Spintronic-based Nonvolatile CMOS VLSI

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The exponential reduction of the feature size in the past decades, known as Moore's law, has been the key to the current great success of the semiconductor very-large-scale-integrated-circuit (VLSI) technology. Today, logic VLSI, where intelligent systems are integrated on a single chip die, is one of the key technologies in modern society, determining the quality of the systems from small to large as well as the social infrastructure. The current approach, however, is coming to an end because of ever increasing power consumption and interconnection delay that limit the performance of VLSI. Magnetic tunnel junction (MTJ), a spintronics device, brings a new horizon to the quest. MTJ offers nonvolatile memory element capable of fast nondestructive-read and write, scaling to nanometer dimensions, and high endurance, all with its back-end-of-line (BEOL) compatibility that allows integration of MTJs in interconnection part of VLSI. Combined with the VLSI technology, MTJ makes it possible not only to realize nonvolatile, high density, and fast random access memories, but also to construct nonvolatile VLSI logic circuits that have unprecedented low power capability and compactness that overcome the present limit of power and delay [1, 2]. I will discuss the development of MTJs, in particular its material and physics aspects together with its scaling potential with perpendicular interface anisotropy [3]. I will conclude my talk with future prospects touching upon electric-field manipulation of magnetism [4, 5].

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