Micron: le Memorie del Futuro

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Process R&D

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Italy

Micron at a Glance

Micron is one of the world's leading providers of advanced semiconductor memory solutions

Founded: October 1978, Boise, ID

FY2010 Net Sales to Date (FQ1-2010, FQ2-2010, FQ3-2010): $5.9 billion

NASDAQ Symbol: MU

Employees: ~23,000 worldwide

Products: DRAM, Flash memory, SSDs, CMOS image sensors and memory modules in multiple technologies, generations, configurations, and packages.

Markets We Serve: Micron's products are designed to meet the diverse needs of computing, networking, server, consumer, mobile, automotive, and industrial applications.

Patents: 17,230

Process R&D Global Presence


California

Idaho (HQ)

Colorado


New Hampshire


Belgium

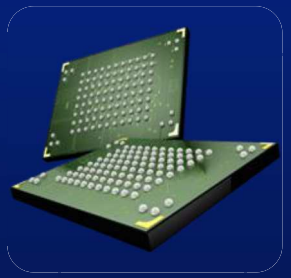

Italy


India


Singapore

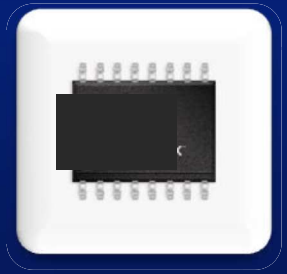

Taiwan

Broadest Product Portfolio



NAND

- Discrete SLC and MLC: 128Mb-64Gb
- Small/Large/Very Large Page+
- Managed: SLC/MLC eMMC (Auto Grade), Compact Flash, ClearNAND
- 1.8V & 3V Solutions
- Comprehensive package portfolio
- Evolution path to Phase Change Memory



NOR

- Complete parallel & serial portfolio (512kB-2Gb+)
- 1.8 & 3V solutions
- Comprehensive package portfolio
- Automotive Grade Solutions
- Evolution path to Phase Change Memory

DRAM

- Full portfolio from legacy to leading-edge
- SDR, DDR 1/2/3, densities up to 4GB
- DDR3 offerings down to 1.35V and up to DDR3-1600
- Automotive Grade Solutions

