From Silicon to Solutions: Getting the Right Memory Mix for the Application

Ed Doller
Numonyx CTO

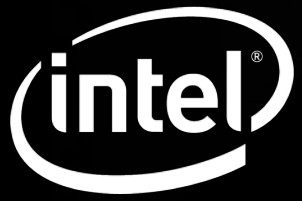
Flash Memory Summit 2008

Legal Notices and Important Information Regarding this Presentation

- Numonyx may make changes to specifications and product descriptions at any time, without notice.
- All products, dates, and figures specified are preliminary based on current expectations, and are subject to change without notice.
- Numonyx and the Numonyx logo are trademarks or registered trademarks of Numonyx Corporation or its subsidiaries in the United States and other countries.
- *Other names and brands may be claimed as the property of others.
- Copyright © 2008 Numonyx Corporation.

numonyx™

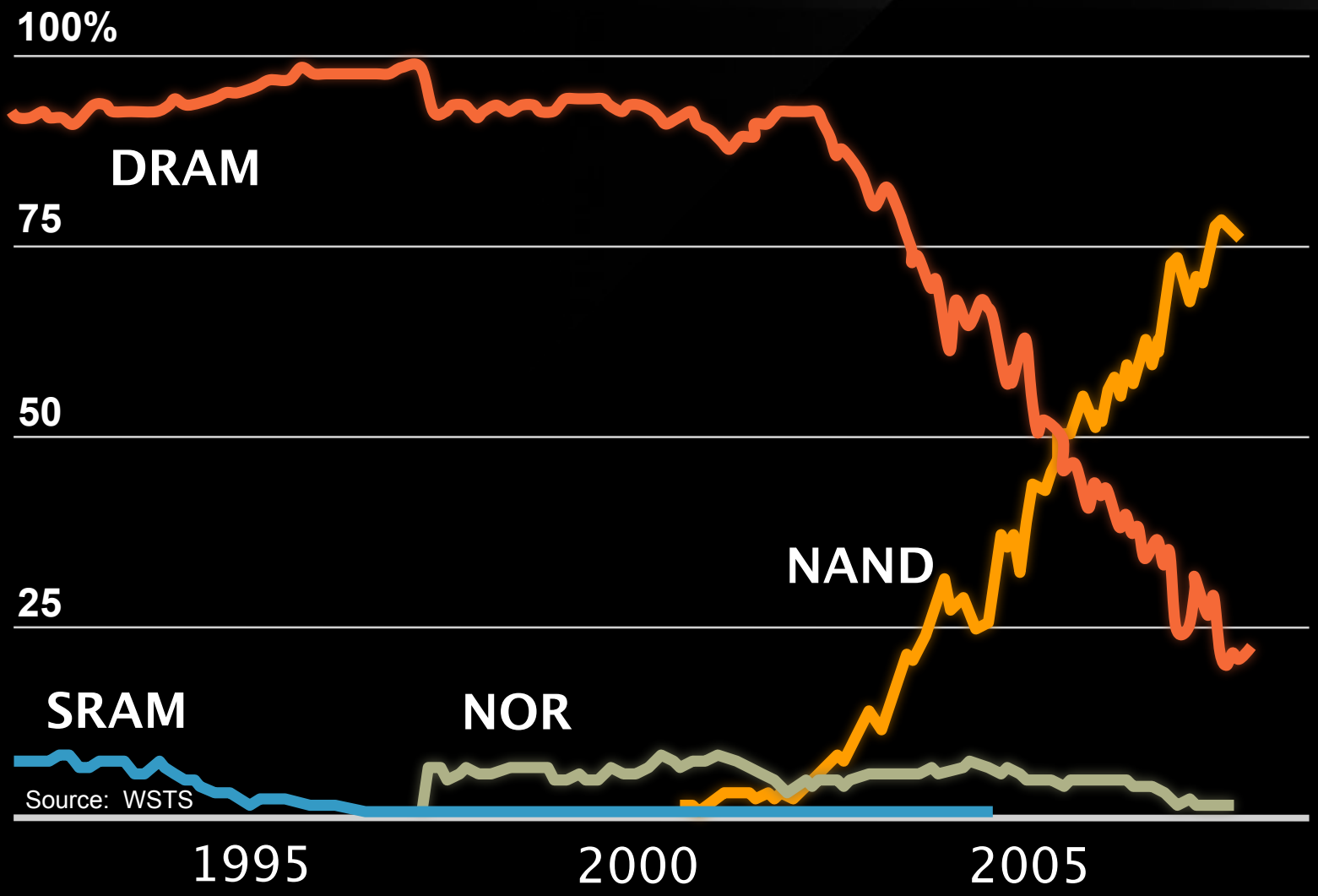
Numonyx Introduction



- A new company created by the contribution of non-volatile memory assets by STMicroelectronics and Intel with cash contributed by Francisco Partners
  - Ownership split ~49% / 45% / 6%
- First day of business March 31st, 2008
- Technology portfolio includes:
  - NAND, NOR, PCM, RAM, Multi-chip solutions, & S/W

