AA03

Current Status and Future Outlook of STT-RAM Technology

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Non-volatile STT-RAM (spin-transfer torque random access memory) is a new memory technology that combines the capacity and cost benefits of DRAM, the fast read and write performance of SRAM and the non-volatility of Flash with essentially unlimited endurance. It has excellent write selectivity, excellent scalability beyond the 45 nm technology node, low power consumption and a simpler architecture and manufacturing process than first-generation, field-switched MRAM. It has the potential to revolutionize the performance of electronic products in many areas, create new sectors in the semiconductor industry and give rise to entirely new products not yet envisaged.

This paper will describe the current status of STT-RAM memory technology, discuss the key technical issues involved in its commercialization, and outline future potential applications and products. Recent, dramatic advances in STT write current density reduction [1-3] have made it possible to design single-level STT-RAM unit cells as small as 6 F^2, where F is the minimum feature size, making STT-RAM's density not just superior to SRAM, but also competitive with DRAM and NOR Flash; even smaller unit cells may be possible in the future with multi-level architectures [4]. The principles of MTJ design and materials optimization to achieve low write current, while at the same time maintaining high thermal stability, will be presented, as will details of MTJ integration with standard CMOS processes to form STT-RAM memory arrays. Specific aspects of STT-RAM chip performance at the 90 nm technology node will also be presented and discussed, including write voltage distribution, thermal stability and data retention, MTJ barrier reliability and endurance, and read disturb. Finally, an analysis of STT-RAM scalability will be presented, outlining the trends in write current and thermal stability at the 45 nm technology node and beyond, and the future prospects for STT-RAM incorporating MTJs with perpendicular magnetic anisotropy (PMA) [5].

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[5] Grandis U.S. patents 6967863 and 6992359.

AA04

Good Scalability of Study of Spin Torque Transfer MRAMs with Perpendicular Magnetization MTJs

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TMR elements with perpendicular magnetization (P-TMR) were proposed to have a potential to have small critical switching current(Ic) [1],[2],[3][4]. P-TMR was proved to have 3-5 times more efficiency than those with longitudinal magnetization[5],[6],[7],[8]. However, the Ic was still over 200 micro-amperes for a 100nm diameter element which was too large for a gigabit density memory. Recently, further reduction in the Ic was reported [9]. The Ic for 50nm diameter element was only about 50 micro-amperes.

In this talk, scalability in non-volatility and in switching speed, and in switching current will be also addressed and concluded that P-TMR will be a promising solution for a scalable giga bits density non-volatile random access memory.

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