Digital Media Group Products

Cards for Photography

Good Cards

Better Cards

Best Cards

Mobile Cards

Mobile Cards

Gaming Cards

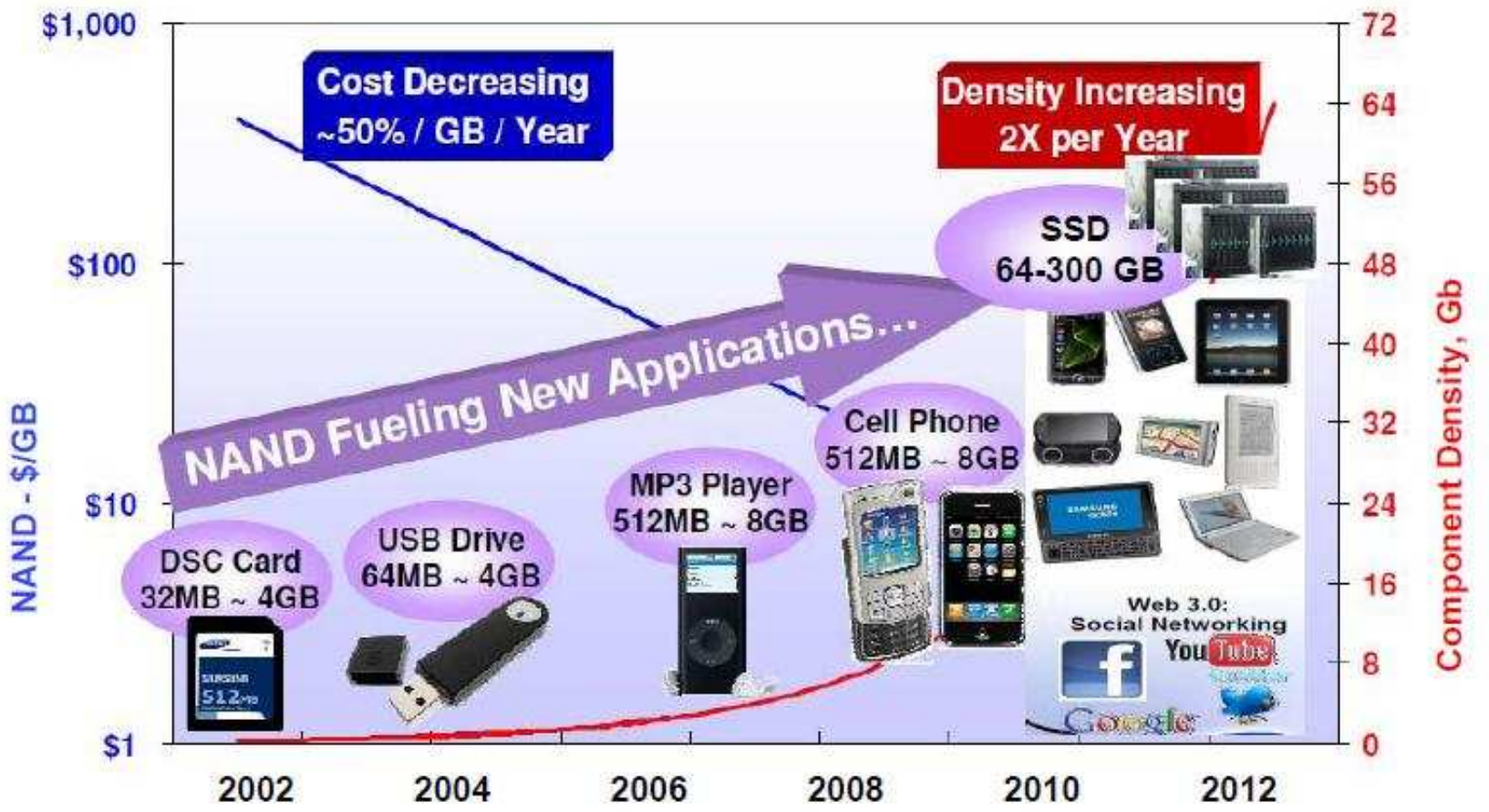
Gaming Cards

Solid State Drives

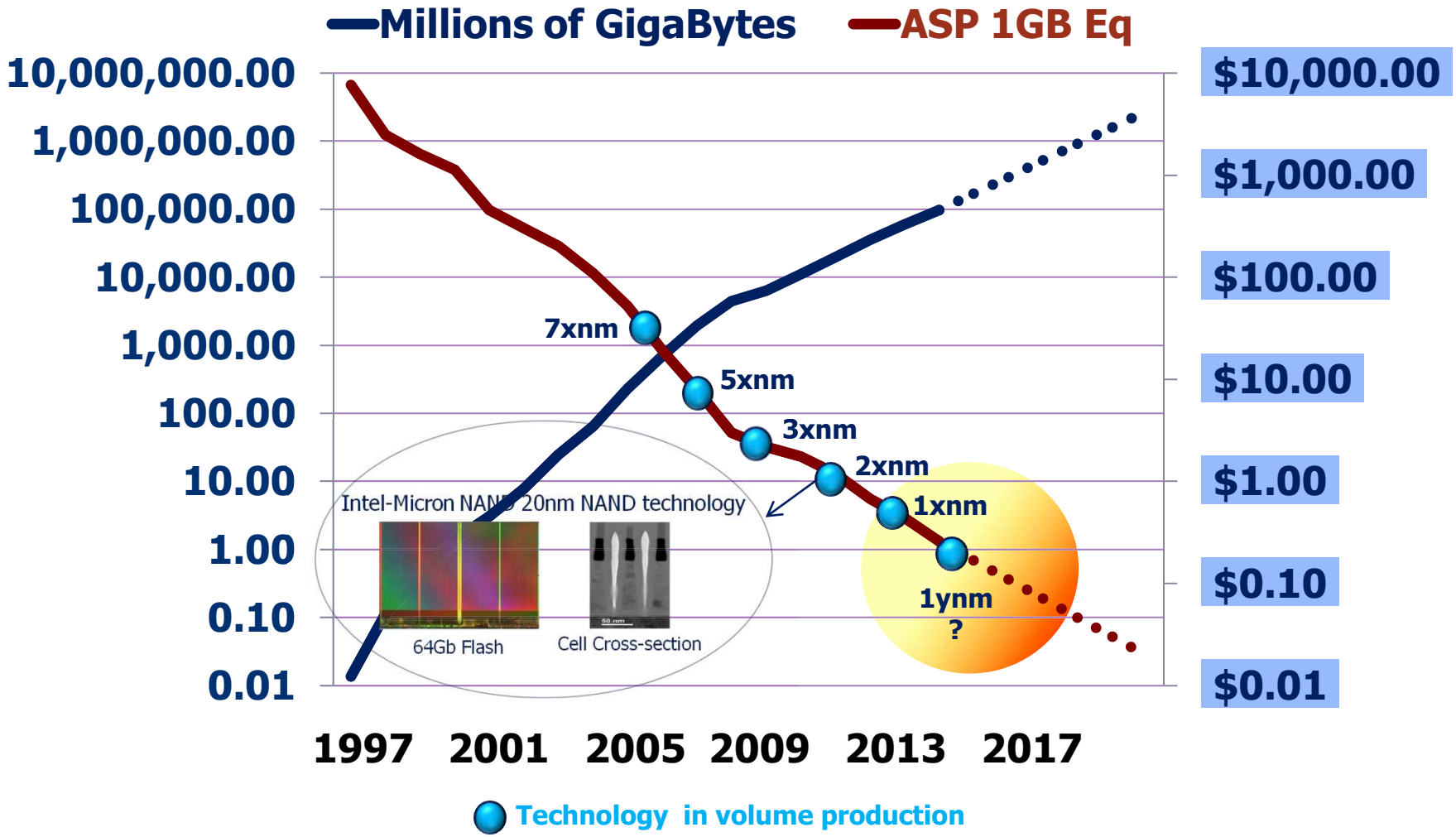
USB Flash Drives

DRAM Modules

