Noncollinear magnetic random access memory

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Semiconductor random access memory (RAM) is a fast, volatile memory used by computers to store data. In the early 2000s, it was demonstrated that magnetic moments can be manipulated using electric currents, enabling the development of magnetic RAM (MRAM) that matches the speed of semiconductor RAM while also being non-volatile—that is, capable of retaining data even when power is turned off. Although MRAM has been realized, it is currently used only in specialized applications. One of the main barriers to broader adoption is the collinear alignment of magnetic layers in state-of-the-art designs, which thus rely on thermal agitation to induce the noncollinear alignment necessary for current-driven magnetization switching. Recently, we have identified novel spacer layers that can be inserted between magnetic layers to precisely control the relative orientation of their magnetic moments, enabling the required noncollinear alignment for efficient current-induced switching. In this talk, I will present the composition and fabrication of the spacer layers used to establish noncollinear coupling as well as a theoretical framework that we have developed to explain how these layers control the angle between adjacent magnetic moments. Additionally, I will present results from micromagnetic simulations, through which we explored MRAM designs that incorporate noncollinear coupling. These demonstrate switching performance that is twice as fast as and more energy-efficient than the state-of-the-art.