Engineering Document

Resistive switching for next generation Flash technology

Christie Marrian, Spansion

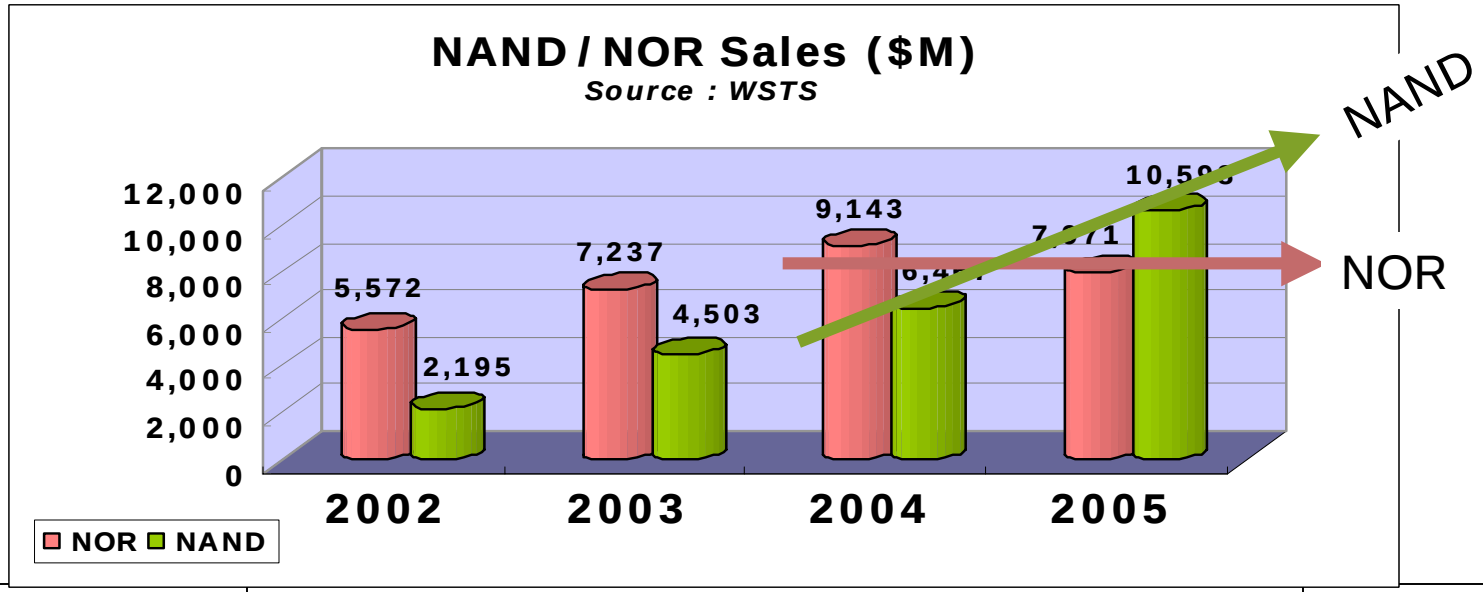
10/24/07

Cautionary Statement

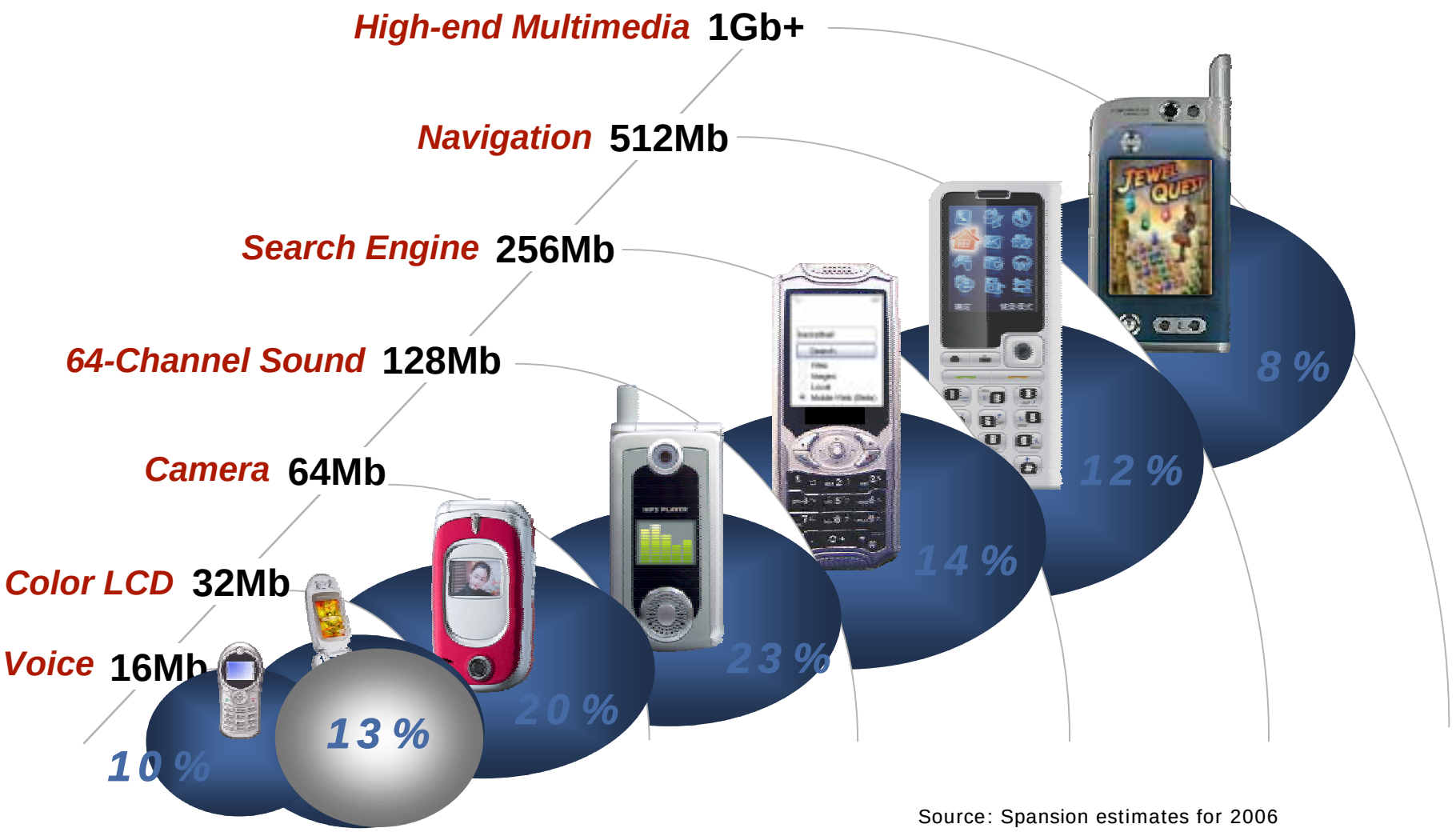
This presentation and comments made pursuant thereto may contain forward-looking statements that are made pursuant to the safe harbor provisions of the Private Securities Litigation Reform Act of 1995, including statements regarding future deployment of MirrorBit™ technology, the company's ability to capitalize on its product and technology leadership and its operational efficiency. Investors are cautioned that the forward-looking statements in this presentation involve risks and uncertainties that could cause actual results to differ materially from the company's current expectations, including the possibility that demand for the company's Flash memory products will be lower than currently expected; that customer acceptance of MirrorBit technology will not continue to increase; that OEMs will increasingly choose NAND-based Flash memory products over NOR- and MirrorBit ORNAND architecture-based Flash memory products for their applications; that there will be a lack of customer acceptance of MirrorBit ORNAND architecture-based Flash memory products; that the company will not achieve its current product and technology introduction or implementation schedules; that the company will not be able to meet customer demand during cyclical industry or economic downturns; that competitors will introduce new memory technologies that render the company's Flash memory products uncompetitive or obsolete. The company urges investors to review in detail the risks and uncertainties in the company's Securities and Exchange Commission filings, including but not limited to the company's Annual Report on Form 10-K for the year ended December 25, 2005.