Semiconductor Memory in Everyday Life

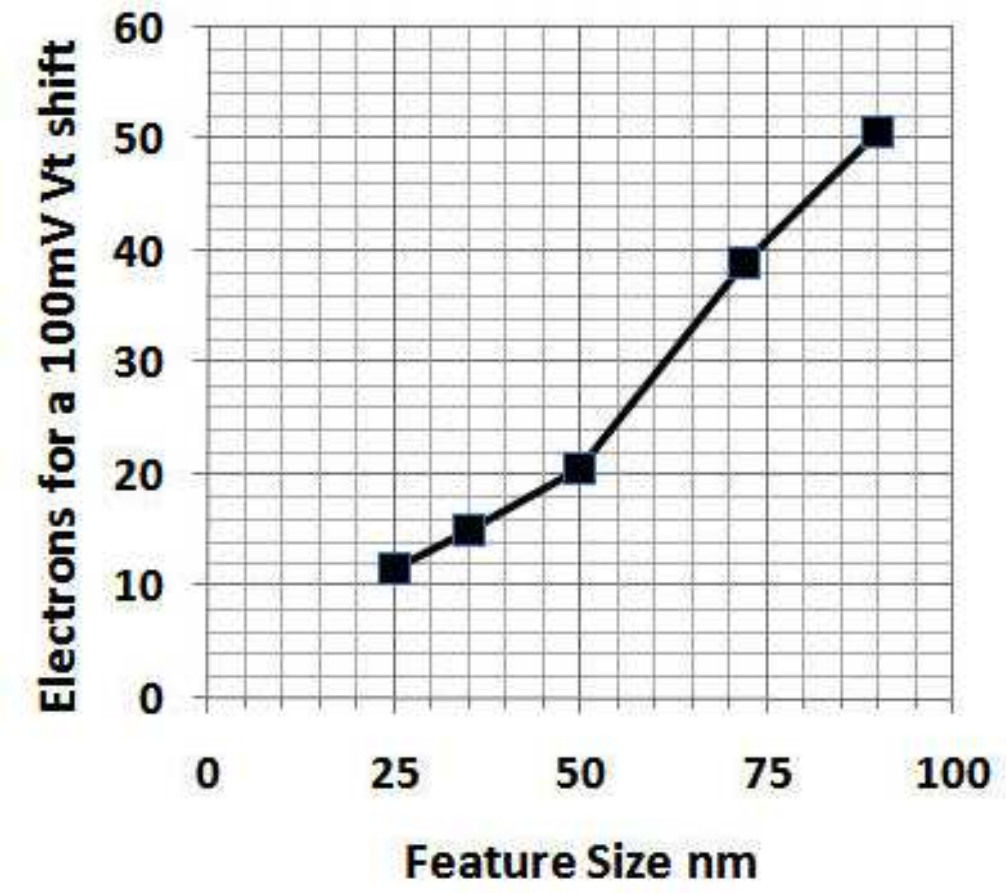


Memory Technology Nodes Over Time



Source: Gartner

NAND Scaling Running Out of Electrons



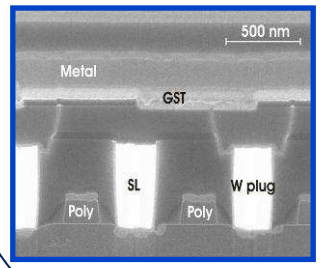
NAND Replacement Strategy!

- Just need to figure out when NAND hits the wall and be standing on tracks with a better technology
- Technology needs to be competitive in most metrics
- Scale vertically to continue cost reduction

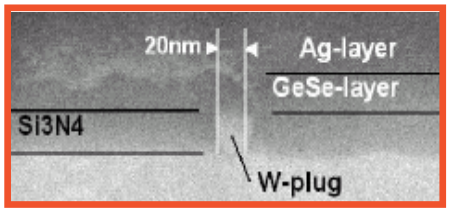
Emerging Memories
Near-term And Long-term Alternatives

