New Speed Record for Magnetic Memories

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(PhysOrg.com) -- An experiment carried out at the Physikalisch-Technische Bundesanstalt (PTB) has realized spin torque switching of a nanomagnet as fast as the fundamental speed limit allows. Using this so-called ballistic switching future non-volatile magnetic memories could operate as fast as the fastest non-volatile memories. The experiments are described in the next issue of *Physical Review Letters* (22 August, 2008).

Fast memory chips such as DRAMs and SRAMs (Dynamic and Static Random Access Memory) commonly used today have one decisive disadvantage: in case of power interruption, they lose their stored information. This problem could be solved by magnetic memory chips called MRAMs (Magnetic Random Access Memory). In MRAM the digital information is not stored by means of electric charge but by means of the orientation of the magnetization of a magnetic cell.

The latest generation of MRAM uses the so-called spin torque effect for programming the magnetic bits. Using spin torque the memory state of the cell can be programmed in a very simple way just by applying a current pulse. A positive current switches the magnetization to one direction (digital state "0") and a negative current to the other (digital state "1"). Spin torque MRAM further promise a high storage density comparable to DRAM and Flash. Most major semiconductor chip producers are developing spin torque memories and market introduction is expected, soon.

A spin torque current pulse excites a rotational motion of the magnetization of the memory cell – the so-called precession. Normally,

the magnetization has to undergo several precessional turns before reliable magnetization reversal takes place. Therefore present spin torque MRAM prototypes must operate with rather long write pulses of about 10 nanoseconds duration which limits the MRAM clock speed.

In the experiment carried out at PTB Braunschweig spin torque magnetization reversal has now been realized by a single precessional turn, only. This so called "ballistic" spin torque magnetization reversal corresponds to the ultra short physical limit of spin torque magnetization reversal time. It was achieved by precise tailoring of the current pulse parameters in combination with a small magnetic bias field.

Using ballistic spin torque reversal future MRAM could be programmed by current pulses shorter than 1 nanosecond corresponding to write clock rates well above 1 GHz. It could thus enable a high-density and non-volatile memory operating at the clock rates of the fastest volatile memories.

Citation: Quasi-ballistic spin torque magnetization reversal, S. Serrano-Guisan, K. Rott, G. Reiss, J. Langer, B. Ocker, and H. W. Schumacher, *Physical Review Letters* 33 (2008)

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