Magnetic and Magnetoelectronic Memory and Logic

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We are investigating the fabrication and magnetic properties of magnetic logic and memory devices. These consist of multilayer magnetoresistive ring-shaped structures as shown in Figure 1. The magnetic multilayers show giant magnetoresistance, in which the resistance is a function of the relative orientation of the magnetization directions in the magnetic layers. These small structures have potential uses in magnetic-random-access memories (MRAM), magnetic logic devices, and other magneto-electronic applications. Unlike that of conventional MRAM devices, the ring-shaped geometry of these devices allows for a complex response with multiple stable resistance states. This capability can be used for multi-bit memory and for programmable, non-volatile memory.

These devices are programmed using either a magnetic field or a current. Recently, we have been examining how the response of these structures depends on the magnitude of the magnetic field cycling. We found ranges of stable behavior where the response can be extremely uniform, and other field ranges where a variety of stochastic reversal paths occur. We have also shown that spin-polarized currents can reverse the devices in a low-power process. We are now exploring communication between these devices.

Simultaneously, we are exploring high-frequency behavior of magnetic nanostructures through giant magnetoimpedance. In GMI, the impedance of nanoscale structures varies dramatically with magnetic field and with frequency in the GHz range, and this variation can be used for sensitive magnetic field detection.

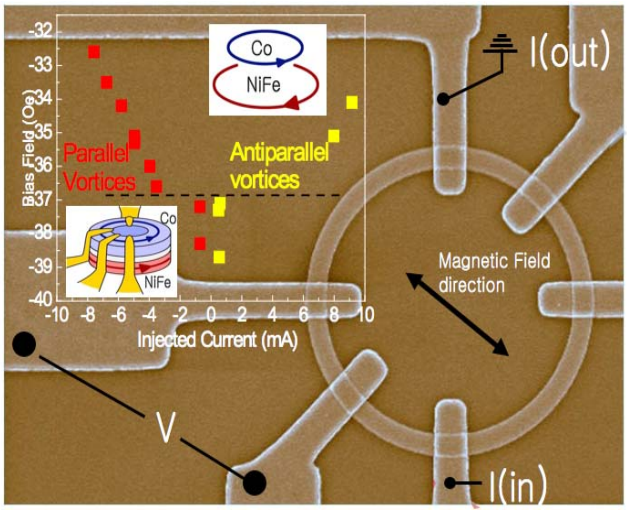

Figure 1: A magnetic ring made from Co/Cu/NiFe with diameter of 5 µm and several non-magnetic contacts overlaid. The inset shows the combination of current and magnetic field required to switch the ring from one magnetic state to another.

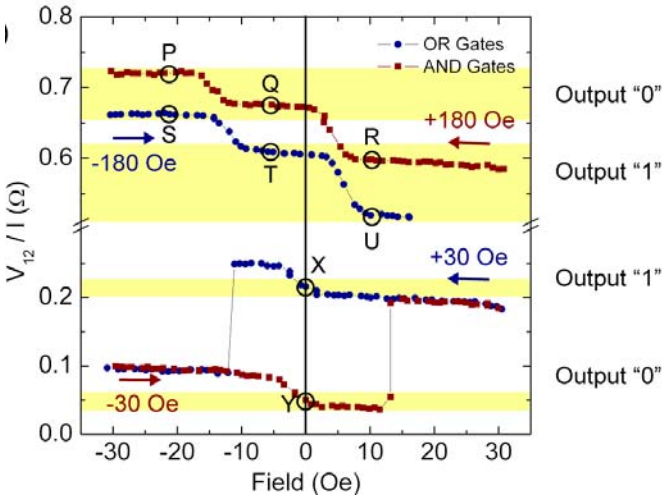

Figure 2: Electrical response of a magnetic ring tested under different field ranges, showing large resistance changes that can be used for logic operations.

References

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