

A Closer Look at NAND Flash

Dean Klein

Vice President of Memory System Development



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NAND World Dominance

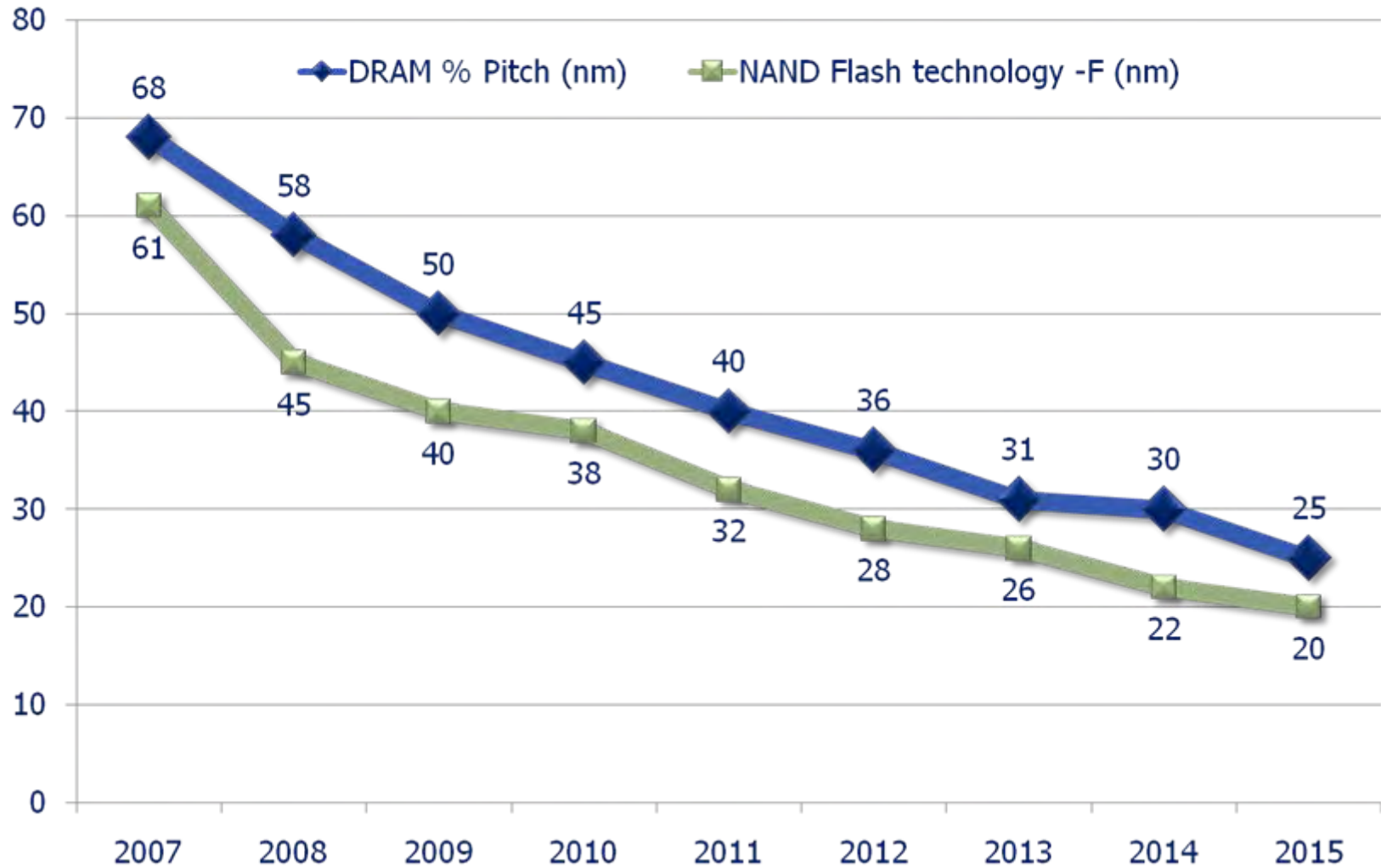


Now, let's be honest.

It's not about write cycles. It's about usage scenarios and choosing the "write" NAND for the application.

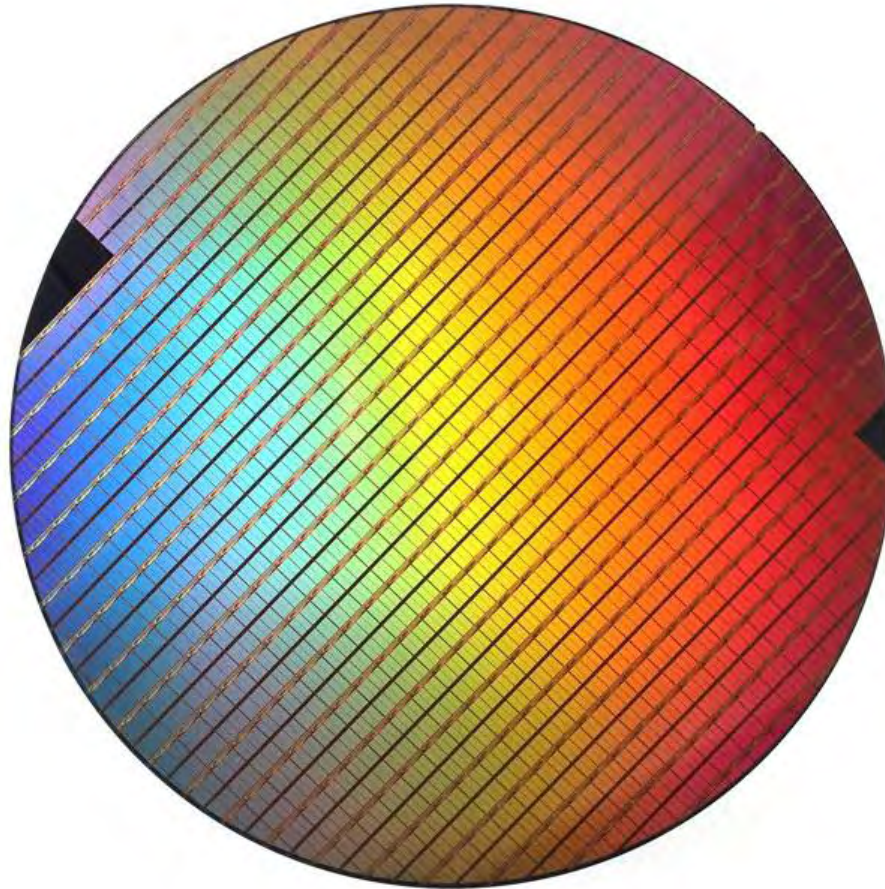


Now, let's be brutally honest.