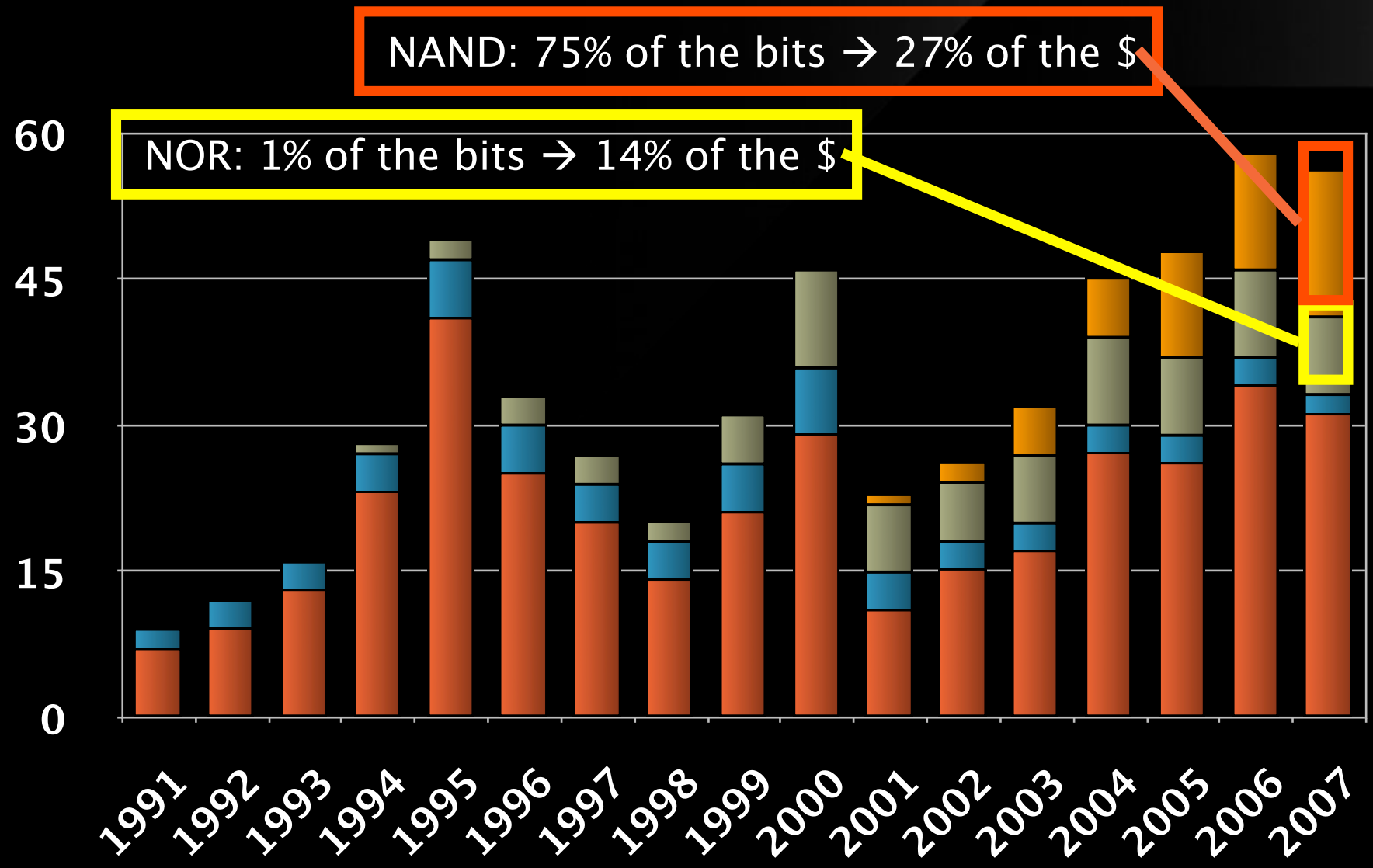
numonyx™

Bits as Percentage of Total



numonyx™

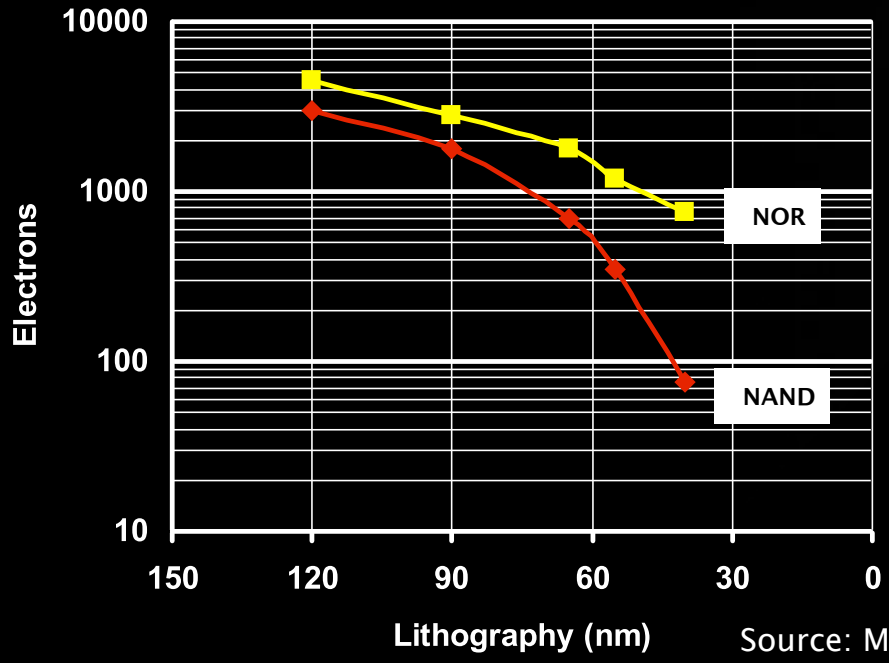
Memory Revenue



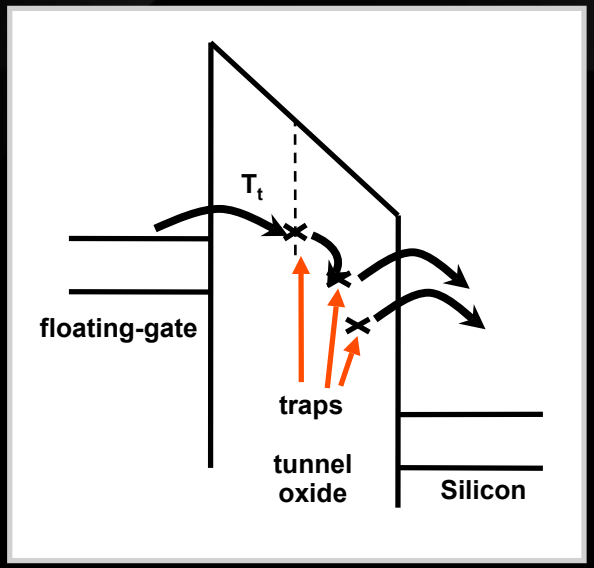
Source: WSTS, 2007 final

numonyx™

Scaling & Reliability Challenges

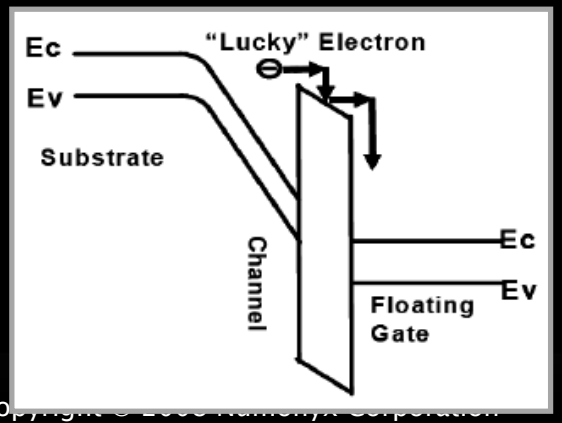


Source: My data



NOR Reliability: Write / Erase Tox traps leading to TAT or de-trapping of trapped oxide electrons

