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VCMA-Controlled MTJ Devices For Probabilistic Computing Applications

A technical paper titled “Probabilistic computing with voltage-controlled dynamics in magnetic tunnel junctions” was published by researchers at Northwestern University, University of Messina, Western Digital Corporation, and Universitat Jaume I.

Abstract:

“Probabilistic (p-) computing is a physics-based approach to addressing computational problems which are difficult to solve by conventional von Neumann computers. A key requirement for p-computing is the realization of fast, compact, and energy-efficient probabilistic bits. Stochastic magnetic tunnel junctions (MTJs) with low energy barriers, where the relative dwell time in each state is controlled by current, have been proposed as a candidate to implement p-bits. This approach presents challenges due to the need for precise control of a small energy barrier across large numbers of MTJs, and due to the need for an analog control signal. Here we demonstrate an alternative p-bit design based on perpendicular MTJs that uses the voltage-controlled magnetic anisotropy (VCMA) effect to create the random state of a p-bit on demand. The MTJs are stable (i.e. have large energy barriers) in the absence of voltage, and VCMA-induced dynamics are used to generate random numbers in less than 10 ns/bit. We then show a compact method of implementing p-bits by using VC-MTJs without a bias current. As a demonstration of the feasibility of the proposed p-bits and high quality of the generated random numbers, we solve up to 40 bit integer factorization problems using experimental bit-streams generated by VC-MTJs. Our proposal can impact the development of p-computers, both by supporting a fully spintronic implementation of a p-bit, and alternatively, by enabling true random number generation at low cost for ultralow-power and compact p-computers implemented in complementary metal-oxide semiconductor chips.”