Introduction

- NAND market
  - Almost 100% data storage.
  - Memories are mostly for memory cards or memory products.
- NOR market
  - Mainly for code storage.
  - Memories are embedded in systems.
- NOR flash memory technology
  - Only for NOR market? No.



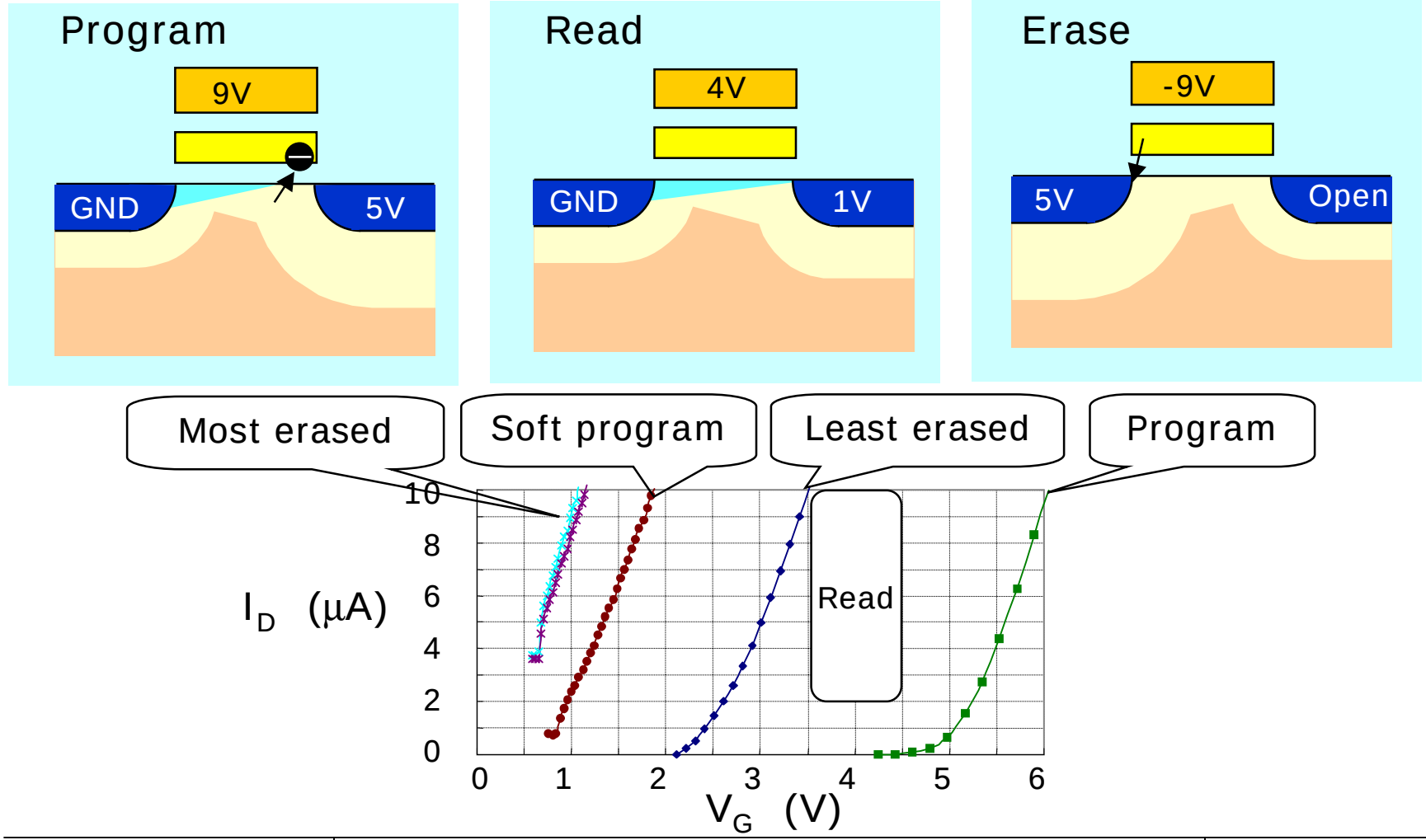
Cellular Requirements



Source: Spansion estimates for 2006

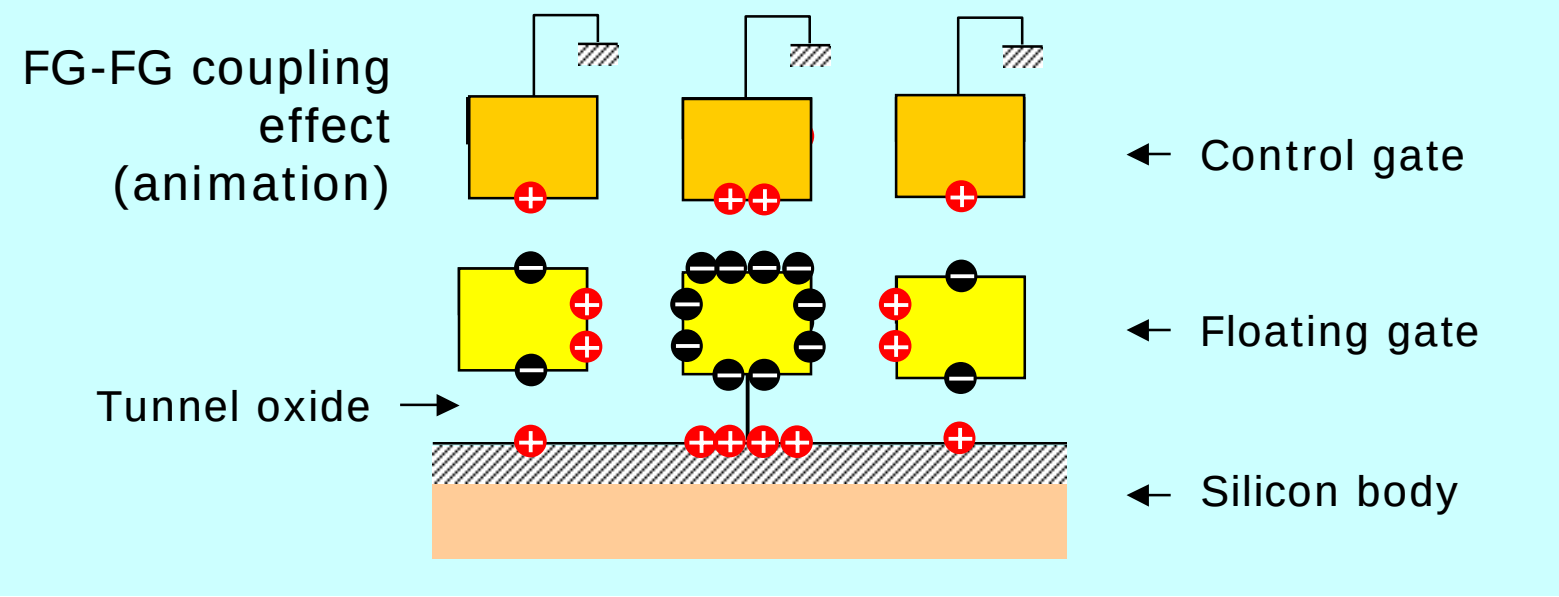
Floating Gate Cell Basic Operations

- Initial cell V_T is low (Data 1).