NAND Scaling & Reliability: Electrons



NOR (ETOX & NROM) Scaling: 3.2ev required to surmount Si-SiO2 barrier → Limits Cell Gate Length Scaling

numonyx™

New Technologies

FRAM technology puts the "intelligence" in airbag systems

by *by Duncan Bennett, Strategic Marketing Manager, Ramtron International Corp.*
ECN Asia

Safety systems for automobiles are expected to become more sophisticated over the next several years. A principal driver of this trend is expected regulation which will impact
system
on the
what t

Tuesday, Feb. 26 2008

Freescale MRAM Rockets into Space

BusinessWire
Comtex

NUREMBERG, Germany, Feb 26, 2008 (BUSINESS WIRE) -- Freescale Semiconductor, the leading
provide
memory
automo
tempera
board a

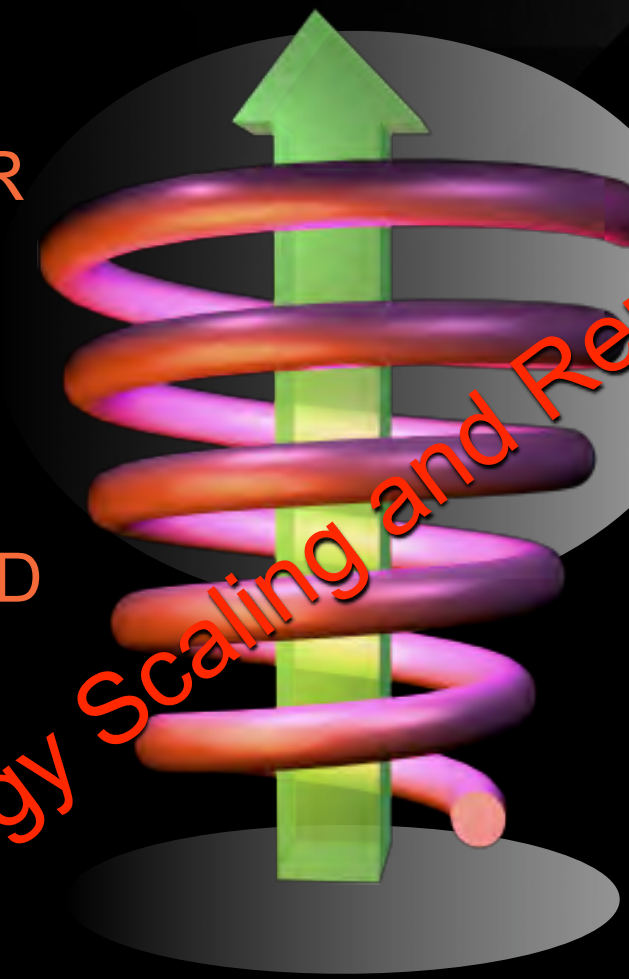
Phase change memory prototypes released

5 March 2008

Intel and *STMicroelectronics* reached a key industry milestone recently as they began shipping prototype samples of a future product using a new, innovative memory technology called phase change memory (PCM). The prototypes are the first functional silicon to be delivered to customers for evaluation, bringing the technology one step closer to adoption.