FERAM

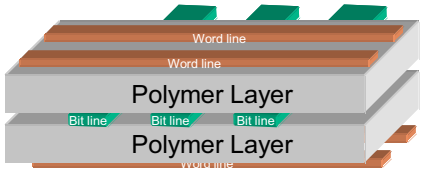
PCM



PMC RRAM

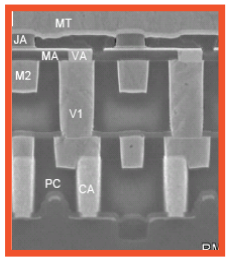


Polymer FeRAM

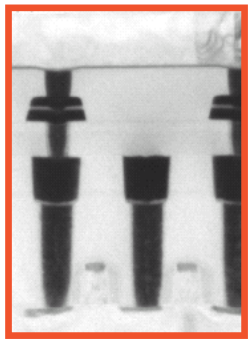


CNT

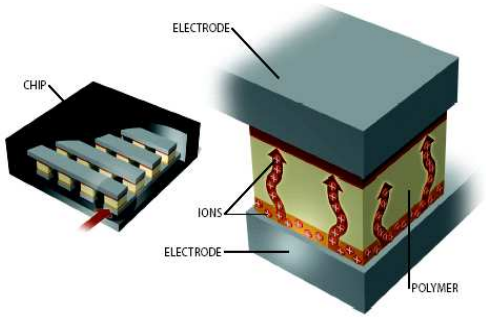
MRAM



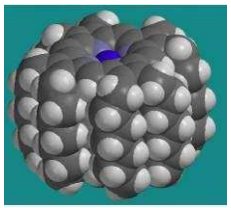
MOx-RRAM



Polymer RRAM

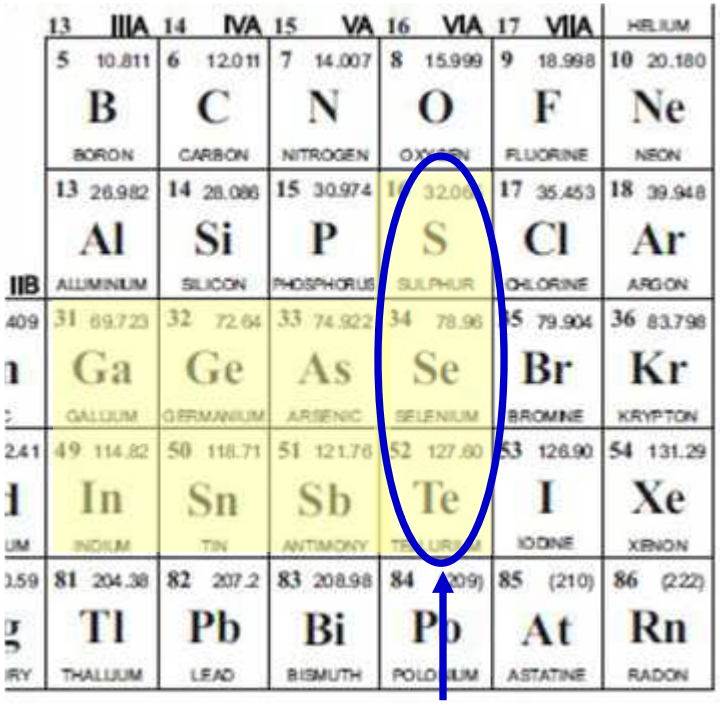


Molecular



Phase Change Memory (PCM)

Chalcogenide Materials

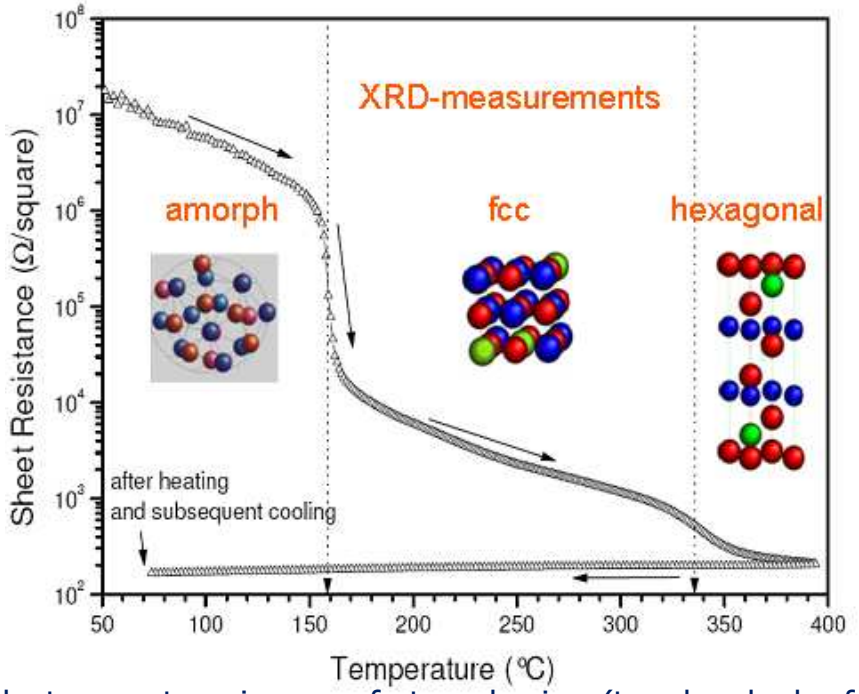


Chalcogenic Elements

- Chalcogenide materials are alloys with an element of the VI group of the periodic table, usually combined with IV and V group elements (As_2S_3, As_2Te_3, $SnSb_2Te_4$, GeTe, Sb_2Te_3, $Ge_2Sb_2Te_5$…)