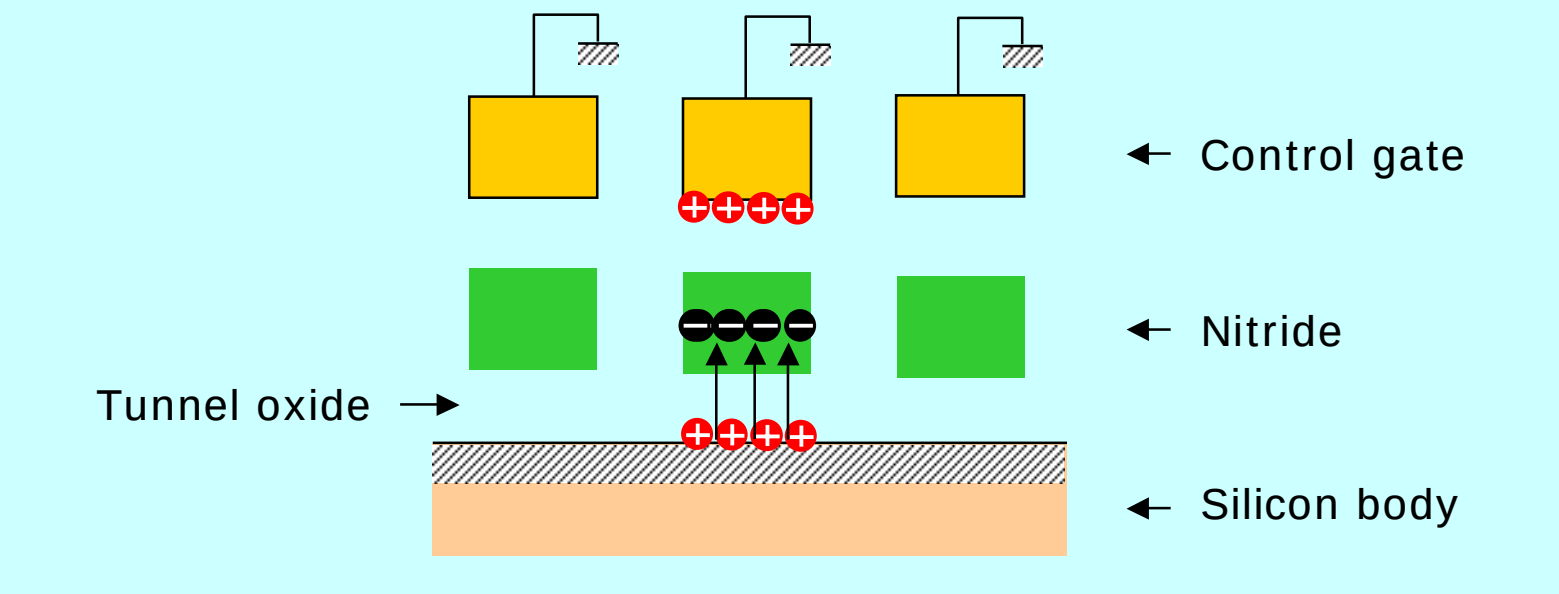
Floating Gate Scaling Barrier

- Floating gate electro-static interaction
  - Narrow floating-gate spacing
  - Tall floating gate



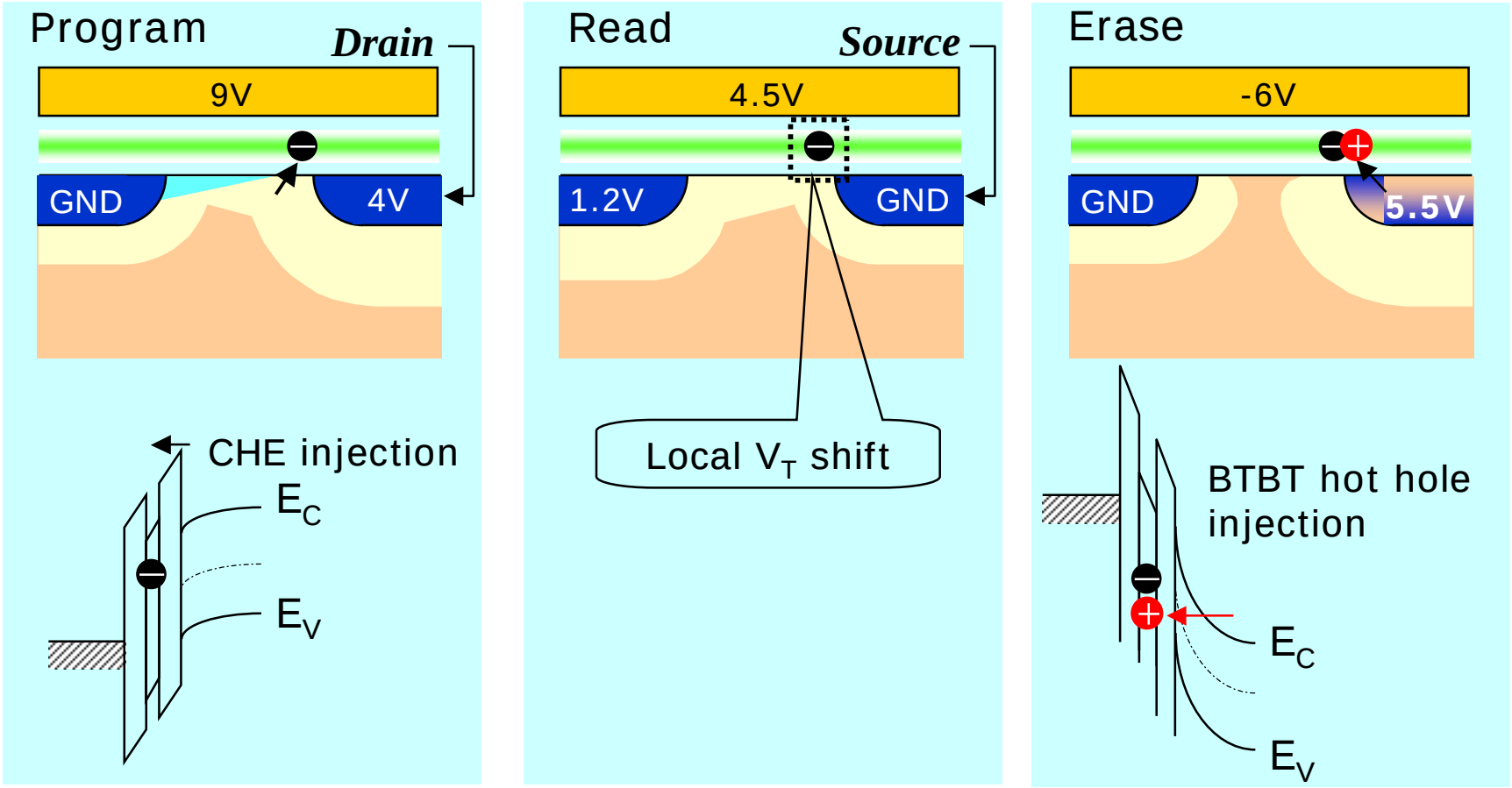
Nitride Storage

- The favorite NVM technology
  - Charge does not move around the storage electrode
  - Less floating gate electro-static interaction results in denser memories.