numonyx™

Chaos



NAND v. NOR

MLC or SLC

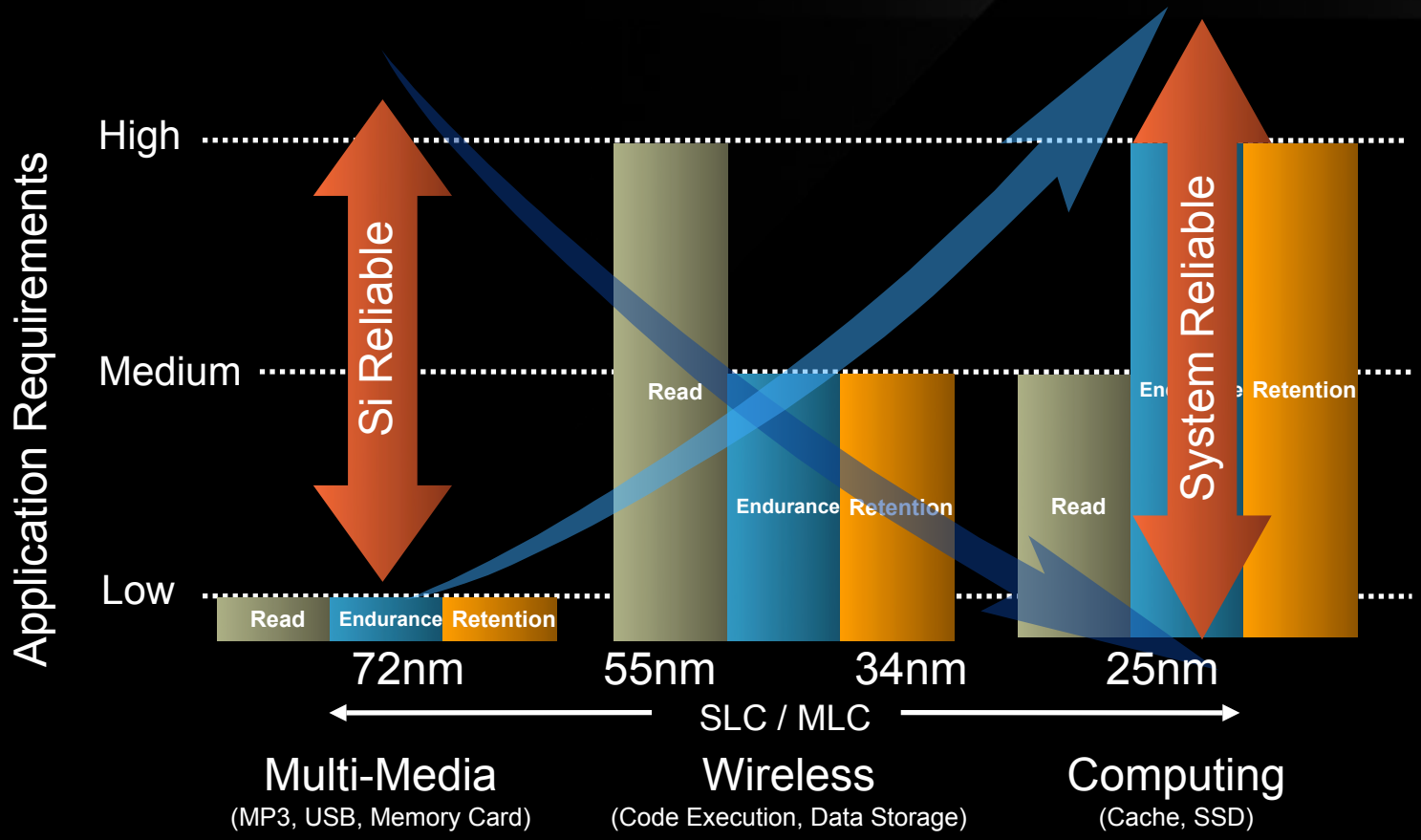
XiP or SnD

Managed?

Technology Scaling and Replacements

numonyx™

Technology & Application



Application specific system solutions required as technology scales → Higher Cost

numonyx™

Technology Capability Assessment

Attributes	PCM	EEPROM	NOR	NAND	DRAM

numonyx™

Technology Capability Assessment

Attributes	PCM	EEPROM	NOR	NAND	DRAM
Non-Volatile	Yes	Yes	Yes	Yes	No

numonyx™

Technology Capability Assessment

Attributes	PCM	EEPROM	NOR	NAND	DRAM
Non-Volatile	Yes	Yes	Yes	Yes	No
Clear Scaling to	15 nm	?	32 nm	32 nm	32 nm

