Delivering Nanosecond-Class Persistent Memory

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MRAM In Use Today & Tomorrow

- **1st Generation MRAM: Toggle MRAM**
  - Up to 16Mb SRAM/SPI/QSPI
  - 10Mpcs shipment milestone
  - High quality track record
  - Adopted by leading OEMs
  - Metadata storage & logging

- **2nd Generation MRAM: Spin-Torque MRAM**
  - Scales to Gigabit with fast DDRx interface
  - 64Mb DDR3 ST-MRAM samples in customer evaluation
  - OEMs developing new system architectures
  - Non-volatile Buffers and Caches for Storage/RAID
  - Protecting data in flight and coalesce buffers

- **Embedded MRAM**
  - Over 10M units shipped to date
  - Expanding to 300mm processes

Building the MRAM Ecosystem

- **Increasing the awareness of MRAM's advantages**
  - Versatile use as memory or storage device
  - Persistent memory architecture element
- **Optimizing memory host controller ecosystem**
  - Enable mixed use of MRAM combined with DRAM
  - Increase availability for FPGAs and SOC development
  - SSD/ROC controller roadmaps aligning with ST-MRAM
- **MRAM BEOL manufacturing eco system**
  - Establishment of volume manufacturing at 300mm
  - Improving availability and cost of BE processing
- **Expanding MRAM market opportunities**
  - Scaling to Gb densities yields exponential growth
  - Developing persistent memory optimized interface

Future Opportunities for MRAM

- **MRAM complements today's memory technologies**
  - MRAM & NAND:
    - MRAM performance, endurance & reliability is superior
    - Performance storage tier - Tape-Disk-NAND-MRAM
    - Combined NAND/MRAM for Enterprise SSD & Hybrid Drives
    - Extend NAND life with MRAM high endurance buffer
  - MRAM & DRAM:
    - DRAM scaling hits refresh bandwidth barrier **even if** it scales
    - Power fail system design is a significant problem for DRAM
    - Combined DRAM/MRAM NVDIMM for read/write caches
- **Embedded MRAM & potential DRAM replacement**