Computing using Voltage-Controlled Stochasticity in MRAM

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The adoption of magnetoresistive random access memory (MRAM) by major semiconductor manufacturers not only presents the potential to replace existing embedded memory types (e.g., initially embedded Flash and eventually, embedded SRAM) with MRAM, but also provides an unprecedented opportunity to develop unconventional computing architectures that utilize the physics of these newly available MRAM devices (i.e., magnetic tunnel junctions, MTJs) within mainstream semiconductor manufacturing platforms. In this talk we will first discuss the challenges facing existing embedded spin-transfer torque (STT-) MRAM in terms of scaling to higher bit densities while achieving speed and endurance that make it competitive against SRAM. We will then discuss how voltage-controlled (as opposed to current-controlled) MRAM cells can potentially overcome these challenges, and present our recent results in the development of voltage-controlled MRAM (VCM) cells. We then discuss how appropriately designed modified MRAM cells with low retention time can be used to fulfill unconventional roles within a computing system, notably as electrically controlled stochastic bitstream (SBS) generators. We then discuss the application of such MRAM-based SBS generators to true random number generation and to stochastic computing (SC), and present our recent results on the implementation of an SC-based artificial neural network using a series of stochastic MRAM cells [1]. Finally, we extend some of the presented ideas to more exploratory MRAM materials based on antiferromagnets, which provide immunity to large external magnetic fields, eliminate bit-to-bit magnetic interactions, and provide significantly faster dynamics, which are expected to be beneficial for both high-speed memory and stochastic computing applications [2-4].


More information about the event and the speaker:
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