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Electrical-field bidirectional switching of full MTJs

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Category
Engineering & Physical Sciences/Design Specifications
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Software & IT/Algorithms

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A full MTJ stack device with bidirectional magnetization switching purely through an electric field

IP Status: Issued Patent #11,183,227, Continuation filed #17/450,852

Applications

- Spin based memory and logic devices

Key Benefits & Differentiators

- **Electrical-field switching of MTJs:** consumes low power while improving speed and reducing error rate
- **Ultralow energy performance:** Current does not pass through a high resistive tunnel barrier
- **Easy integration to currently available devices:** Compatible with current standard CMOS technology and with geometry structure similar to currently available devices

Electrical-field bidirectional switching of MTJs

The scaling of conventional semiconductor devices are highly dependent on device reliability and power consumption. Improvements in these two critical factors are continuously pursued. Currently, electrical field switching of perpendicular magnetic tunnel junctions (p-MTJs) either uses an external magnetic field or spin transfer torques to break the time-reversal symmetry for switching. However, MTJ devices with switching relying only on the electrical field can achieve lower power consumption and error rates.

Researchers at the University of Minnesota have developed a bidirectional switching mechanism of a full MTJ stack and device that, unlike other technologies, relies only on the electrical field. This proposed technology performs bidirectional switching of the perpendicular magnetization via the electric-field manipulated exchange coupling of the synthetic antiferromagnetic free layer. This E-field driven magnetization switching of MTJ devices approach enables ultralow energy performance, ultrafast switching speed, low write error rate and read disturbances. This technology is compatible with currently used geometry and standard CMOS technologies, which facilitates easy integration with conventional devices in the market. This invention can also be used as a novel design for spin based memory and logic devices. The proposed device has high stability, scalability, and can easily be fabricated in wafer scale.

Phase of Development

TRL: 7
This technology has been tested in a relevant environment and is under experimental validation. The bidirectional magnetization switching has been demonstrated in p-MTJs with the synthetic antiferromagnetic free layer. The exchange coupling change by electric-field was observed through gating and tunneling effect

Desired Partnerships

This technology is now available for:

- License
- Sponsored research
- Co-development

Please contact our office to share your business' needs and learn more.

Researchers

- **Jian-Ping Wang** Distinguished McKnight Professor, Department of Electrical and Computer Engineering

References

1. Delin Zhang, Mukund Bapna, Wei Jiang, Duarte Sousa, Yu-Ching Liao, Zhengyang Zhao, Yang Lv, Protyush Sahu, Deyuan Lyu, Azad Naeemi, Tony Low, Sara A. Majetich, and Jian-Ping Wang , https://doi.org/10.1021/acs.nanolett.1c03395, Nano Letters