numonyx™

Technology Capability Assessment

Attributes	PCM	EEPROM	NOR	NAND	DRAM
Non-Volatile	Yes	Yes	Yes	Yes	No
Clear Scaling to	15 nm	?	32 nm	32 nm	32 nm
Blk Granularity	Small/Byte	Small/ Byte	Large	Large	Small/Byte

numonyx™

Technology Capability Assessment

Attributes	PCM	EEPROM	NOR	NAND	DRAM
Non-Volatile	Yes	Yes	Yes	Yes	No
Clear Scaling to	15 nm	?	32 nm	32 nm	32 nm
Blk Granularity	Small/Byte	Small/ Byte	Large	Large	Small/Byte
Byte/Bit Write	Yes	Yes	Yes	# of Ops	Yes

numonyx™

Technology Capability Assessment

Attributes	PCM	EEPROM	NOR	NAND	DRAM
Non-Volatile	Yes	Yes	Yes	Yes	No
Clear Scaling to	15 nm	?	32 nm	32 nm	32 nm
Blk Granularity	Small/Byte	Small/ Byte	Large	Large	Small/Byte
Byte/Bit Write	Yes	Yes	Yes	# of Ops	Yes
Erase Required	No	No	Yes	Yes	No

numonyx™

Technology Capability Assessment

Attributes	PCM	EEPROM	NOR	NAND	DRAM
Non-Volatile	Yes	Yes	Yes	Yes	No
Clear Scaling to	15 nm	?	32 nm	32 nm	32 nm
Blk Granularity	Small/Byte	Small/ Byte	Large	Large	Small/Byte
Byte/Bit Write	Yes	Yes	Yes	# of Ops	Yes
Erase Required	No	No	Yes	Yes	No
Software	Easy	Easy	Moderate	Hard	Easy

numonyx™

Technology Capability Assessment

Attributes	PCM	EEPROM	NOR	NAND	DRAM
Non-Volatile	Yes	Yes	Yes	Yes	No
Clear Scaling to	15 nm	?	32 nm	32 nm	32 nm
Blk Granularity	Small/Byte	Small/ Byte	Large	Large	Small/Byte
Byte/Bit Write	Yes	Yes	Yes	# of Ops	Yes
Erase Required	No	No	Yes	Yes	No
Software	Easy	Easy	Moderate	Hard	Easy
Power	~Flash	~Flash	~Flash	~Flash	High

numonyx™

Technology Capability Assessment

Attributes	PCM	EEPROM	NOR	NAND	DRAM
Non-Volatile	Yes	Yes	Yes	Yes	No
Clear Scaling to	15 nm	?	32 nm	32 nm	32 nm
Blk Granularity	Small/Byte	Small/ Byte	Large	Large	Small/Byte
Byte/Bit Write	Yes	Yes	Yes	# of Ops	Yes
Erase Required	No	No	Yes	Yes	No
Software	Easy	Easy	Moderate	Hard	Easy
Power	~Flash	~Flash	~Flash	~Flash	High
Write Bandwidth	1- 15+MB/s	13-30KB/s	0.5-2 MB/s	10+ MB/s	100s+MB/s

numonyx™

Technology Capability Assessment

Attributes	PCM	EEPROM	NOR	NAND	DRAM
Non-Volatile	Yes	Yes	Yes	Yes	No
Clear Scaling to	15 nm	?	32 nm	32 nm	32 nm
Blk Granularity	Small/Byte	Small/ Byte	Large	Large	Small/Byte
Byte/Bit Write	Yes	Yes	Yes	# of Ops	Yes
Erase Required	No	No	Yes	Yes	No
Software	Easy	Easy	Moderate	Hard	Easy
Power	~Flash	~Flash	~Flash	~Flash	High
Write Bandwidth	1- 15+MB/s	13-30KB/s	0.5-2 MB/s	10+ MB/s	100s+MB/s
Read Latency	50 - 100 ns	200-200ns	70-100 ns	15-50 µs	20 - 80 ns

