Magnetic tunnel junction for next generation integrated circuits

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A magnetic tunnel junction (MTJ) consists of two metal ferromagnetic layers separated by an insulator thin enough that current passes through the layer via tunneling. The resistance of an MTJ depends on relative orientation of the two magnetizations of the layers, making it possible to encode information in a novolatile fashion on the direction of one layer while keeping the other layer's direction fixed. The resistance is usually low when the magnetizations are parallel and high when antiparallel. The resistance difference divided by the low resistance is called tunnel-magnetoresistance (TMR). Giant TMR and current-induced magnetization switching recently realized in MTJs have opened a new possibility for next generation integrated circuits. The unique features offered by MTJ are the combination of nonvolatility, fast read and write, virtually unlimited rewrite, CMOS compatibility with back-end process, small footprint, and scalability beyond 22 nm. These advantages are not easily matched by other technologies. I will first discuss the physics and material science of MTJs. Then I show that the MTJ/CMOS hybrid integrated circuit approach not only makes it possible to realize nonvolatile high-density fast random access memories, but also can solve many of the major challenges – the so-called red-brick walls – that current integrated circuit technology is facing.

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