Process Equipment Capabilities for STT MRAM Manufacturing

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OUTLINE

▪ Background, including need for STT MRAM as embedded memory

▪ Process Flow and Key Process Equipment for STT MRAM

▪ Summary and Outlook
Embedded Flash and SRAM Scaling

Scaling limiters:
Cost: Additional mask/process steps
Performance: Integration of HKMG logic with embedded Flash

Embedded Flash

Current MCU Chip

STT-MRAM MCU Chip

6T SRAM

Scaling limiters:
Area (Cost): 6T SRAM scaling challenged, while many AI applications call for more on-DIE working memory

Embedded SRAM

1T STT-MRAM

~65% shrink
Achieving basic functions of memory

1. **Store**: Energy barrier ($\Delta \sim E/k_B T$) between 2 magnetization states
2. **Read**: Sense amplifier to distinguish the two resistance states (TMR%)
3. **Write**: FL magnetization direction switching at current $> \text{critical current (I}_C\text{)}$
Insertion in BEOL with up to 4 additional masks*, on top of logic that resides in FEOL

* Optional bottom and top contact and mark open mask steps
Key Integration Steps for MTJ Module

1. Bottom Contact:
   Atomic level smoothness

2. MTJ Stack PVD:
   Complex stack of 10+ layers
   Precise thicknesses control
   (sub Angstrom)
   Interface and texture control

3. HM Dep & Etch:
   Low Temp Dielectric Deposition

4. Stack Etch & Encapsulation
   No metal re-dep on edge
   Minimize damage/intermixing
   Low Temp Encapsulation

5. Oxide CMP:
   Precise stop on iso/dense metal

Critical: Controllability of uniformity, stoichiometry, structure, interfaces & damage free patterning
MTJ CD of 20-50nm and dense pitch is desired
Key Process Equipment

- Bottom Contact
- MTJ Stack Dep
- Pillar Patterning
- MTJ Etch & Encapsulation
- Oxide Fill & CMP

- LK Prime™ (CMP)
- Endura™ M/C PVD
- Centura™ (HM Etch)
- VeritySEM™ (Metrology)
- Centura™ Etch, Nitride
- Producer™ (Dielectric)
STT MRAM for “SRAM” Applications

Materials & Etch process improvements key to enabling SRAM replacement
Summary

- Applied Materials focusing on High Volume Manufacturing Equipment that enables STT MRAM device performance, yield and cost. Multiple tools shipped.

- Initial adoption is being seen for STT MRAM as eFlash replacement, where device specs have been demonstrated

- Stack deposition and etch performance improving to a point that we expect to see STT MRAM expanding into some SRAM replacement in near future