Phase Transition

- Certain alloys containing one/more group VI elements (chalcogenide) exhibit reversible transition between the disordered (amorphous) and ordered (crystalline) atomic structure



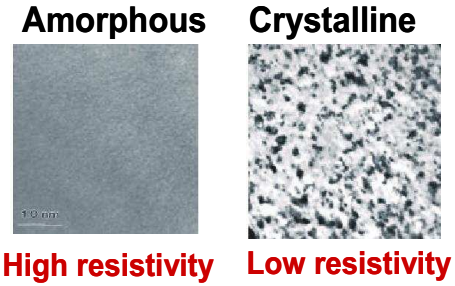
$Ge_2Sb_2Te_5$

- Phase transition, induced by temperature, is a very fast mechanism (tens-hundreds of ns)

Phase Change Memory Concept

Storing mechanism

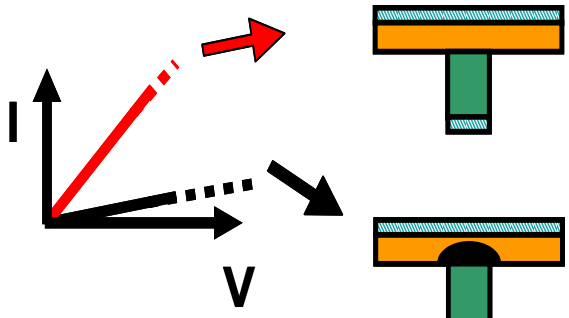
amorphous / poly-crystal phases of a chalcogenide alloy, usually $Ge_2Sb_2Te_5$ (GST)



Reading mechanism

resistance change of the GST

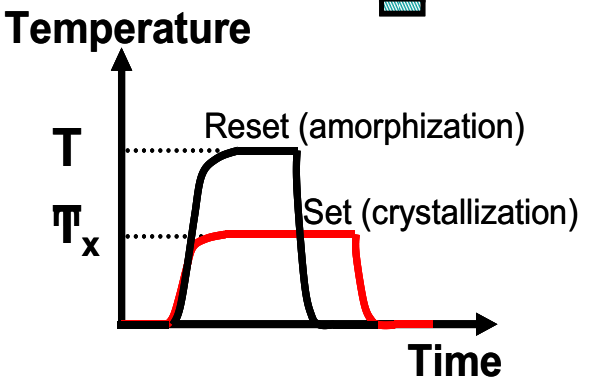
amorphous → high resistance (~ 10Ω*cm) → reset state
crystalline → low resistance (~ 10mΩ*cm) → set state



Writing mechanism

self-heating due to current flow (Joule effect)

melting temperature (T_m ~ 630C, for t_{RESET} ~ 10-100ns)
crystallization temperature (T_x ~ 400C, for t_{SET} ~ 100-1000ns)



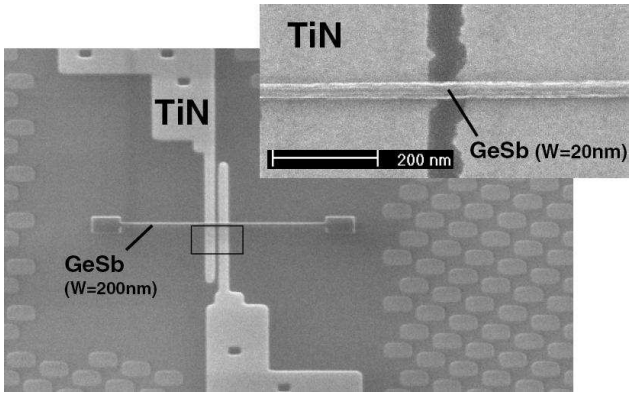
Phase Change Memory Key Attributes

- Non Volatility
- Flexibility
  - No Erase, Bit alterable, Continuous Writing
- Lower power consumption than RAM
- Fast Writes
- Read bandwidth and writing throughput
- eXecution in Place
- Extended endurance