Source: INTERNATIONAL TECHNOLOGY ROADMAP FOR SEMICONDUCTORS 2007 EDITION PROCESS INTEGRATION, DEVICES, AND STRUCTURES

Micron 34nm, 32Gbit NAND

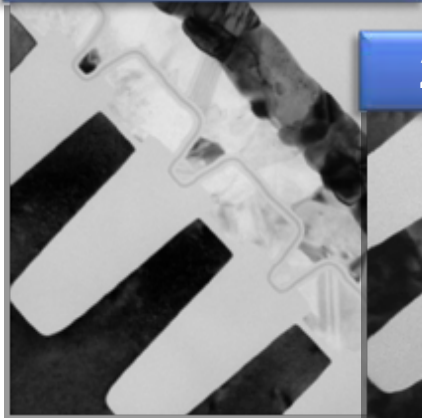


Approximately 1.6 terabytes of NAND per wafer

Rapid Scaling Driving Early Learning

Isolation

2004 90nm



2005 72nm



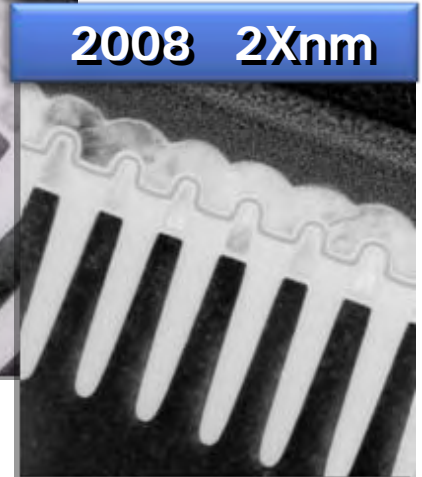
2006 50nm



2007 3Xnm



2008 2Xnm



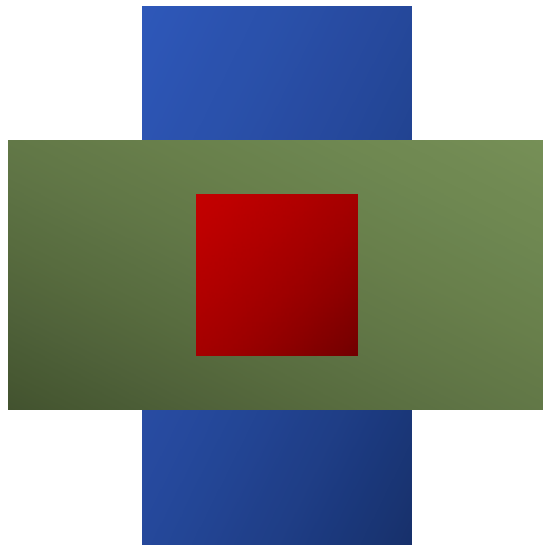
Comparative Memory Cells

Cell Size (μ^2)	Tech Node (nm)	Cell size (F^2)	Endurance
IBM/Infineon MRAM			
0.74	130	44	Excellent
Freescale 6T-SRAM			
0.69	65	163	Excellent
Intel 45nm 6T-SRAM			
0.27	45	135	Excellent
Freescale TFS: Nanocrystalline			
0.13	90	16	Unknown
Freescale eDRAM			
0.12	65	28	Excellent
Samsung 512Mbit PRAM Device			
0.050	95	5.5	Good
Micron 40-series DRAM			
0.037	78	6	Excellent
Micron 60-series NAND			
0.0046	34	4	Good

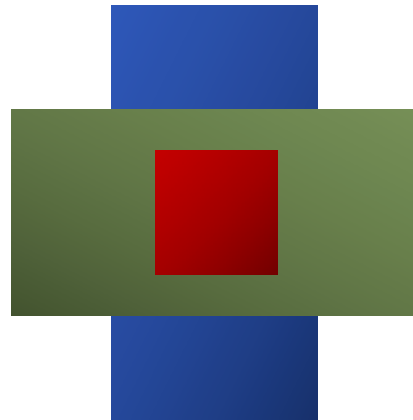
Straight Talk: Bits vs. Shrink

2 bits, 4 bits, 6 bits a dollar? All for NAND, stand up & holler

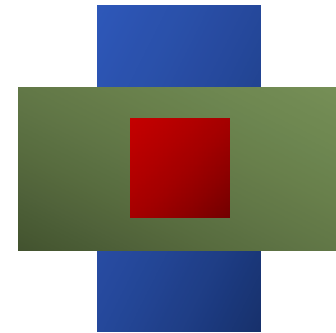
- Scaled Cell Sizes:



56nm
@ 3-bits/cell
=4181nm²/bit

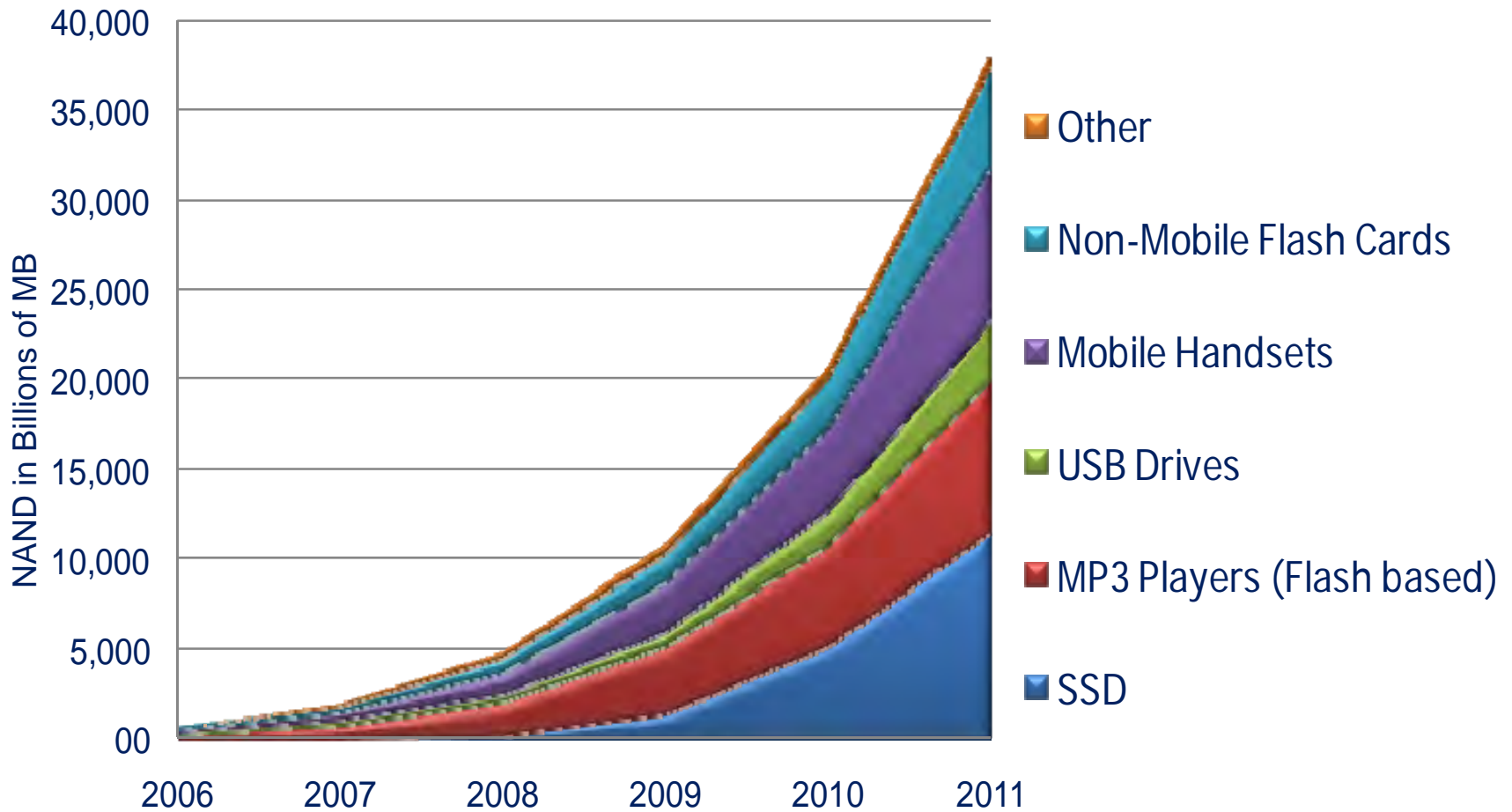


43nm
@ 2-bits/cell
=3698nm²/bit



34nm
@ 2-bits/cell
=2312nm²/bit

NAND Will Adapt to the Market



Source: iSuppli JAN 08

Getting dialed in on the applications

- Interfaces optimizations
- Process optimizations
- Controller optimizations
- Design optimizations

NAND Optimizations: ONFI 2.0 HS-NAND

Feature	Standard NAND	High Speed NAND
“Standard” Asynchronous Interface	Yes	Yes
Synchronous Interface	No	Yes
tRC	≥ 25ns (SDR)	7.5ns (DDR)
tWC	≥ 25ns (SDR)	7.5ns (DDR)
Standardized	ONFI 1.0	ONFI 2.0
Scalable to higher performance	No	Yes
Cache Mode	Some	Yes
VCCq	3.3V	1.7V to 1.95V
VCC	3.3V	2.7V to 3.6V
Parameter Page	Some	Yes
Package	TSOP	BGA

