Tailoring Magnetic Spin Textures in La0.7Sr0.3MnO3-Based Micromagnets

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The development of next-generation computing devices based on spintronics and magnonics requires an understanding of how magnetic spin textures can be tailored in patterned magnetic materials. Within the wide range of magnetic materials available, complex oxides such as ferromagnetic (FM) La0.7Sr0.3MnO3 (LSMO) and antiferromagnetic (AF) La1-xSrxFeO3 (LSFO) provide an ideal platform for tailoring magnetic spin textures when lithographically patterned as nano/micromagnets. This unique tunability arises due to the strong interactions among charge, spin, lattice, and orbital degrees of freedom. In this talk I demonstrate how an intricate interplay exists between shape and magnetocrystalline anisotropy energies as well as exchange coupling interactions at LSMO/LSFO interfaces. Therefore, the resulting AF and FM spin textures can be controlled using parameters such as the LSMO and LSFO layer thicknesses, micromagnet shape, and temperature [1]-[3]. These spin textures are imaged using x-ray photoemission electron microscopy for a variety of shapes (circles, squares, triangles, and hexagons with their edges oriented along different low-index crystallographic directions) with and without their core regions removed ("donut structures"). LSMO nanomagnets are also patterned into artificial spin-ice (ASI) structures [4]-[5], where large arrays of nanomagnets are arranged in geometries where all the magnetic interactions cannot be satisfied simultaneously. While one might expect shape anisotropy to dictate Ising states in the nanomagnets, the unique combination of magnetic parameters associated with LSMO enables the formation of both Ising and complex spin textures (CSTs) based on the nano-island width and spacing. These CSTs consist of single and double vortices and alter the nature of dipolar coupling among nanomagnets, giving rise to exotic physics in the ASI lattices. These studies demonstrate that complex oxides provide a unique platform for engineering FM and AF spin textures for next-generation spin-based devices.

[1] Y. Takamura et al., "Spin-Flop Coupling and Exchange Bias in Embedded Complex Oxide Micromagnets," Phys. Rev. Lett., vol. 111, 107201, Sep 2013.

[2] M. S. Lee et al., "Tailoring Spin Textures in Complex Oxide Micromagnets," ACS Nano, vol. 10, pp. 8545-8551, Sep 2016.

[3] M. S. Lee et al., "Controlling Antiferromagnetic Domains in Patterned La0.7Sr0.3FeO3 Thin Films," J. Appl. Phys., vol. 127, 203901, May 2020.

[4] R. V. Chopdekar et al., "Nanostructured Complex Oxides as a Route Towards Thermal Behavior in Artificial Spin Ice Systems," Phys. Rev. Mater., vol. 1, 024401, Jul 2017.

[5] D. Sasaki et al., "Formation of Complex Spin Textures in Thermally Demagnetized La0.7Sr0.3MnO3 Artificial-Spin-Ice Structures," Phys. Rev. Appl., vol. 17, 064057, Jun 2022.

Bio

Yayoi Takamura received the B.S. degree from Cornell University in 1998 and the M.S. and Ph.D. degrees from Stanford University in 2000 and 2004, all in the field of Materials Science and Engineering. She was a postdoctoral researcher at University of California, Berkeley, with Prof. Yuri Suzuki in the Department of Materials Science and Engineering before joining the Department of Materials Science and Engineering at University of California, Davis, in July 2006. Since July 2020, she has been serving as Department Chair. Her research focuses on the growth of complex oxide thin films, heterostructures, and nanostructures and the characterization of the novel functional properties associated with their interfaces.

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