numonyx™

Technology Capability Assessment

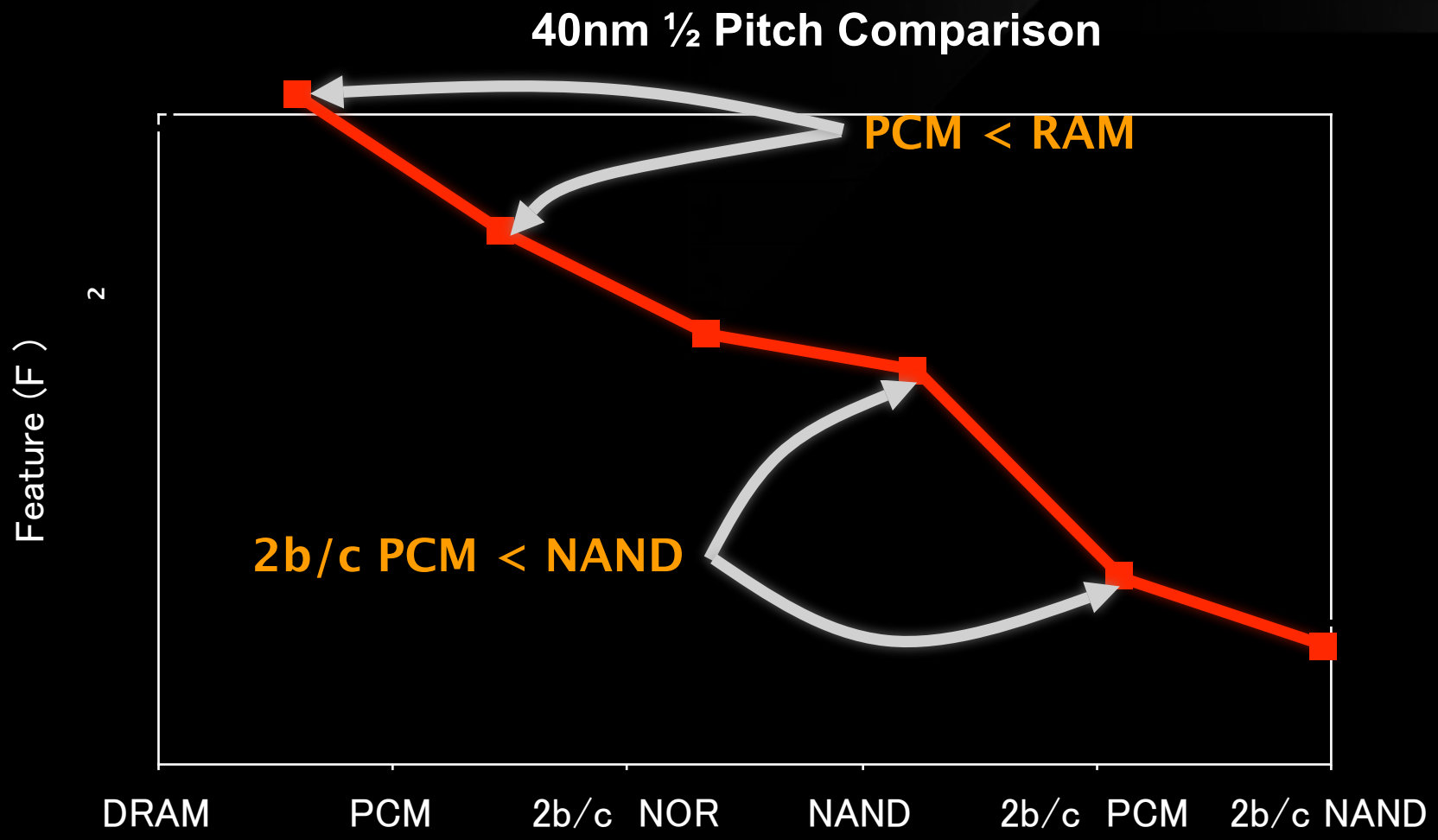
PCM: Lower Theoretical Cost & Power

PCM: Scalability, bit alterable, endurance

PCM: Much Lower Cost & Much Faster Writes

Attributes	PCM	EEPROM	NOR	NAND	DRAM
Non-Volatile	Yes	Yes	Yes	Yes	No
Clear Scaling to	15 nm	?	32 nm	32 nm	32 nm
Blk Granularity	Small/Byte	Small/ Byte	Large	Large	Small/Byte
Byte/Bit Write	Yes	Yes	Yes	# of Ops	Yes
Erase Required	No	No	Yes	Yes	No
Software	Easy	Easy	Moderate	Hard	Easy
Power	~Flash	~Flash	~Flash	~Flash	High
Write Bandwidth	1- 15+MB/s	13-30KB/s	0.5-2 MB/s	10+ MB/s	100s+MB/s
Read Latency	50 - 100 ns	200-200ns	70-100 ns	15-50 µs	20 - 80 ns
Endurance	10^{6+}	10^{5} -10^{6}	105	10^{4-5}	Unlimited