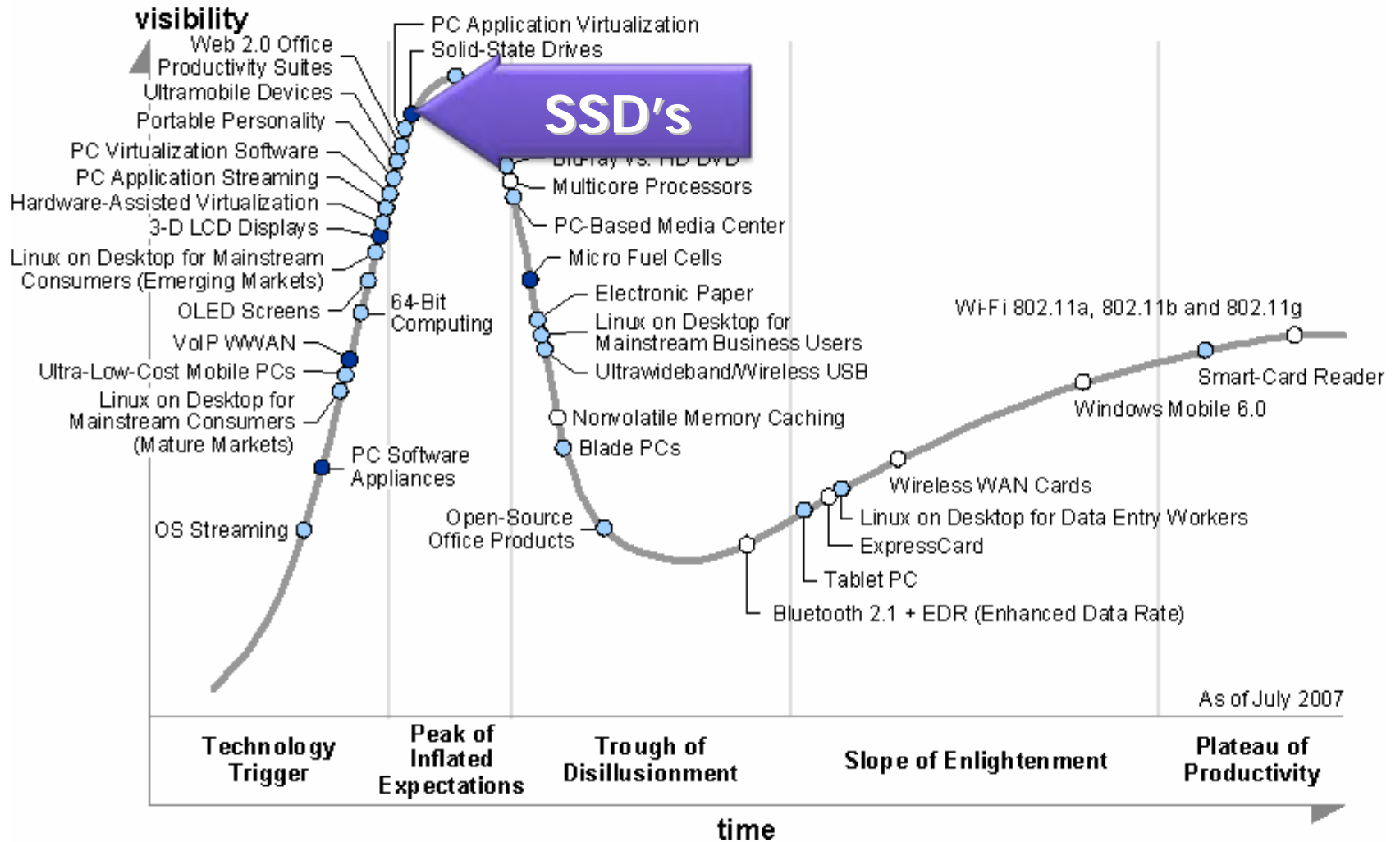
A natural extension to Standard NAND

Interface Optimization: Performance Comparison

	High Speed NAND	Traditional SLC NAND	MLC NAND	MLC NOR
Read Performance	200 MB/sec	40 MB/sec	33 MB/sec	103 MB/sec
Write Performance	100 MB/sec	15 MB/sec	3.5 MB/sec	< 1 MB/sec
Erase Performance	1.5 ms	1.5 ms	2 ms	900 ms

Solid State Drives

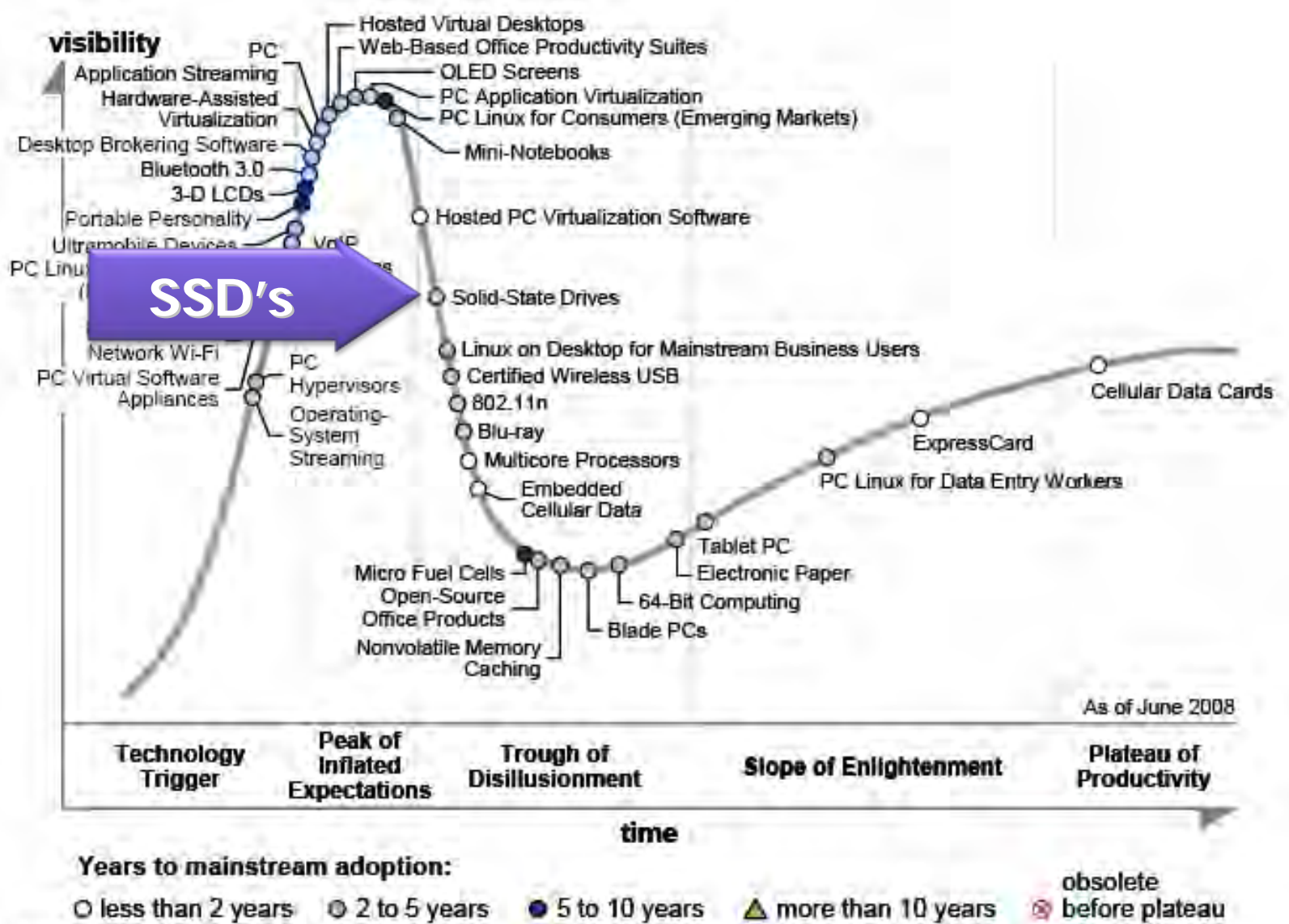
Gartner's Hype Cycle for PC Technologies 2007



