependent components. A comprehensive symmetry analysis rules out nonmagnetic origins of this spin texture. These findings suggest an emergent non-relativistic spin structure enabled by epitaxial strain in the ultra-thin limit, marking a distinct departure from the behavior of relaxed or bulk RuO_2. Our work opens new perspectives for exploring symmetry-breaking mechanisms and spin textures in oxide heterostructures.

2:00pm **MI1-MoA-3 On the Sign of the Rashba Parameter in Image-Potential States**, ***Markus Donath***, *Fabian Schöttke,* University of Münster, Germany*; Kaishu Kawaguchi,* University of Tokyo, Japan*; Kenta Kuroda,* Hiroshima University, Japan*; Peter Krüger, Thorsten Deilmann,* University of Münster, Germany*; Ayumi Harasawa, Shuntaro Tani, Yohei Kobayashi, Takeshi Kondo,* University of Tokyo, Japan

For spintronic devices, spin manipulation without external magnetic fields is highly desirable. At surfaces and two-dimensional materials, the spin degeneracy of electronic states can be lifted by the Rashba effect. The Rashba effect in surface states at high-*Z* materials is related to both the strong spin-orbit interaction in heavy atoms and the orbital angular momentum arising from the inversion-symmetry breaking at the surface. Image-potential surface states are simple model systems, where spin-dependent effects can be studied in view of spintronic applications. Our study on Bi_2Se_3 and Bi_2Te_3 showcases that the orbital angular momentum causes an intrinsically reversed Rashba parameter $\alpha_R \approx -100$ meV Å, i.e., a reversed spin splitting compared with the prototypical Rashba-split Au(111) crystal-induced surface state [1] or the image-potential state at Re(0001) [2]. The sign of α_R is decisive for controlling the absolute spin directions in view of spintronic devices. We present a consistent picture of spin-resolved experimental data from inverse photoemission and three-photon photoemission together with calculations from density-functional theory and many-body perturbation theory.

[1] M. Hoesch *et al.*, Phys. Rev. B **69**, 241401(R) (2004); S. N. P. Wissing *et al.*, New J. Phys. **15**, 105001 (2013).
[2] F. Schöttke *et al.*, Phys. Rev. B **105**, 155419 (2022).

2:15pm **MI1-MoA-4 High Magnetocrystalline Anisotropy-Driven Fuel Cell Electrocatalysis in PtPdFe Intermetallic Alloys**, *Muhammad Irfansyah Maulana, **Jong-Sung Yu**,* DGIST, Republic of Korea

Ordered Pt-based intermetallic alloys are emerging as efficient oxygen reduction reaction (ORR) electrocatalysts in hydrogen fuel cells, outperforming their disordered counterparts. However, the intrinsic role of atomic ordering in governing ORR catalytic performance remains unclear. In this work, we report ferromagnetic PtPdFe ternary intermetallics with structurally ordered tetragonal $L1_0$ and cubic $L1_2$ phases (Figure 1a), each featuring distinct crystal structures and atomic arrangements. Our study highlights magnetocrystalline anisotropy as a key structure-dependent descriptor that governs ORR activity in these alloys. Electrochemical half- and single-cell tests reveal that $L1_0$-PtPdFe magnetic intermetallic catalysts (MICs) deliver higher ORR activity than their $L1_2$ counterparts (Figure 1b). Combined experimental and theoretical analyses attribute this enhancement to the unique tetragonal $L1_0$ structure, where strong 5d–3d orbital interactions along the c-axis induce ferromagnetic ordering and elevate magnetocrystalline anisotropy energy, thereby accelerating ORR kinetics. Furthermore, membrane electrode assemblies fabricated by $L1_0$-PtPdFe cathode MICs sustain fuel cell performance beyond the 2025 US Department of Energy stability targets under H_2–O_2, H_2–air, and H_2–N_2 conditions. These findings establish a new design principle for Pt-based intermetallic catalysts, demonstrating that magnetic anisotropy arising from ferromagnetic ordering can be strategically harnessed to optimize fuel cell performance.

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