

## 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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### INVENTORS

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### OTHER INFORMATION

#### KEYWORDS

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

#### CATEGORIZED AS

- ▶ [Computer](#)
- ▶ [Hardware](#)
- ▶ [Engineering](#)
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#### RELATED CASES

2014-322-0

- ▶ [Vsat Structure for Nonvolatile Memory Device](#)
- ▶ [A Read-Disturbance-Free Nonvolatile Content Adressable Memory](#)
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