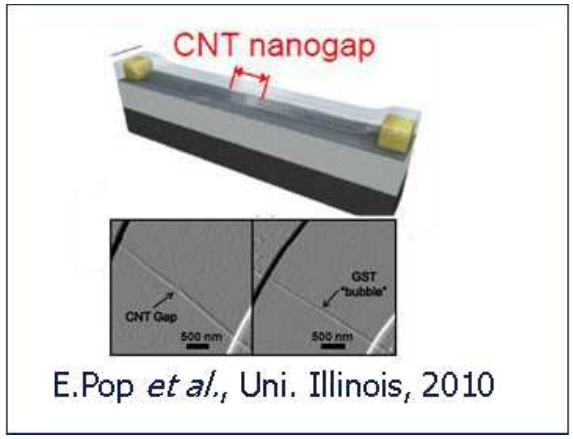
Attributes	PCM	EEPROM	NOR	NAND	DRAM
Non-Volatile	Yes	Yes	Yes	Yes	No
Scaling	sub-2x nm	n.a.	3x nm	2x nm	3x nm
Granularity	Small/Byte	Small/Byte	Large	Large	Small/Byte
Erase	No	No	Yes	Yes	No
Software	Easy	Easy	Moderate	Hard	Easy
Power	~Flash	~Flash	~Flash	~Flash	High
Write Bandwidth	1- 15+ MB/s	13-30 KB/s	0.5-2 MB/s	10+ MB/s	100+ MB/s
Read Latency	50 - 100 ns	200-200 ns	70-100 ns	15 - 50 us	20 - 80 ns
Endurance	10^{6+}	10^{5} -10^{6}	10^{5}	10^{4-5}	Unlimited

Le PCM forniscono un nuovo set di caratteristiche che combinano componenti di NVM con DRAM

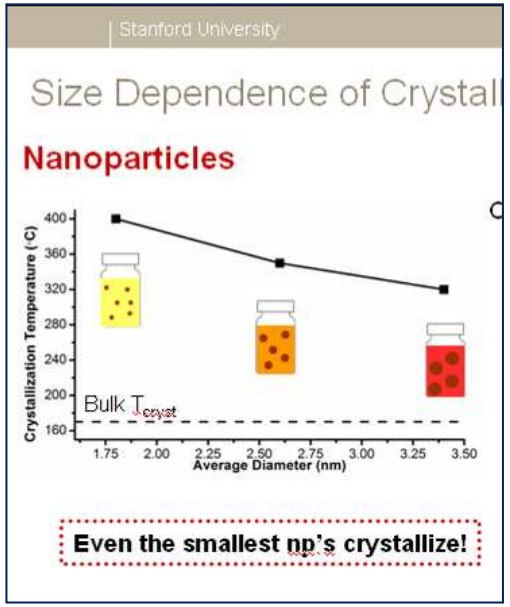
Ultimate Scalability of PCM



Y. C. Chen et al., IEDM 2006

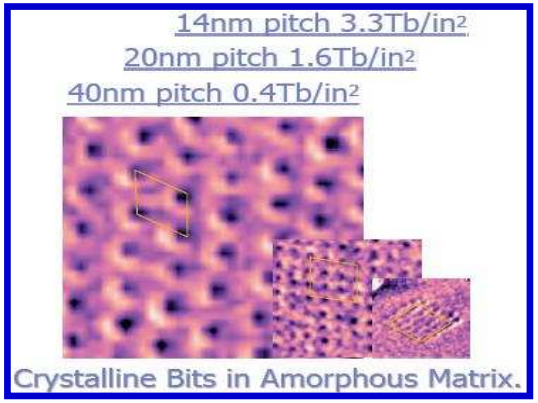


E.Pop *et al.*, Uni. Illinois, 2010



P.Wong, EPCOS 2010

- Device functionality demonstrated on 60 nm^2 active area
- Reset current <10uA
- Phase change mechanism appears scalable to at least ~5nm