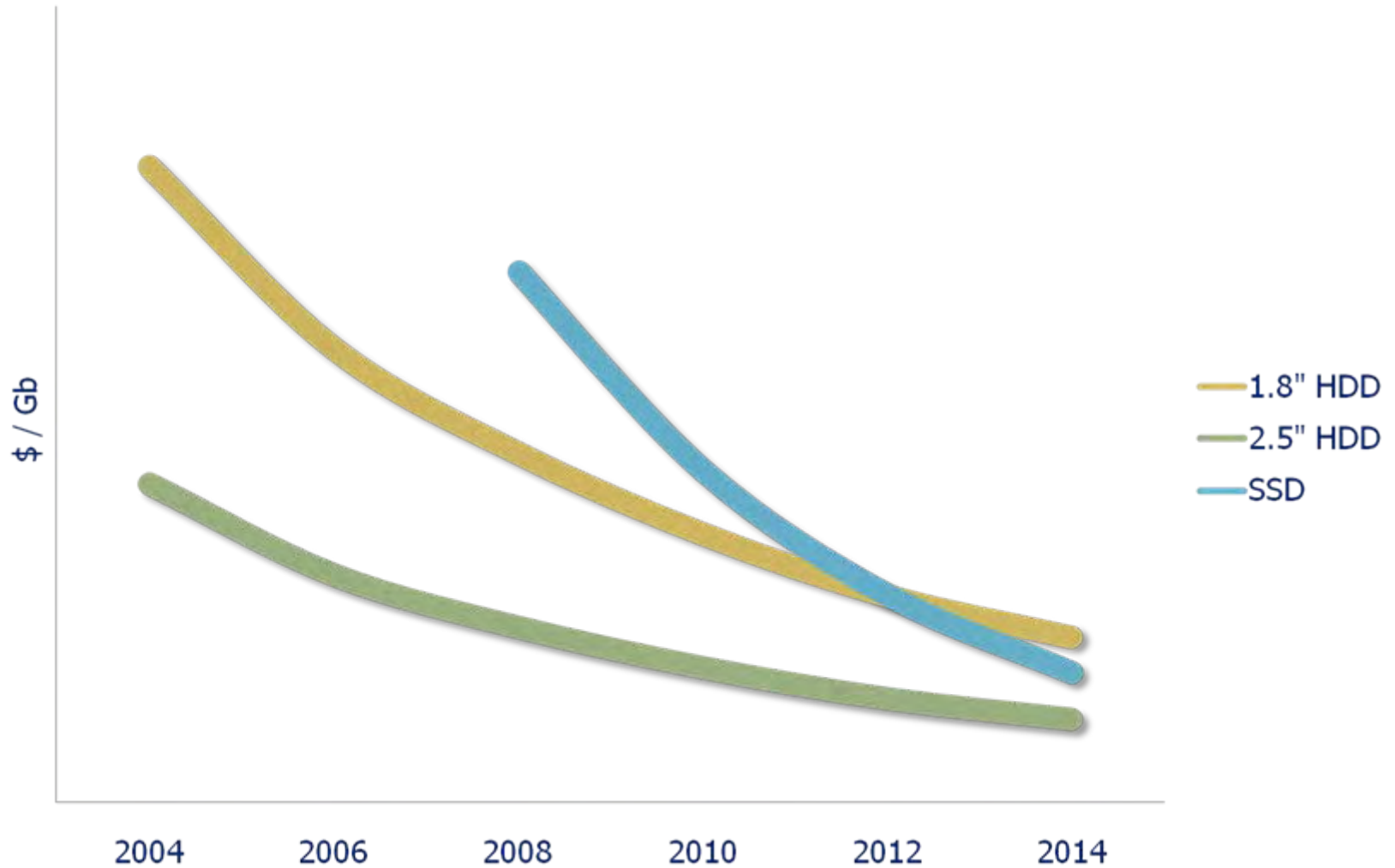
Years to mainstream adoption:

- less than 2 years
- 2 to 5 years
- 5 to 10 years
- ▲ more than 10 years
- ⊗ obsolete before plateau

Gartner's Hype Cycle for PC Technologies 2008



SSD Cost Parity?



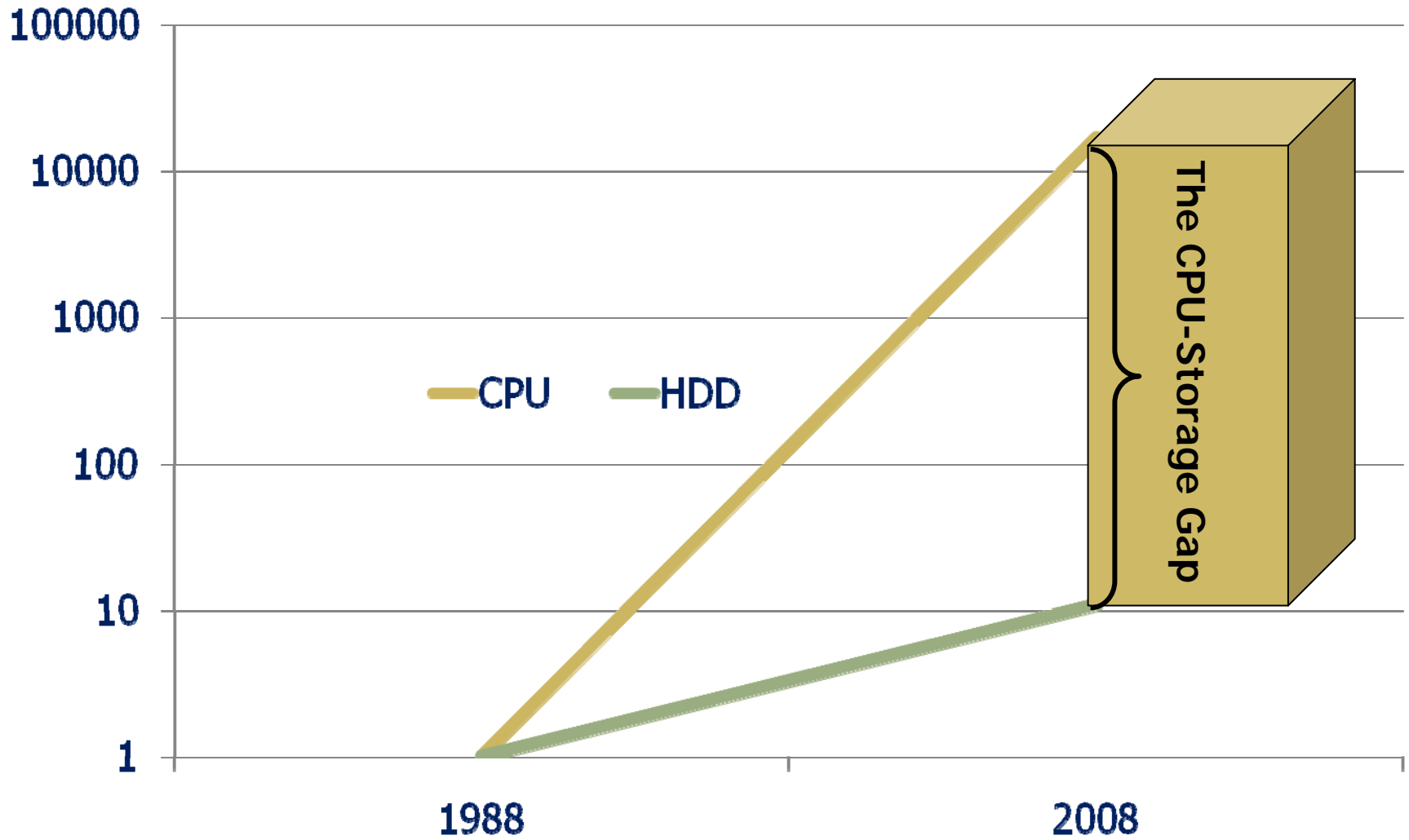
Why SSD's?