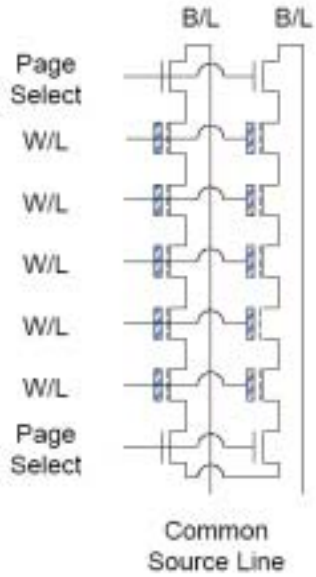
MirrorBit Basic Operations

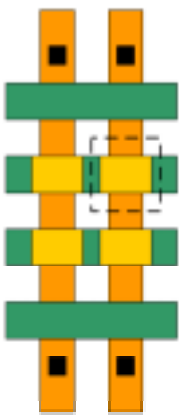
- Channel hot electron (CHE) programming
- Transpose source and drain for reading the data
- Band to band (BTBT) hot hole injection erasing



Cell Operation

Floating-Gate NAND

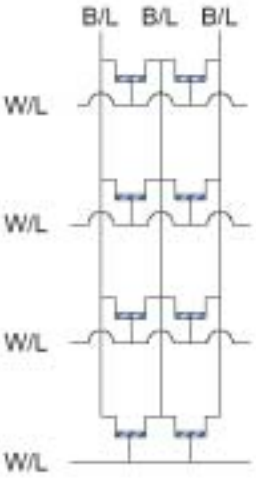


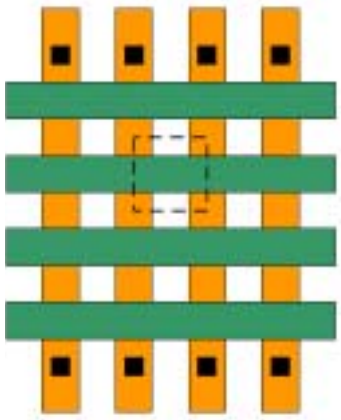


Cell Size: ~4.5λ^2

	W/L	B/L	Common
Read	5V	0.5V	0V
Program	18V	0/10V	0V
Erase	0V	18V	Float

MirrorBit™ technology

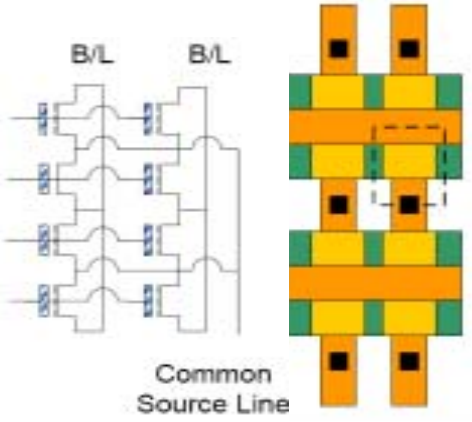




Cell Size: ~(6λ^2)/2

	W/L	B/Ln	B/L n+1
Read	5V	1.5V	0V
Program	10V	5/0V	0V
Erase	-6V	5V	Float

Floating-Gate NOR

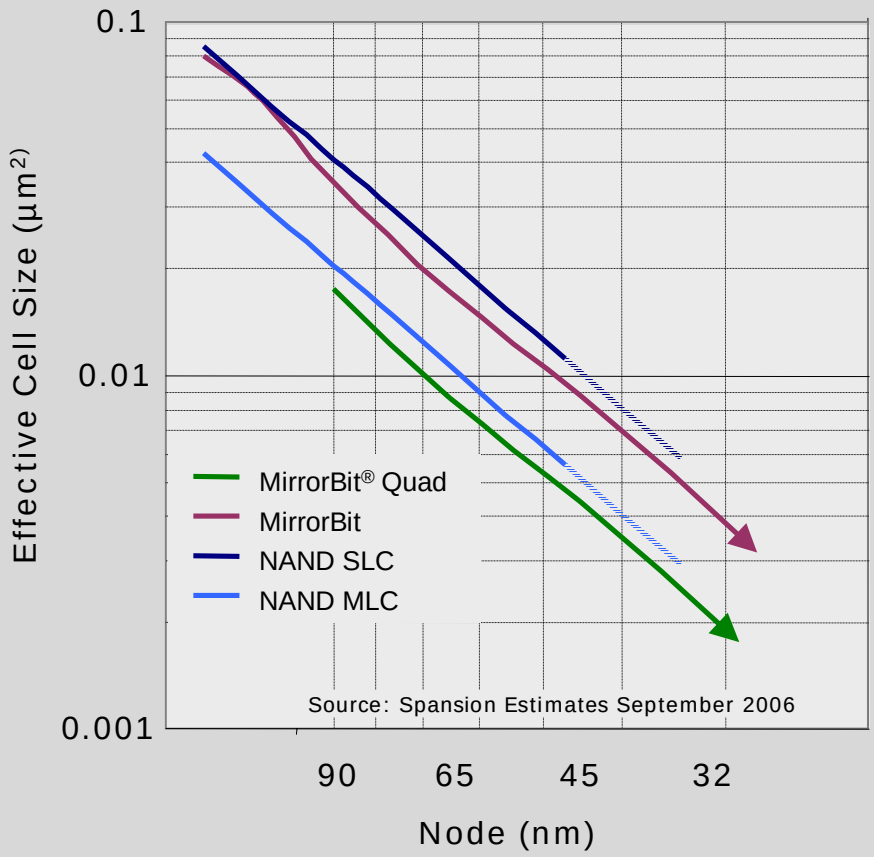


Cell Size: ~9.5λ^2

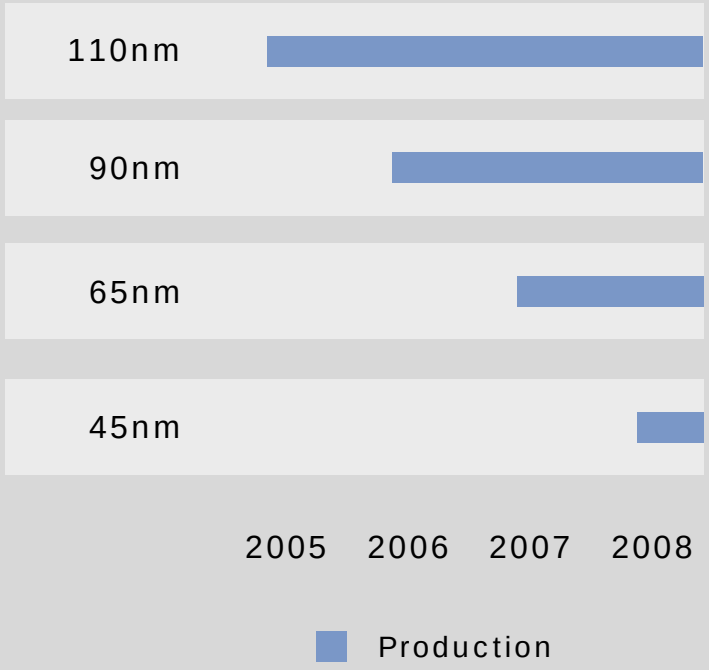
	W/L	B/L	Common
Read	5V	0.5V	0V
Program	10V	5/0V	0V
Erase	-18V	0V	Float

