Department of Materials Science and Engineering Seminar Series 2023

NOVEL PERPENDICULAR MAGNETIC MATERIALS FOR SPIN-ORBIT TORQUE MAGNETIC MEMORY

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E7-03-06, Seminar Room 1

Abstract

Perpendicular magnetization anisotropic (PMA) materials offered superiority of density, access time, and write power consumption in magnetic memory compared to magnet with in-plane magnetization anisotropy. The electrical manipulation of the magnetization in PMA materials with spin-orbit torque (SOT) requiring breaking inversion symmetry and mirror symmetry is studied for their promised application in spintronics.

We first demonstrate the impact of interface oxidation on the generation of out-of-plane (OOP) SOT $L1_1$ CuPt/ferromagnet heterostructure. By introducing an oxidized CuPt surface, we found the field-free switching performance shows remarkable improvement. OOP effective field measurement indicates that the oxidation treatment can enhance the OOP effective field by more than 2 times. Secondly, we focus on developing the spin logic devices utilizing the crystal symmetry-based OOP SOT materials. By introducing an alternative degree of freedom, a direction vector, we demonstrate that the vector adder operation can serve as a new working principle and enable complex logic functions by the all-electric method. The vector-adder-based spin logic utilized the symmetry-dependent free-field current-induced magnetization switching in the $L1_1$ CuPt/CoPt crystal structure. We fabricate a logic device with this essential characteristic to achieve AND, OR, NAND, NOR, IMP, and NIMP Boolean logic gates. Then, we construct a 2-bit full adder with only 2 independent devices, realizing the SUM and CARRY logic separately. Finally, we use the intermediate states of the domain wall nucleation-dominated magnetization reversal in the $L1_1$ CuPt/CoPt bilayers to construct the sigmoidal function. We demonstrate the live training of a deep learning network by using 3*3 sigmoidal neurons to recognize the images from the MNIST database with a high recognition rate (87.5%).

Biography

ZhaoTieyang received his B.Sc. degree in the Department of MSE at Sichuan University, China. He is currently a Ph.D. candidate in the Department of MSE under the supervision of Prof.Chen Jingsheng, focusing on spintronics. His current research focuses on SOT switching in new perpendicular magnetic materials for SOT devices.

Please join us!

HOST: Prof. Ouyang