Magnetic Memory Bits with Perpendicular Magnetization Switched By Current-Induced Spin-Orbit Torques

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SUMMARY

UCLA researchers in the Department of Electrical and Computer Engineering have developed a novel spin-orbit-torque (SOT)-controlled magnetic random access memory driven by in-plane currents.

BACKGROUND

Magnetization switching by current-induced spin-orbit torques (SOTs) has been attracting great attention for its potential applications in ultra low power memory and logic devices. The use of SOTs in nonmagnetic metal/ferromagnet/insulator structures allows for a significantly lower write current compared to regular spin-transfer-torque (STT) devices. It can also greatly improve the energy efficiency and scalability for new SOT-based devices such as magnetic random access memory (SOT-MRAM). However, practical use of SOT effects is limited by its requirement of an in-plane external magnetic field, in order to switch ferromagnets with a perpendicular (out-of-plane) magnetization.

INNOVATION

Researchers at UCLA have developed a novel nonmagnetic metal/ferromagnet/insulator structure which provides a SOT, resulting in zero-field current-induced switching of perpendicular magnetization. The device consists of a ferromagnetic free layer, a ferromagnetic fixed layer, a dielectric tunnel barrier, and a high-spin-orbit-coupling material, and has a structural mirror asymmetry along the in-plane direction. The lateral structural asymmetry effectively replaces the role of the external in-plane magnetic field and eliminates the use of external magnetic fields, bringing SOT-based spintronic devices such as SOT-MRAM closer to practical application.

APPLICATIONS

- Serves as building blocks for SOT-controlled magnetic random access memory (SOT-MRAM)
- Memory applications to provide high integration density
- Layers of SOT-MRAM may be stacked to increase larger effective density

ADVANTAGES

- No need for any magnetic bias field
- Reduced design complexity
- More practical for wide application

STATE OF DEVELOPMENT

The described SOT structure has been tested experimentally.

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	9,343,658	05/17/2016	2014-322

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- Vertical-Stacked-Array-Transistor (VSAT) for Nonvolatile Memory Devices

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OTHER INFORMATION

KEYWORDS

Spin-orbit torque, SOT, magnetic random access memory, MRAM

CATEGORIZED AS

- **Computer**
  - Hardware
- **Engineering**
  - Engineering

RELATED CASES

2014-322-0

- Vsat Structure for Nonvolatile Memory Device
- A Read-Disturbance-Free Nonvolatile Content Adressable Memory
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- Anti-Ferromagnetic Magneto-Electric Spin-Orbit Read Logic

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