- Performance

SSD – Performance



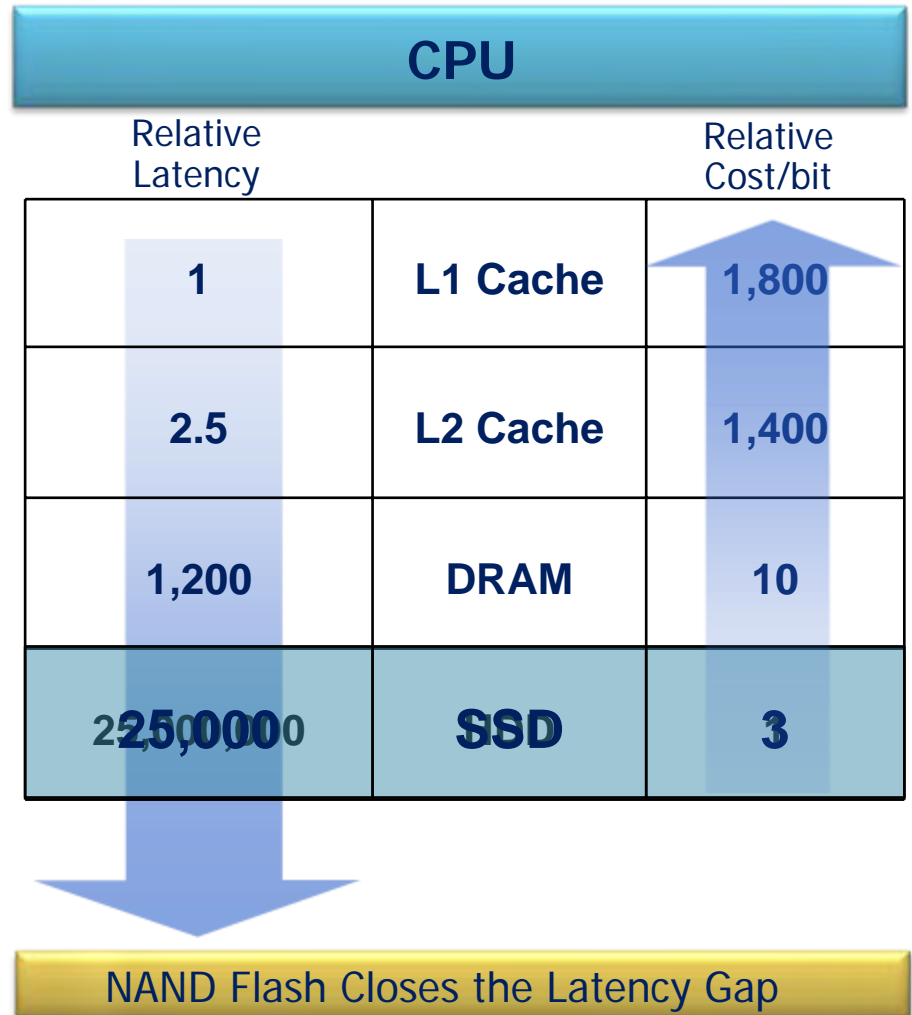
The Storage Gap



SSDs in Computing



NAND



Cost/bit Data as of November 2007

Why SSD's?

- Performance
- Power

SSD – Energy



Notebooks: SSD's *Can* Improve Battery Life

A recent editorial review highlighted that power consumption **increases** when solid state drives are used in today's notebook computers.



HDD



SSD

Notebooks: SSD's *Can* Improve Battery Life

A recent editorial review highlighted that power consumption **decreases** when solid state drives are used in today's notebook computers.



HDD



Notebooks: SSD's *Can* Improve Battery Life

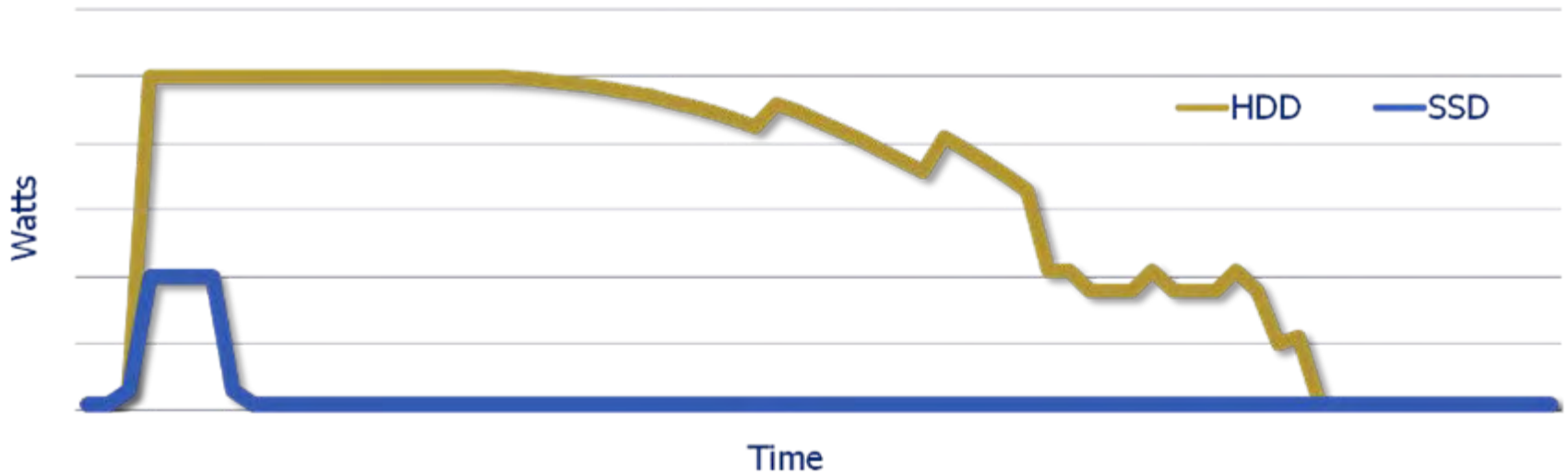
- Requirements:
 - A well-designed SSD
 - Efficient Wear Management Algorithms
 - An Efficient Controller
 - Notebook Optimizations for SSD's
 - Operating System Improvements
 - New SATA commands: ID and Trim
 - Disable Defrag

SSD: Power and Performance



SSDs do more with less power

Power Profile



Why SSD's?

