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Nanomagnetic Bit Cells for MRAM Applications

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Magnetoresistive Random Access Memory (MRAM) combines magnetic tunnel junction devices with standard silicon-based microelectronics to obtain the combined attributes of non-volatility, high-speed operation, and unlimited read/write endurance not found in any other existing memory technology. The first MRAM product to market, Freescale's 4Mb MR2A16A, is built on 180 nm CMOS technology with magnetic bit cells of 300 nm minimum dimensions integrated in the upper layers of metal. At these dimensions, both the magnetic switching and magnetoresistive property distributions are governed by a combination of material and patterning variations. One of the keys to controlling these distributions and insuring manufacturability was the invention of the Toggle Write mode. This mode uses a balanced synthetic antiferromagnetic free layer combined with a phased write pulse sequence to achieve robust magnetic switching margin by eliminating the half-select disturb issue found in conventional approaches. Another crucial solution was the ability to deposit and pattern high-quality, high-TMR magnetic tunnel junctions with narrow bit-to-bit resistance variation, low defect density and long-term reliability. In this talk, I will present details of each of the above technology elements, the performance and bit cell reliability, and the scaling behavior to the reduced dimensions of advanced technology nodes.