Docket #: S19-491

Next-Generation Nonvolatile Memory

Researchers at Stanford have demonstrated a new type of energy-efficient and ultrathin memory. This low-energy cost memory is based on stacking orders in the atomically thin limit, associated with tiny changes in the position of one atomic layer with respect to another. Development of this kind of ultracompact memory with faster operation speed and smaller energy consumption is critical – it is estimated that global data volume will reach 44 zettabytes by 2020 and exceed the capabilities of current computing and memory devices. To achieve such orders of improvement in memory devices, it is essential to realize new operation mechanisms and to store information by nonclassical carriers. The new memory, called Berry curvature memory, is enabled by electrically driven stacking transitions with low-energy cost in nanometer-thick layered materials. It stores non-volatile information in a quantum geometrical property known as Berry curvature. The energy cost of such memory can be fundamentally as low as 0.1aJ/nm2, which is 3-5 orders smaller than that in current DRAM and GST-phase change memory and is not limited by thermal losses. The sliding of the atomic layers can occur very rapidly with a fundamental speed limit in the terahertz regime, indicating the potential to operate a hundred times faster than current data storage.

Stage of Development
Proof of concept

Applications

- Memory, processor and modulator with low-energy cost, ultrathin and ultrafast performance

Advantages

- **Energy saving**

    - 0.1 aJ/nm2 (work estimation)
    - 10 fJ/nm2 (DDR4 DRAM from Micron)
- **Ultrathin: ~ 3 nm**
- **Nonclassical carrier:**
    - Topological protection
    - Non-destructive reading
- **THz operation speed is fundamentally allowed**

Publications

- Jun Xiao, Ying Wang, Hua Wang, C. D. Pemmaraju, Siqi Wang, Philipp Muscher, Edbert J. Sie, Clara M. Nyby, Thomas P. Devereaux, Xiaofeng Qian, Xiang Zhang, Aaron M. Lindenberg. 2019. Berry curvature through memory via electrically driven stacking transitions Nature Physics (in press, 2020) arXiv:1912.01037 (2019).

Patents

- Published Application: 20210159398

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