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Spin orbit torque generating materials

A novel material with a large spin Hall angle for applications in spintronic devices.

Technology No. 20170137

IP Status: US Patent Issued; **Application #:** 10,878,985

Applications

- Spintronics memory and logic devices

Key Benefits and Differentiators

- Novel spin Hall material BixSe(1-x) exhibits a giant spin Hall angle (greater than 3.5 at room temperature)
- Large spin Hall conductivity
- Compatible with existing CMOS technology
- Enables creation of power-efficient devices

Overview

Spintronic devices - spin-based devices that harness the intrinsic spin of electrons and their associated magnetic moments, in addition to electronic phenomena that arise from the fundamental electronic charges of electrons - may be used as alternatives to or in conjunction with electronic devices. Spin-orbit torque (SOT) in spin Hall materials/ferromagnetic heterostructures is of great interest due to its efficient switching of magnetization in spintronic devices. For instance, SOT switching is hypothesized to be potentially faster and more efficient than spin transfer torque (STT) switching that is typically used in magnetic tunneling junction (MTJ) devices for memory and logic applications. However, a reliable method to produce materials with sufficient spin Hall angle is currently not available.

Prof. Jian-Ping Wang’s group at the University of Minnesota has developed a novel material with a large spin Hall angle: up to 100x that of heavy metals. This material is ideal for developing magnetic memory devices such as magnetic domain wall-based devices, where spin-transfer torque and spin-orbit torque combine to efficiently operate

the device. This new spin Hall material and device has several advantages:

- It produces large spin-orbit torque that can efficiently switch in and out of plane magnetization.
- In a device with a ferromagnetic insulator as the magnetic layer, it can produce large spin-orbit torque with a very small current.
- In a device such as magnetic domain wall, spin-transfer torque and spin orbit torque work together to produce large domain wall velocity.

The researchers have discovered SOT from magnetron-sputtered BixSe(1-x) thin film in a BixSe(1-x) /CoFeB heterostructure by using a novel DC planar Hall method. The spin Hall angle from the BixSe(1-x) thin film was found to be as large as 22.41, which is the largest ever reported at room temperature. Moreover, the researchers have demonstrated switching of perpendicular magnetization using SOT from the BixSe(1-x) with the lowest-ever switching current density reported in a bilayer system, 2.7×105 A/cm2, at room temperature. Furthermore, the smooth surface of the BixSe(1-x) film yields better device performance, and growth of the film on a silicon substrate enables easier integration into existing CMOS devices. The giant spin Hall angle, large spin Hall conductivity, low switching current density at room temperature, smooth surface, and growth of the films on silicon substrate make the magnetron-sputtered BixSe(1-x) thin film a very strong candidate as an SOT generator in SOT-based memory and logic devices.

Phase of Development

TRL: 3-4
Lab scale material synthesized and characterized.

Desired Partnerships

This technology is now available for:

- License
- Sponsored research
- Co-development

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Researchers

- **Jian-Ping Wang, PhD** Professor, Electrical and Computer Engineering
- **Andre Mkhoyan, PhD** Professor, Chemical Engineering and Materials Science

References

Dc, M., Jamali, M., Chen, J., Hickey, D., Zhang, D., Zhao, Z., Li, H., Quarterman, P., Lv, Y., Mkhyon, A. and Wang, J.P., Giant spin Hall angle from topological insulator Bi x Se (1-x) thin films.

Lv, Y., Kally, J., Zhang, D., Lee, J. S., Jamali, M., Samarth, N., & Wang, J. P., https://doi.org/10.1038/s41467-017-02491-3

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