Magnetization control and detection of antiferromagnetic NiO

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For a long time, there have been no efficient ways of controlling antiferromagnets. Quite a strong magnetic field was required to manipulate the magnetic moments because of a high molecular field and a small magnetic susceptibility [1]. It was also difficult to detect the orientation of the magnetic moments since the net magnetic moment is effectively zero. Nevertheless, the microscopic magnetic moments should in principle exhibit a similar spintronic effect, such as various magnetoresistance effects and the spin torque effect, as seen in ferromagnets [2,3]. In this talk, we show our recent results of the spin torque switching and magnetoresistive detection of the magnetic moments in antiferromagnets [4], leading to novel antiferromagnetic spintronic applications.

Pt 4 nm/ NiO t_{NiO} nm/ Pt 4 nm multilayers were formed by magnetron sputtering. Figure 1 (a) shows the basic principle of the spin torque rotation of the antiferromagnetic moments in a Pt/ NiO/ Pt multilayer structure where the bipartite magnetic moments rotate without a cost to increasing the exchange energy. To experimentally demonstrate, we used the Hall bar structure with the measurement procedure described in Fig. 1 (b). A writing current I_w flowing from the electrode 2 and 3 to the electrodes 1 and 4, as represented by write “1”, rotates the magnetic moments and stabilizes them orthogonal to the direction of I_w. In the same manner, the other current flow of I_w writes “0”. The orientation of the magnetic moments is read, after each write, by the transverse resistance (R_{Hall}). We took advantage of the spin Hall magnetoresistance (SMR) to read out the orientation of the magnetic moments. Figure 1 (c) shows representative results of the sequential write-read operation in Pt/ NiO /Pt as well as Pt/ SiO / Pt with I_w = 38 mA. The operation of write “1” results in a high resistance state and “0” in a low state, which is coherently explained by the spin torque rotation of the magnetic moments and the change of R_{Hall} due to SMR.

[1] L. Neel, *Nobel lectures*, 158 (1970). [2] T. Jungwirth et al., *Nat. Nanotechnol.* 11, 231 (2016). [3] V. Baltz et al., *Rev. Mod. Phys.* **90**, 015005 (2018). [4] T. Moriyama et al., *arXiv:1708.07682* (2017).

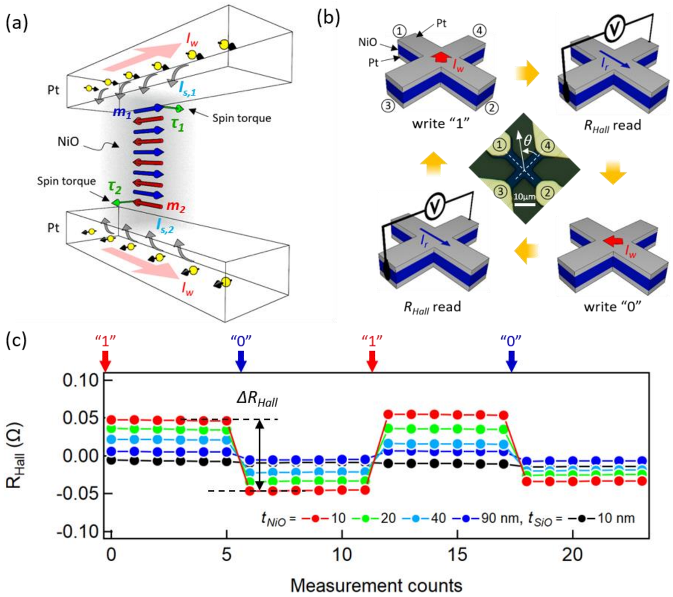

Fig. 1 The spin torque writing scheme and the sequential write-read memory operation.