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Vortex-Core Reversal Dynamics: Towards Vortex Random Access Memory

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An energy-efficient, ultrahigh-density, ultrafast, and nonvolatile solid-state universal memory is a long-held dream in the field of information-storage technology. The magnetic random access memory (MRAM) along with a spin-transfer-torque switching mechanism is a strong candidate-means of realizing that dream, given its nonvolatility, infinite endurance, and fast random access. Magnetic vortices in patterned soft magnetic dots promise ground-breaking applications in information-storage devices, owing to the very stable twofold ground states of either their upward or downward core magnetization orientation and plausible core switching by in-plane alternating magnetic fields or spin-polarized currents. However, two technologically most important but very challenging issues — low-power recording and reliable selection of each memory cell with already existing cross-point architectures — have not yet been resolved for the basic operations in information storage, that is, writing (recording) and readout. Here, we experimentally demonstrate a magnetic vortex random access memory (VRAM) in the basic cross-point architecture. This unique VRAM offers reliable cell selection and low-power-consumption control of switching of out-of-plane core magnetizations using specially designed rotating magnetic fields generated by two orthogonal and unipolar Gaussian-pulse currents along with optimized pulse width and time delay. Our achievement of a new device based on a new material, that is, a medium composed of patterned vortex-state disks, together with the new physics on ultrafast vortex-core switching dynamics, can stimulate further fruitful research on MRAMs that are based on vortex-state dot arrays.