Simulations of an Electrical Read-Write Operation of a Magnetic XOR Gate

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The ever increasing demand for bigger and cheaper bulk memory and therefore the need for scaling will cause the introduction of new device types and materials. Spin based technologies are promising candidates because of their fast switching, high endurance, and non-volatility. The use of spin also enables the combination of information storage and processing in a single device making it possible to create a fully nonvolatile information processing system.

Recently a fully electrical read-write device out of a ferromagnetic semiconductor has been demonstrated [1]. Furthermore, it was proposed to extend this device to a logical XOR shown in Fig.1 enabling the combination of memory storage and logical operations in one unit.

In this work the lower limit of current densities needed to switch between the different logical states of the proposed XOR was studied for devices (Fig.1) of 325nm, 160nm and 80nm disk radii, respectively [2]. A saturation magnetization M_S of 32.000A/m was chosen and a cubic anisotropy with the easy axes oriented parallel to the leads and a cubic anisotropy constant K_c of 2000J/m^3 for the (Ga,Mn)As film was assumed. The switching was realized by 1ns current pulses applied between the opposite leads of the d1 or d2 disks or across the whole structure (diagonal switching) as shown in Fig.1. The critical current densities for the diagonal and d1 switching are shown in Fig.2. Interestingly, the current density to perform the diagonal switching is lower than that for d2 (d1) switching.

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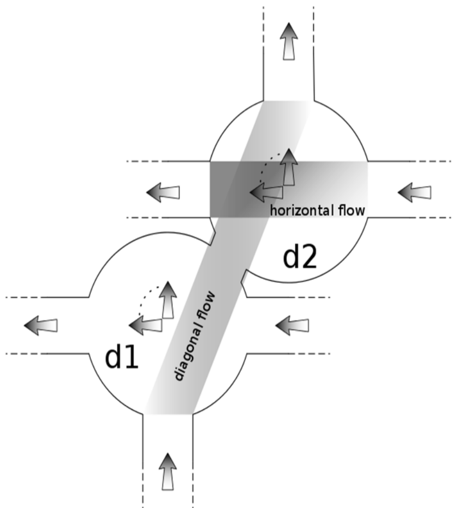

Fig. 1: Basic scheme of XOR.

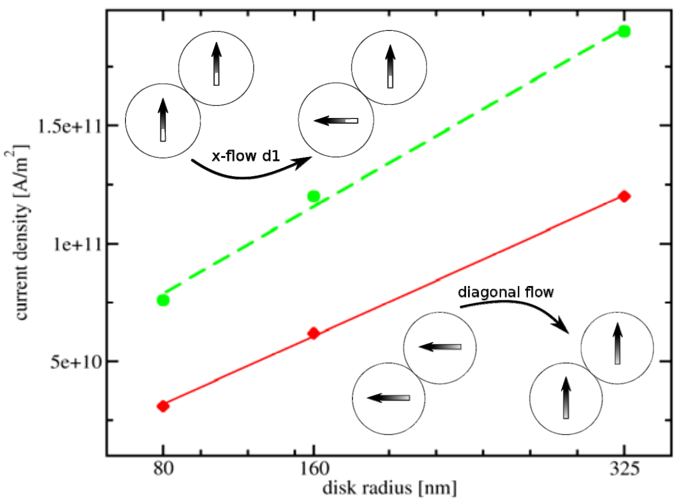

Fig. 2: Current density as a function of disk radius and applied flow path.

References

[1] S. Mark et al., **Phys. Rev. Lett. 106**, 057204 (2011)
[2] http://math.nist.gov/oommf/, (2011)