Lower Switching Current for Spin-Torque Transfer in Magnetic Storage Devices such as Magnetoresistive Random Access Memory (MRAM)

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Spin-Torque Transfer with Lower Magnetic Current Density Would Aid in the Development of MRAM as a Universal Memory System

A composite structure has been developed to reduce current densities required for spin-torque transfer in magnetic storage devices by up to a factor of 50. Spin-torque transfer is a technique for storing data in magnetic storage devices such as magnetoresistive random access memory (MRAM). Improvements in implementation of spin-torque transfer would allow MRAM to be a universal memory storage device usable in virtually all electronics. The major issue in utilizing spin-torque transfer in MRAM (STT-MRAM) is the high power inputs the technique requires and the degradation of the storage elements due to the heat created from these high power inputs. The new composite structure requires lower current densities resulting in lower heat and the degradation of the storage element is slowed. Other methods that attempt to address this issue have only succeeded in lowering the magnetic current densities by about a factor of three.

Structure Reduces Current Density of Switching Currents used in STT-MRAM

In MRAM, each storage element is formed by two magnetic plates, each holding a magnetic field, and separated by an insulating layer. One of the two plates is a permanent magnet set to a particular polarity; the other's magnetic field can be changed to match that of an external field to store memory. A memory device is a combination of such storage elements. Data is stored by changing the magnetization patterns of the various storage elements using spin-torque transfer.

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The composite structure is formed by inserting one or more soft assisting layers between the recording layer and the layer with a permanent polarity. The soft assisting layers have smaller polarities than the recording layer with each assisting layer closer to the recording layer having a stronger polarity than the previous layer.

**FEATURES AND BENEFITS OF STRUCTURE USED IN SPIN-TORQUE TRANSFER IN MRAM:**

- Magnetic current density can be reduced up to a factor of 50 thereby reducing power requirements
- Applications in solid state memory, which could allow for MRAM to be used as a universal memory system utilized in all electronics
- MRAM as a single universal memory system would comprise several of the best features of various memory systems currently used in electronics.
- The reduction in power requirements improves the thermal stability of MRAM elements, which reduces degradation from use
- Possible applications in all electronics such as computers, digital cameras, and mobile phones

**MRAM: Non-volatile and Superior to RAM, DRAM, SRAM, and Flash Memory**

MRAM is a very promising memory storage technique because it has the same speed as static random access memory (SRAM), similar density and about 10% the power consumptions of dynamic random access memory (DRAM), and is quicker and degrades less over time compared to flash memory. MRAM is also non-volatile so it does not need a constant power supply to retain data. For these reasons, MRAM potentially comprises the best features of various memories systems into a single universal memory system for use in all electronics.

**Phase of Development** Micromagnetic simulations have been completed in laboratory. These computer simulations have shown that a reduction in required switching current has been achieved by a factor of 50.

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