MirrorBit® Quad: Technology of the Future—Today

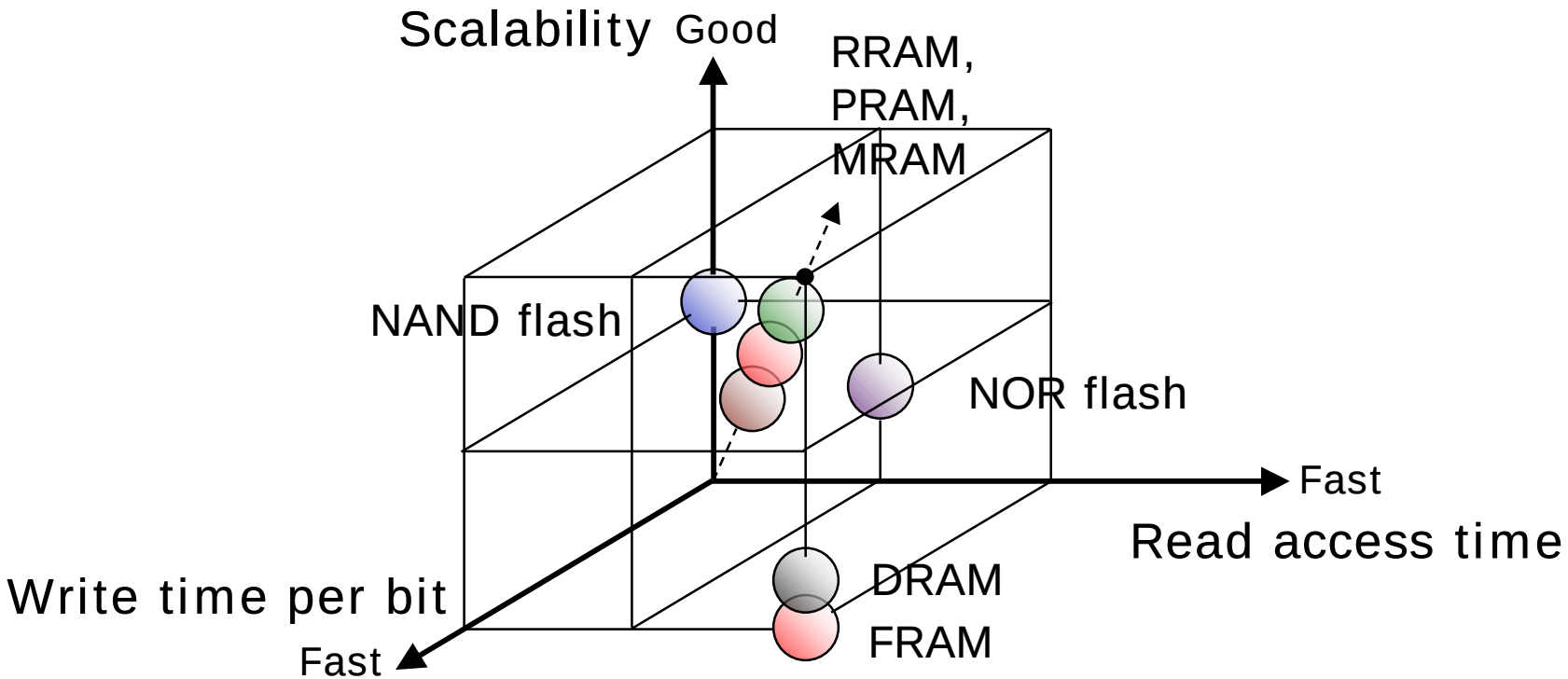
Scaling to 32nm and Beyond



Goal – One Node Per Year

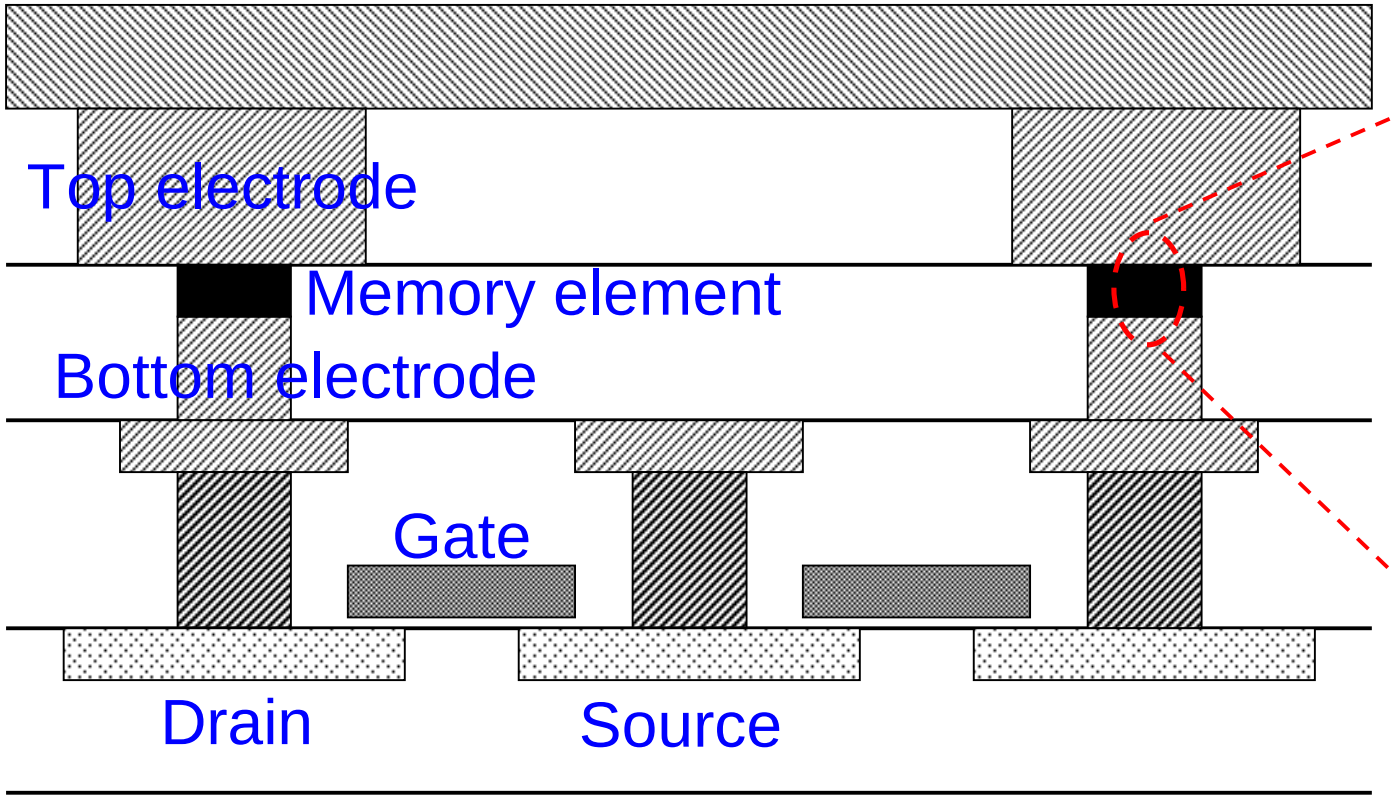


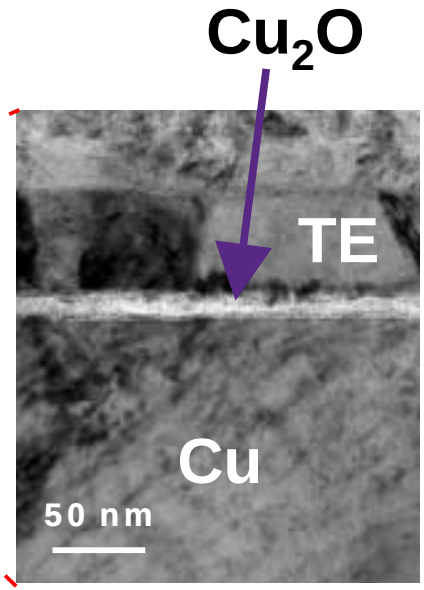
Emerging Memory Technologies



Memory Cell Structure

- MIM memory element built on a via
- Memory element connected with a select transistor
- Fully compatible with standard CMOS process