- Performance
- Power
- Reliability

SSD – Reliability



Cost of Ownership Analysis from SSDs in Notebooks

Notebooks at Micron:

2000 units

Avg lifespan of notebook:

36 months

% of employees w/notebook that would benefit from an SSD:

75%

IT hours to repair HDD failure:

5 hours

IT hours to recover from HDD fatal error:

5 hours

HDDs with fatal error per annum:

15 units

Number of hours employee is idle as a result of HDD repair:

5 hours

Higher Reliability

\$208,300

Increased User Productivity

+ **\$415,775**

Increased Battery Efficiency

+ **\$151,260**

Additional Cost for SSDs

- **\$300,000**

= \$475,335 net savings

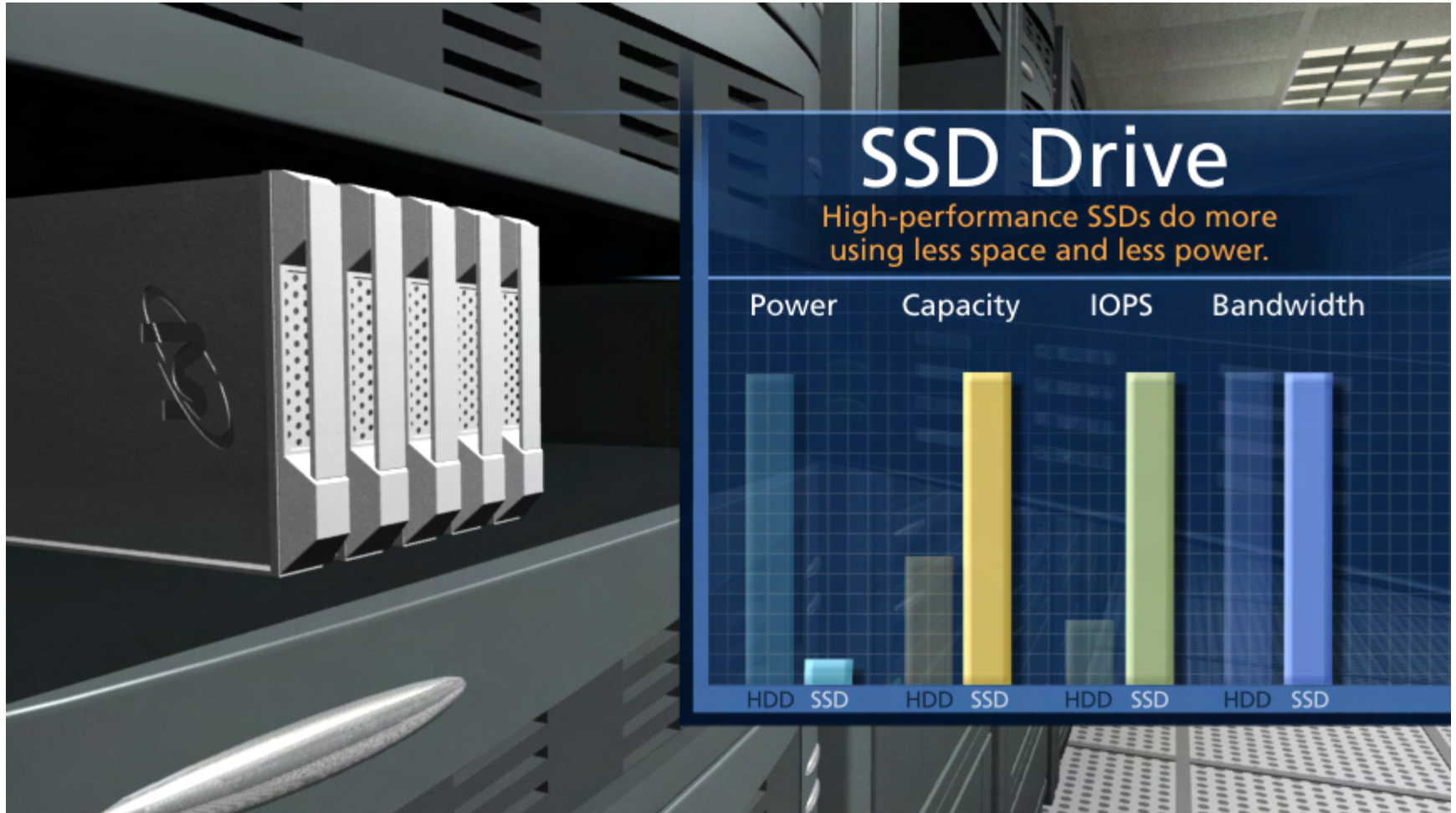