Technology Cost Comparison



numonyx™

Cost comes in many forms…

- The obvious ones
  - Technology, litho, manufactu

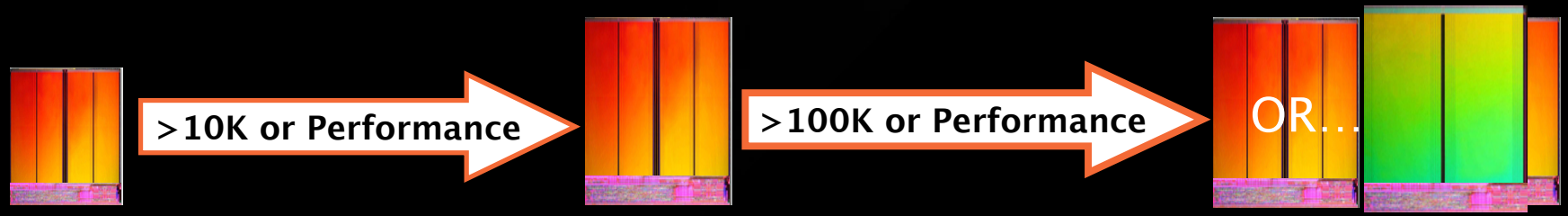
- The not so obvious ones

  - Time-to-market → Ease of use
    - S/W changes
    - Reliability Challenges → Usage Models
    - Manageability → Controller
  - System Level Costs

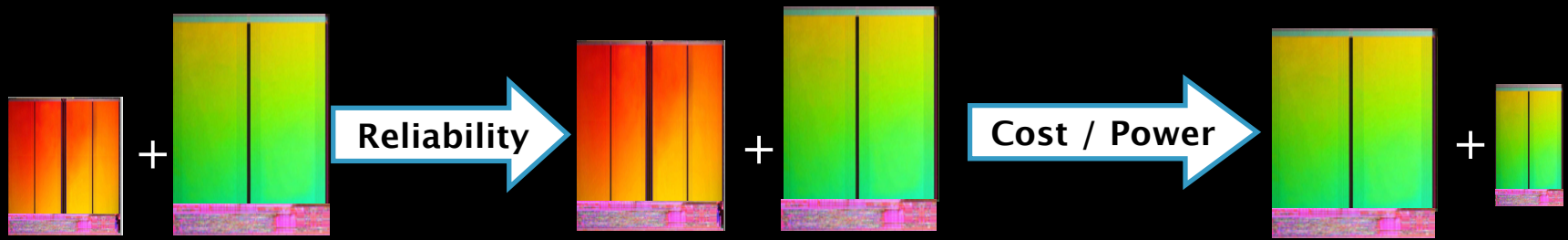
numonyx™

System Level Cost

Example #1: Data Solution – High Performance or High



Example #2: Low Power Code Solution



numonyx™

Summary: What Does This Mean for Us?

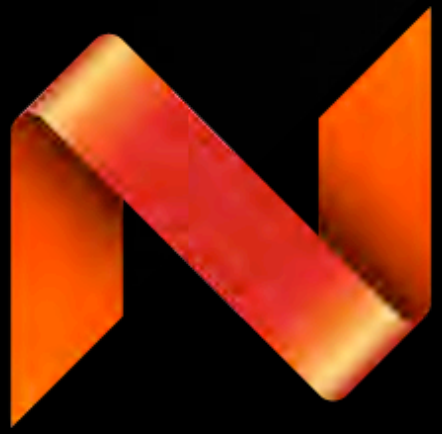
Customers

1. Understand Usage
2. Understand True Cost
3. Work with a Trustworthy Supplier
4. Get your PCM Samples NOW…

Suppliers

1. Provide Technology Transparency
2. S/W & Systems Expertise
3. Si & Solution Standards
4. PCM is the future, lets standardize…

numonyx™



numonyx™