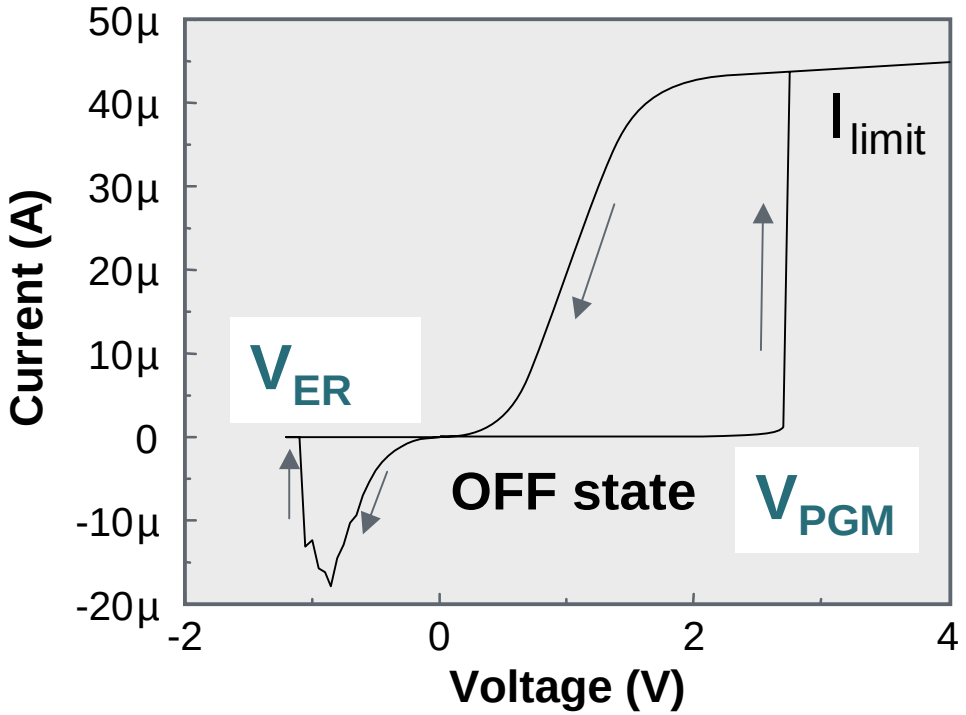




Background – Trapping Model*

- OFF state mainly by **space-charge-limited-conduction (SCLC)** and **Frenkel-Poole (FP)**
- OFF → ON switch at trap-filled-limit voltage (VTFL)

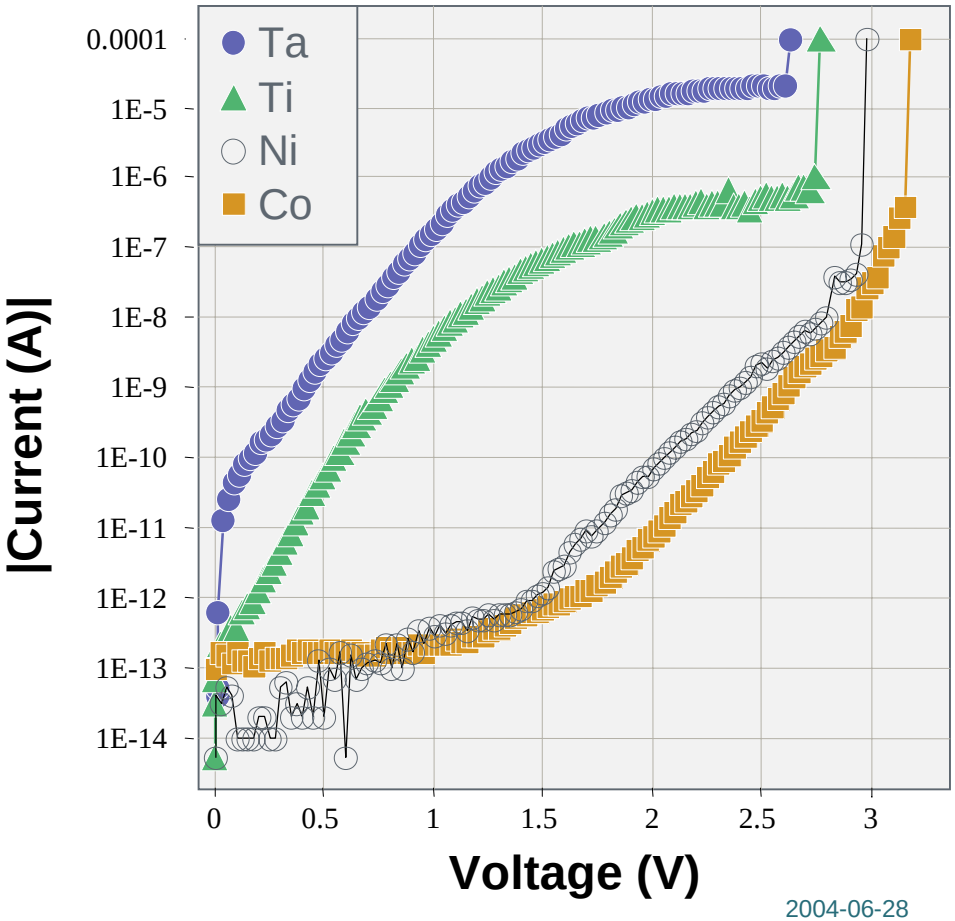
Cu2O MIM Memory Cell



*Chen *et. al* "Non-volatile resistive switching for advanced memory applications," *Electron Devices Meeting, 2005. IEDM Technical Digest. IEEE International* , vol., no.pp. 746- 749, 5-7 Dec. 2005

Electrode Effect

OFF-state current leakage increases with reactivity between top electrode and Cu_2O (Ni/Co<Ti<Ta).



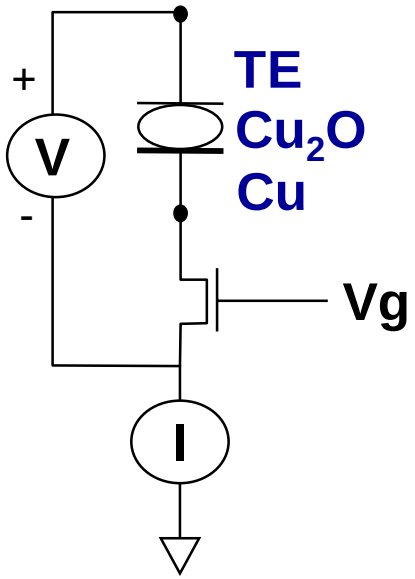
Free energy of formation

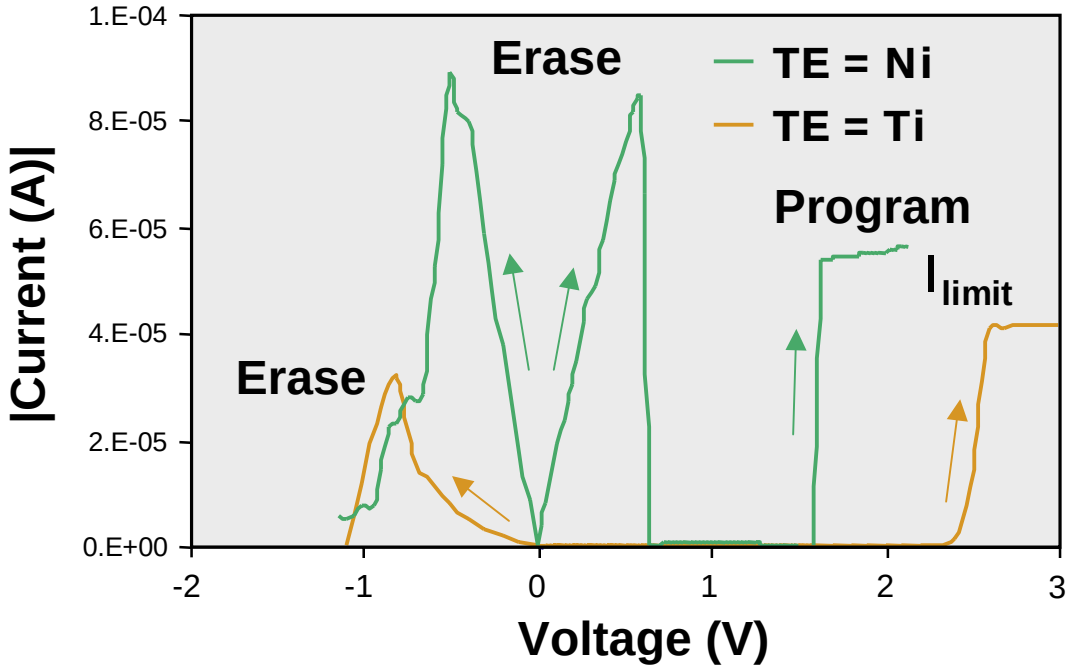
MO_x	ΔG_o (kcal/mole)
CoO	-51
NiO	-51.7
TiO_2	-212
Ta_2O_5	-457