SSD's are not just for Notebooks

- Industrial Applications
- VOD and IPTV
- Enterprise

HDD & SSD in the Enterprise Server Market



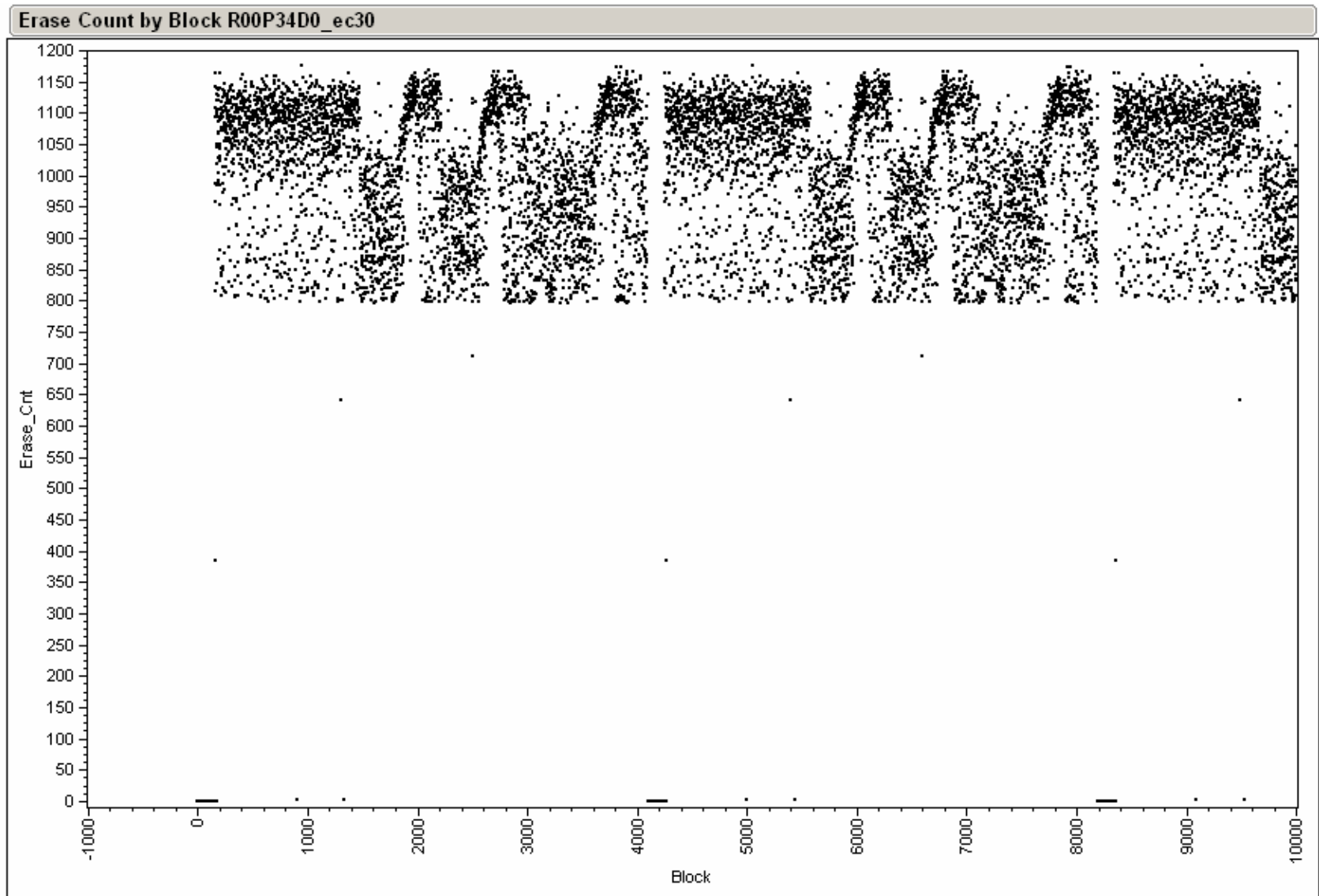
HDD & SSD in the Enterprise Server Market




Making SSD's Enterprise-Ready

- Performance
- Power
- Reliability
- Endurance

Endurance: Wear Leveling

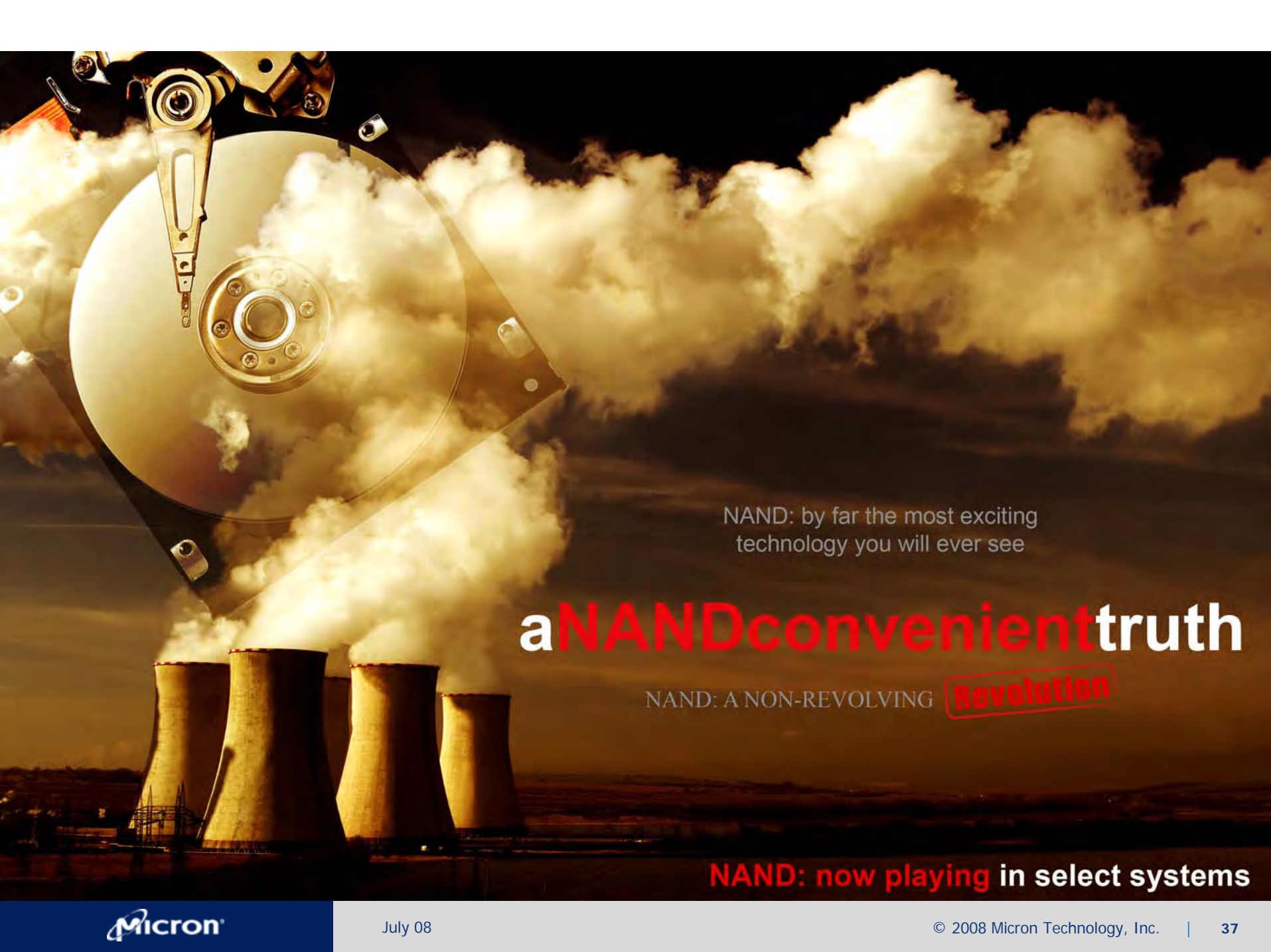




“The brightest
flashes in the world
of thought are
incomplete

– John Tyndall, Scientific Materialism

until they
have been proved
to have their counterparts
in the world of fact.”



NAND: by far the most exciting
technology you will ever see

a **NAND** convenient truth

NAND: A NON-REVOLVING

Revolution

NAND: now playing in select systems

