RETHINKING DESIGN

ETH Zurich Meets Davos during the World Economic Forum's Annual Meeting (22 – 25 January 2019)

Information, photographs, and video footage

Sprinting Magnetic Memory

Zurich, 15 December 2018

Magnetic memory that supports billions of fast read/write cycles. Magnetic data storage has long been considered too slow for use in the working memories of computers. Researchers at ETH Zurich and imec Leuven have now investigated magnetic multilayer systems in which magnetic data writing can be accomplished considerably faster and using less energy.

For nearly seventy years, magnetic tapes and hard disks have been used for data storage in computers. In spite of many new technologies, the controlled magnetization of a data storage medium remains the first choice for archiving information because of its longevity. As a means of realizing random access memories (RAMs) - used as the main memory for processing data in computers - magnetic storage technologies have long been considered inadequate due to its low writing speed and relatively high-energy consumption.

Researchers at ETH Zurich's Department of Materials and colleagues at the imec Leuven, have now shown that using a novel technique, adapted to a nanometer thick metallic multilayers, fast magnetic storage can be achieved without wasting energy.

Magnetization inversion without coils

In traditional magnetic data storage technologies, tape or disk data carriers coated with a metal such as iron or cobalt are used. A current-carrying coil produces a magnetic field that changes the direction of magnetization in a small portion of the data carrier. Compared to the speeds of modern processors, this procedure is very slow, and the electric resistance of the coils leads to energy loss. Therefore, it would be much better if one could change the magnetization direction directly, without taking a detour via magnetic coils.

ETH Zurich researchers, in collaboration with researchers at imec in Belgium and Spintec in France, have demonstrated a technique that could do just that: An electric current passing through a specially coated semiconductor wafer inverted the magnetization in a tiny metal dot. This is made possible by a physical effect called spin-orbit-torque. In this effect, a current flowing in a conductor leads to an accumulation of electrons with opposite magnetic moment (spins) at the edges of the conductor. The electron spins, in turn, create a magnetic field that causes the atoms in a nearby magnetic material to change their orientation.

Possible application in RAMs

Further developments led by Dr. Kevin Garello at the imec research centre in Leuven, Belgium, are investigating the commercial realization of the technique. In a first step, the researchers have optimized their materials in order to make the inversion work even faster and at smaller currents. In a second step, shown in the accompanying figures, the researchers have fabricated prototype magnetic memory cells on top of a 300 mm Si wafer, where conventional CMOS electronic is integrated with the magnetic bits in the form of magnetic tunnel junction devices.

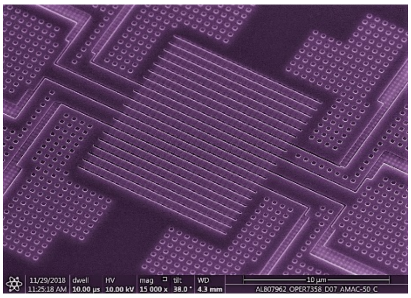

Figure a

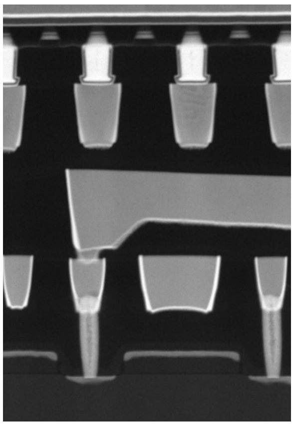

Figure b

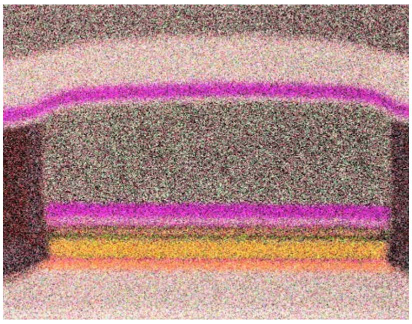

Figure c

Magnetic RAMs (MRAMs) combine the best of two worlds: non-volatile data storage and electronic speed. MRAMs can deliver instant on-off computing, nanosecond read and write times, and reduced energy consumption. Among other things, MRAMs make the loading of the operating system when booting a computer obsolete – the relevant programmes would remain in the working memory even when the power is switched off.

Design team / bios / publications

Prof. Dr. Pietro Gambardella, ETH Zurich Department of Materials, Professor of Magnetism and Interface Physics

https://www.ethz.ch/en/utils/search.MTkzMzUx.html?pagetype=people&search=pietro+gambardella&language=en&lang_filter=false

References

ETH Zurich Magnetism and Interface Physics website
http://www.intermag.mat.ethz.ch/

Images and video material

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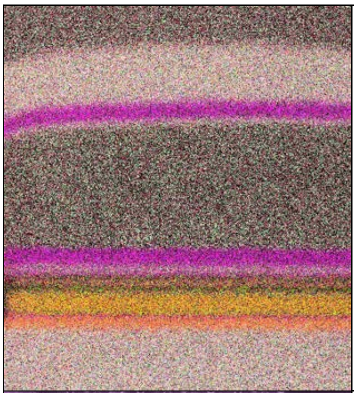
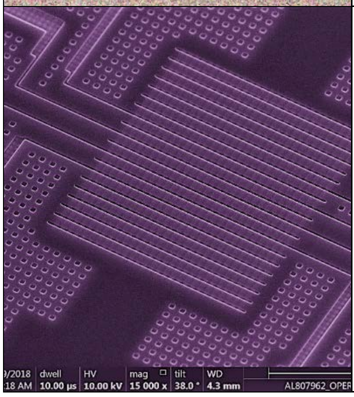
	Cross-section of a magnetic tunnel junction pillar. Different layers shown in colour. Image credit: imec Leuven
	Magnetic memory cells on top of a 300 mm Si wafer. Image credit: imec Leuven