Switching Characteristics: Ni vs. Ti TE

Cells with Ni top electrode
- Erase with both polarity
- Higher erase current

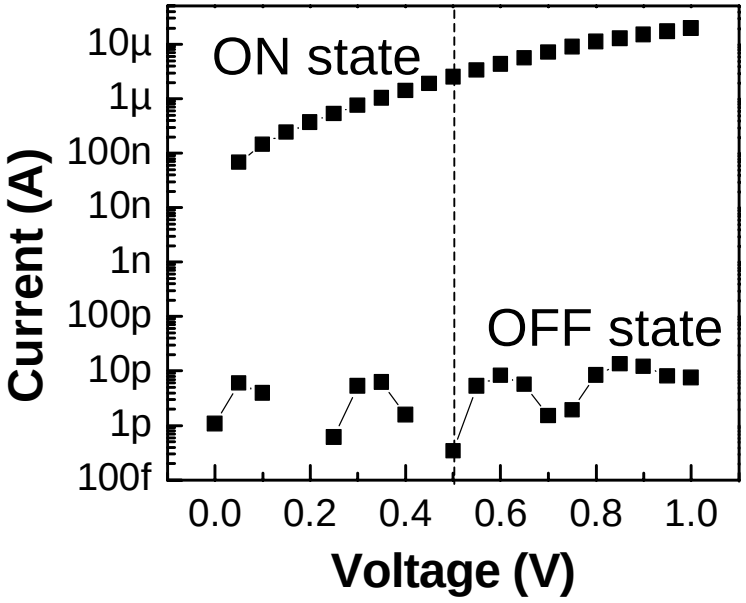
Cells with Ti top electrode
- Reverse polarity field
- Low erase current

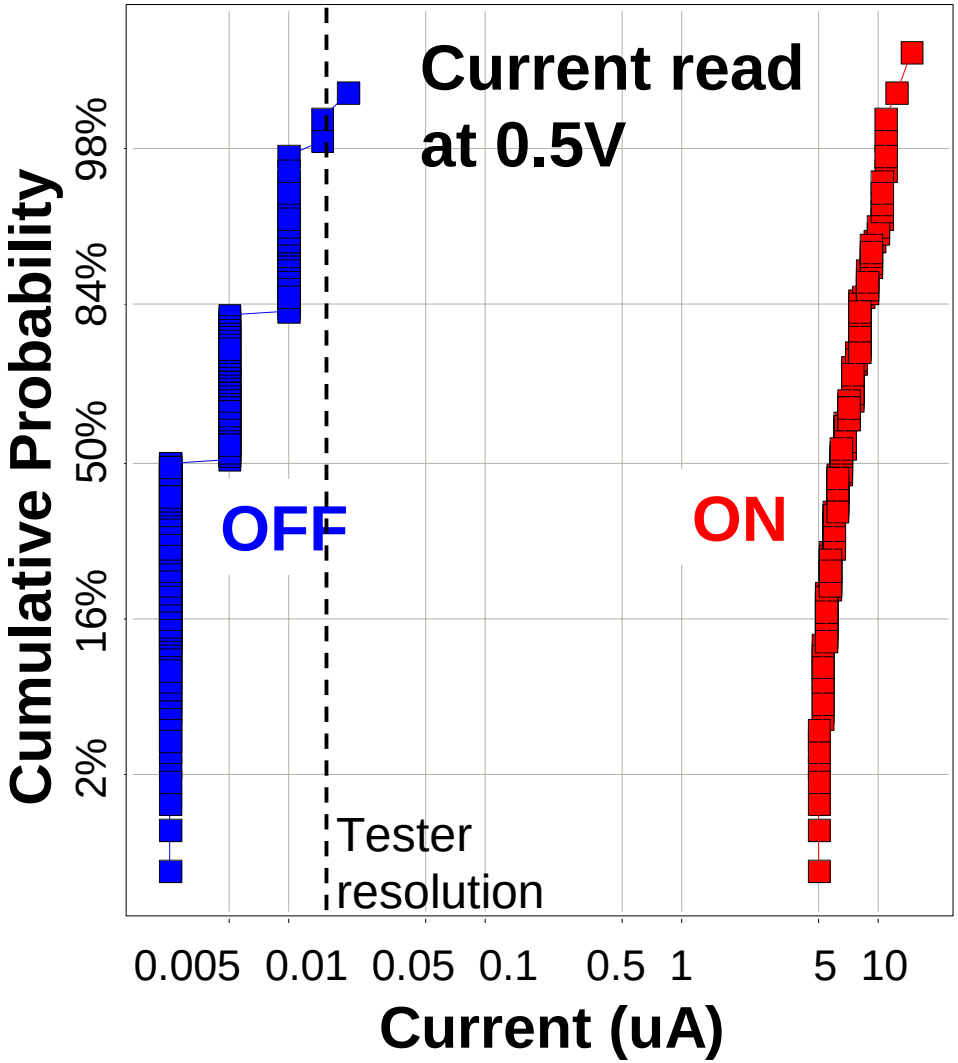




ON/OFF Window

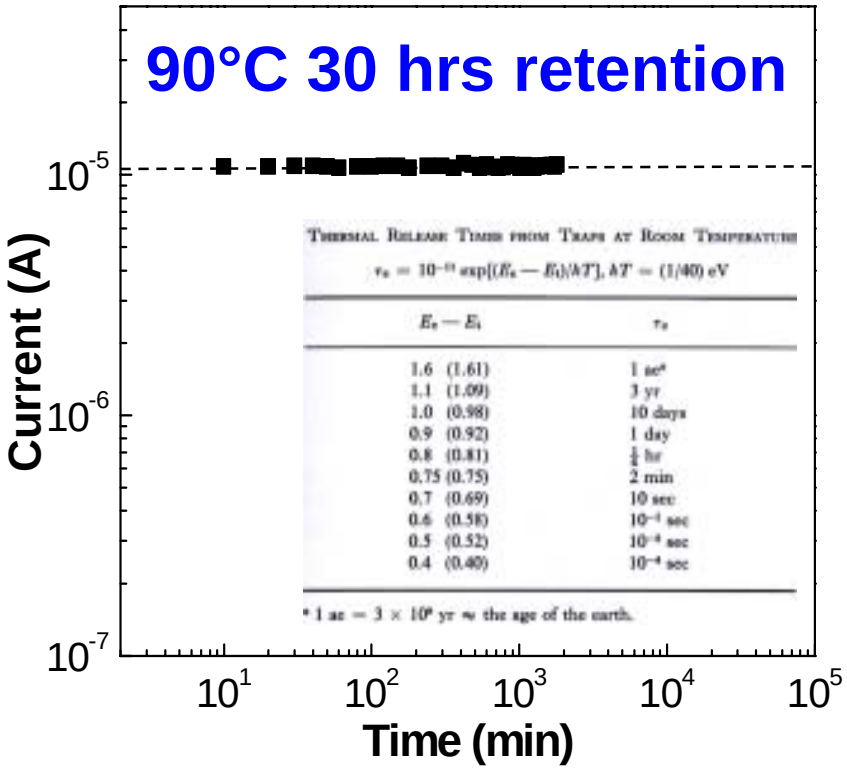
- Model predicts high ON/OFF ratio with deep-trap materials
- ON/OFF ratio of 10^5 – 10^6 observed

