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SHE-CRAM: Computational Random Access Memory (CRAM) based on Spin Hall Effect

Spintronics-based memory array system that performs true in-memory computational operations. The novel spin Hall effect (SHE) technology is used to implement a new CRAM computer architecture (SHE-CRAM) that is capable of inter-raw communication

IP Status: US Patent Issued #11,176,979

Applications

- Traditional CPU-centric computing
- Big data applications
- Deep neural-network applications such as pattern recognitions
- Mobile devices and IoT devices

Key Benefits & Differentiators

- **Reliable, larger noise margin and capable of inter-raw communication:** by performing true-in memory computational operations
- **Low writing voltage and small energy dissipation:** by using materials with ultra high spin Hall efficiency
- **Gating control:** the SHE memory cell uses a three terminal scheme

Technology Summary

In traditional computing systems, a central processing unit retrieves data from a memory, performs an instruction on the data to produce a result and returns the result to memory for storage. Thus, data must be transferred along a bus each time an instruction is executed. The process of physically moving data from memory to the processor introduces significant power consumption and delays, especially for large-scale data analytics applications. Currently this issue is addressed by using near-memory processing (NMP), where the computational unit is put at the periphery of memory. NPM provides fast access to data but still implies high energy consumption and delays.

Researchers at the University of Minnesota have developed a true in-memory computational platform called SHE-CRAM that effectively addresses the communication bottlenecks of current hardware paradigms. The Computational Random Access Memory (CRAM) utilizes spintronics-based memory array to organically enable logic operations within the array. In this invention, a novel spintronics technology, spin Hall effect (SHE) based memory array, is applied to obtain a new CRAM structure. The proposed SHE-CRAM platform is fast, reliable, features a large noise margin and allows inter-raw communication. As a result, this novel computational platform can perform more universal logic operations. The SHE-based CRAM uses materials with ultra high spin Hall efficiency such as BiSe and other topological insulators, which allows low writing voltage and small energy dissipation during computing operations. The SHE-memory cell features a three-terminal scheme, which enables gating control and in turn provides another degree of freedom for computational operations. Thus, the SHE-CRAM platform can significantly

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Category
Engineering & Physical Sciences/Nanotechnology
Engineering & Physical Sciences/Semiconductor
Software & IT/Algorithms
Software & IT/Communications & Networking

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improve CPU-centric computing. Potential applications include big-data analytics, deep neural-network such as pattern recognition, mobile devices, and IoT devices particularly for artificial intelligence (AI).

Phase of Development

TRL: 4-6

A proof of concept has been generated for the memory cell

Desired Partnerships

This technology is now available for:

- License
- Sponsored research
- Co-development

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Press Releases

- **IEEE Spectrum** 7/24/2018
- **University of Minnesota News** 7/27/2018
- **University of Minnesota News** 9/25/2018

Researchers

- **Jian-Ping Wang, PhD** Distinguished McKnight University Professor, Department of Electrical and Computer Engineering
- **Sachin Sapatnekar, PhD** Distinguished McKnight University Professor, Department of Electrical and Computer Engineering
- **Ulya Karpuzcu, PhD** Associate Professor, Department of Electrical and Computer Engineering

References

1. Zabihi, Masoud, Zhengyang Zhao, D. C. Mahendra, Zamshed I. Chowdhury, Salonik Resch, Thomas Peterson, Ulya R. Karpuzcu, Jian-Ping Wang, and Sachin S. Sapatnekar , https://doi.org/10.1109/ISQED.2019.8697377