C. Lam, SRC NVM Forum 2004

Micron Technology in Italia

Micron Italy Outline

Production:	**Imagers - NOR - PCM**
Process R&D:	**Imagers - NOR - PCM**
Design R&D:	**NAND - NOR - PCM – e.MMC**
Business Units:	**WSG - ESG**
Marketing & Sales:	**DRAM - NAND - NOR - PCM**

Agrate R&D - R2 Technology Development Center

- Facility 200mm wafers
- Clean rooms : ≈ 6000 m²

- People Professionality
  - Researchers
  - Engineers/Technicians
  - Manufacturing Operators
- Research Labs & Activites
  - Electrical labs. and Physical/chemical lab.
  - Material and Device Research lab. of National Research Council
  - Strong links with Universities and key European Research Centers

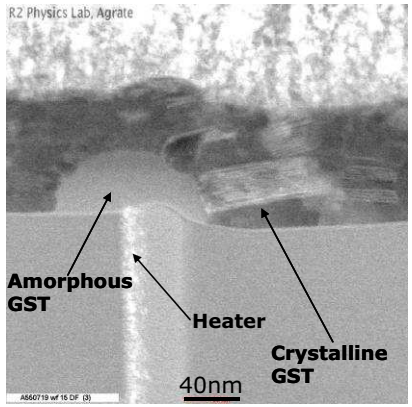
State of the Art 200 mm Equipment

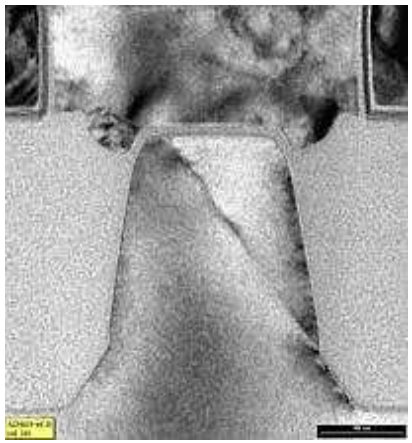
Advanced equipment for production and development of NVM processes.

- 193nm
  High Numerical Aperture Litho
- Immersion Lithography
- Cu Back-end for high aspect ratio structure
- State of the art Plasma Etching Systems
- High-K Dielectric Atomic Layer Deposition
- Multisputter PVD for Chalcogenides deposition (Phase Change Memory)

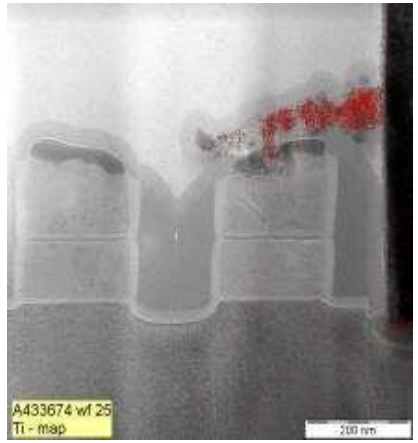
Cooperation with Equipment Vendors, national and international labs, to study and integrate new materials

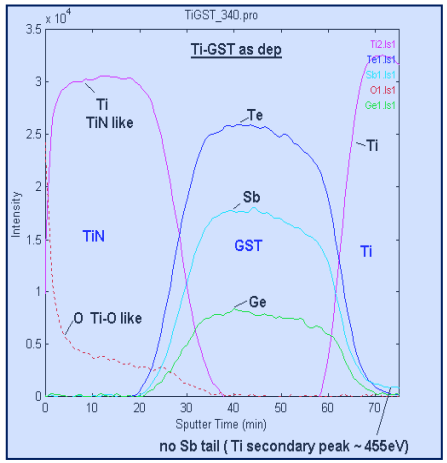
R2 Physics Laboratory





- **Microscopy Service for R2**
  - Technology development
- **Defects & Contamination in Si**
  - Defect reduction in process
  - Si contamination control
- **Physical Failure Analysis**
  - Yield enhancement
- **Materials Analysis**
  - New materials characterization
  - Process problem solving





SEM, FIB, TEM for electron microscopy
Auger, XPS, TOF-SIMS, XRD for materials analysis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