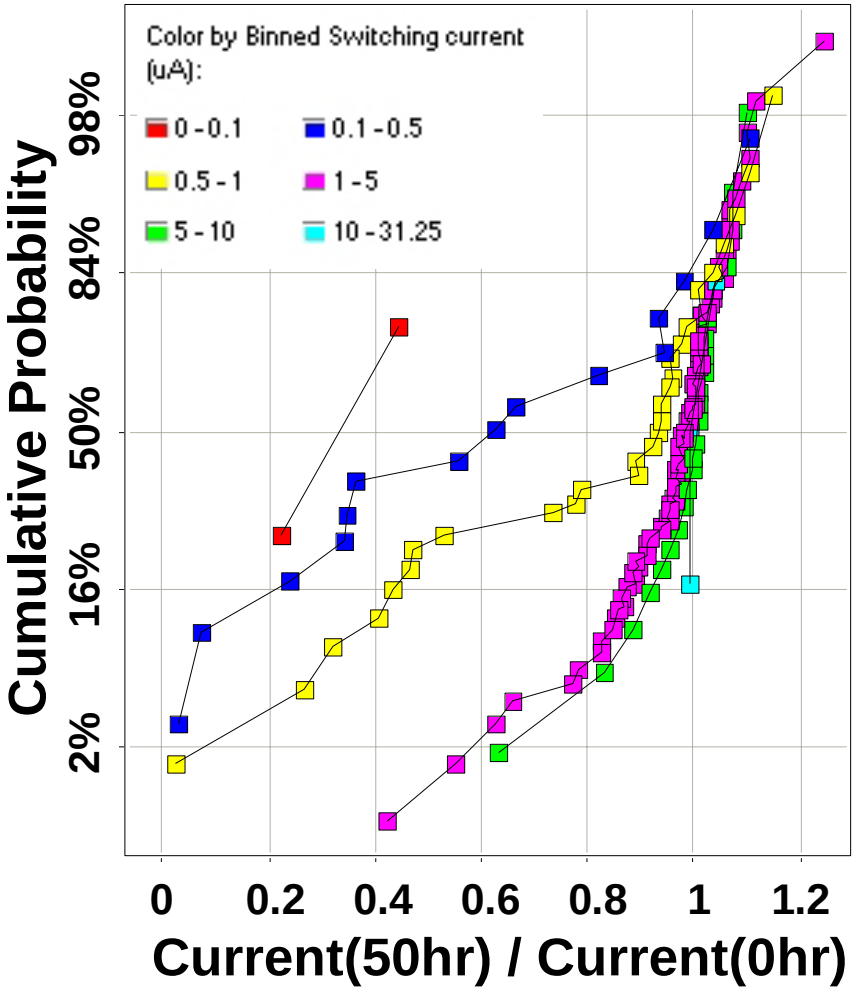




Retention

- Long retention predicted with deep-trap materials
- Retention related to program current

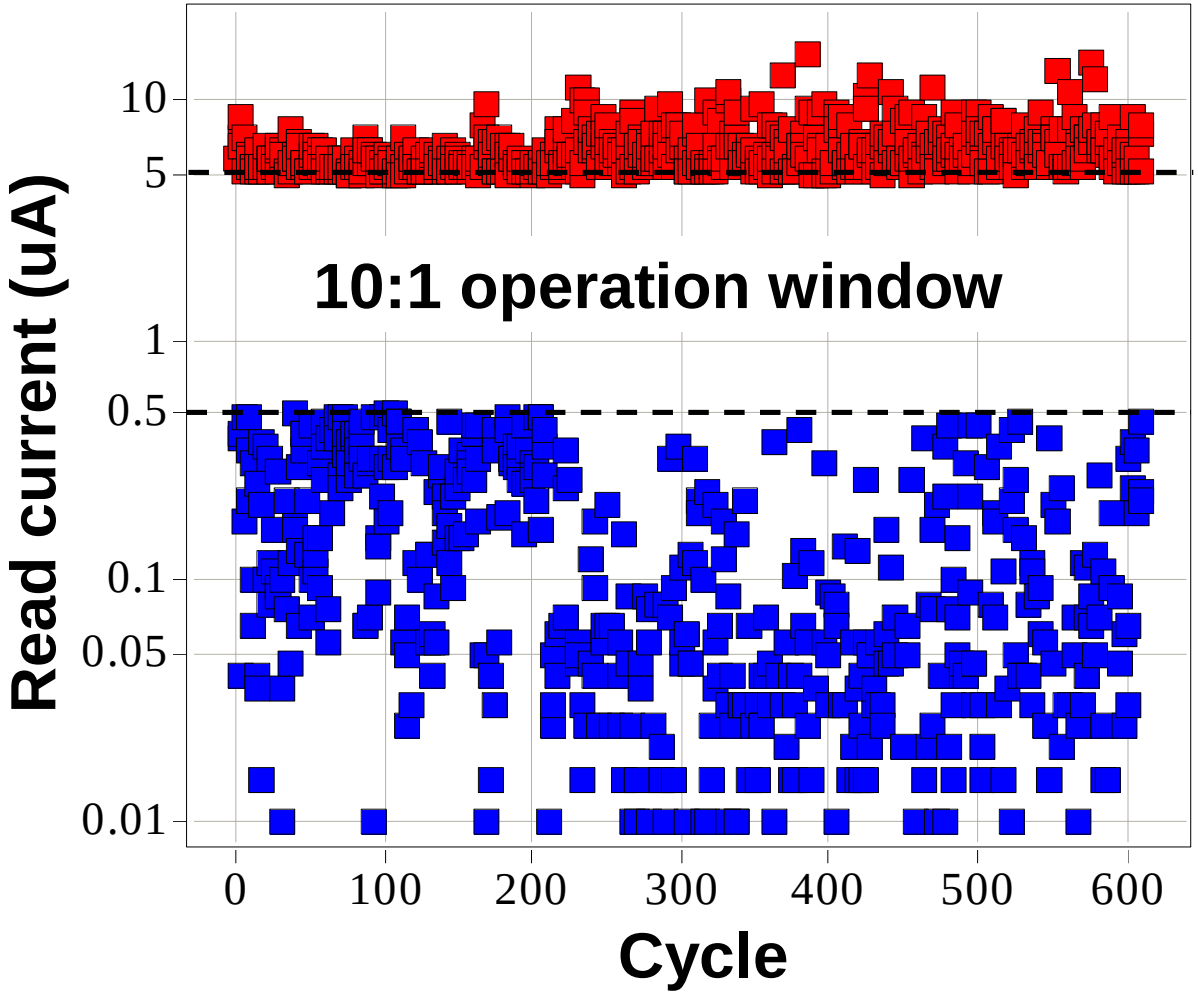




M.A. Lampert et al, “Current injection in solids”, Academic Press, 1970.

Cycling

- Program with 100 ns pulses
- 0.5uA – 5uA window for cycling



Electrical Characteristics Summary

Characteristics		Values
Programming	V/I	(2-5 V) / (~ 50 uA)
	Speed	≤ 100 ns
Erasing	V	1-2 V
	Speed	≤ 100 ns
Retention		30 hours at 90°C tested
Cycling		> 600 cycles tested
Read disturb		Zero up to 25 hours at V < 0.5V
Cell size		0.18 um

A. Chen *et. Al*, *IEDM* 2005

SPANSION

BEOL Thin Film Challenges for RCM

- **Thin ~100A metal oxide films**
- **Hard to etch (process) metal films**
  - **Interfaces in metal-oxide-metal cell**
- **Highly planar CMP**
  - **Maintain electric field uniformity across cell**
- **Phase Change RCM**
  - **Ternary materials plus dopant**
  - **Encapsulation**

SPANSION

T-N Fang, S. Kaza, S. Haddad,
A. Chen, Y-C Wu, Z. Lan,
S. Avanzino, D. Liao,
C. Gopalan, S. Choi, S. Mahdavi,
M. Buynoski, Y. Lin, C. Marrian,
C. Bill, M. VanBuskirk,
and M. Taguchi

Erase Mechanism for Copper Oxide Resistive Switching Memory Cells with Nickel Electrode

Advanced Memory Group
Spansion Inc

SPANSION®


SPANSION™

Trademark Attribution

Spansion, the Spansion Logo and combinations thereof are trademarks of Spansion LLC. Other product names used in this presentation are for identification purposes only and may be trademarks of their respective companies.