



SSD Adoption: When, Where, How?

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- SSD adoption: drivers and barriers
- Introducing the Netbook (ULCPC)
- Vertical integration a key
- Summary - conclusions

SSD Adoption: Drivers and Barriers

- SSD adoption drivers:
 - Ruggedness, performance, power consumption, form factor, heat, noise
- What about cost and capacity?
- Are these barriers today?

Introducing the Netbook



- Adopted as new “must have” device
- Primary purpose - surfing the Web

Netbook Market Drivers

Three important benefits explain why this new market is so compelling:

- Convenient web connectivity
- Easy mobility
- Low cost



Netbook Market Positioning

Low cost

Smartphone
(~0.5lbs., 2"-3")



Netbook
(~2.2lbs., 7"-9")



Affordability

Traditional Notebook
(~7.5lbs. , 14"-19")



Ultra Mobile PC (UMPC)
(~1.3lbs., 4.5"-7")



High cost

Low

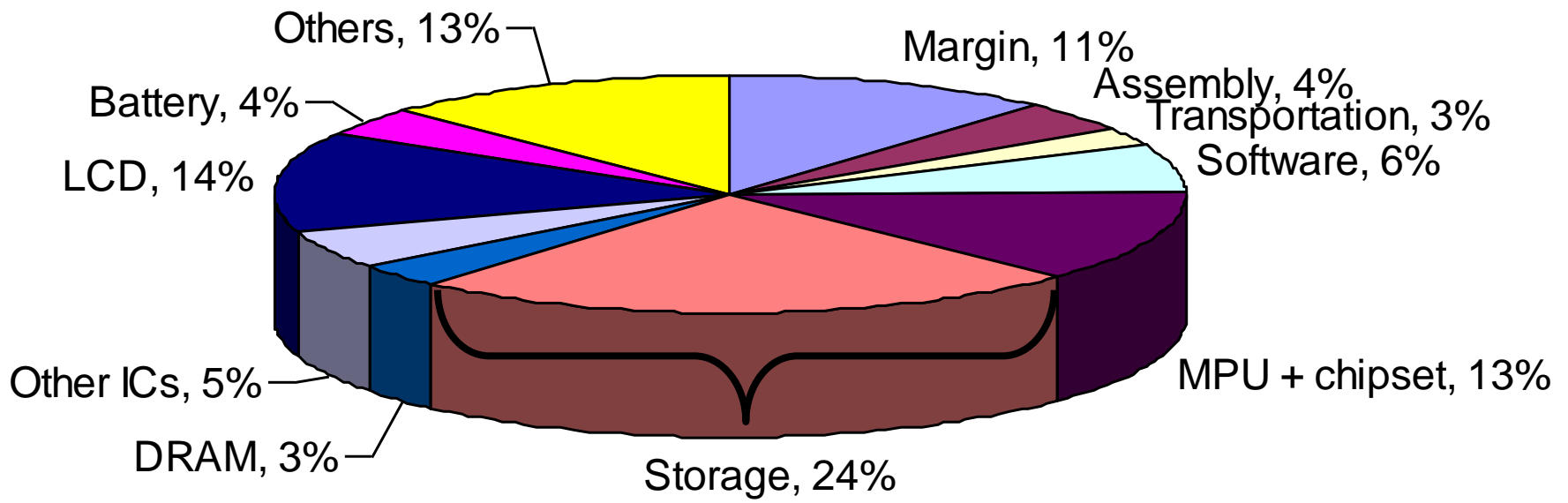
Usability

High

Today's Typical Netbook Specifications

Retail price	\$250-\$600
Weight	~2lbs
LCD panel	7"-9"
Storage type & capacity(*)	Flash-based solid state drive (SSD)
	4GB-16GB
Microprocessor	Intel Celeron-M, Atom, VIA C7-M
Operating system	Linux, Microsoft XP
Memory card slot	1-2
Wireless Connection (**)	802.11b/g
(*) HDD options are available for higher capacity	
(**) Some manufacturers are partnering with service providers for 3G web access	

Netbook Components Relative Cost



Netbook PCB - HDD or SSD?



SSD Value for Netbooks Endorsed by Analysts and PC OEMs

“From a storage perspective, ULCPCs and SSDs appear to be a good match.

SSDs provide the required:

- *Small form factor*
- *Durability*
- *Low power consumption*

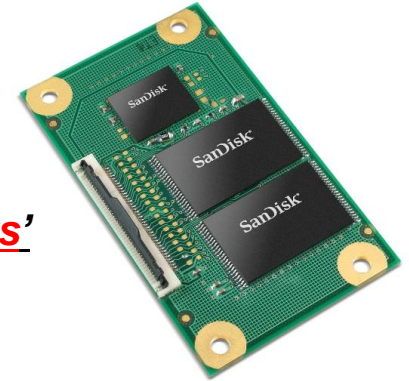
*...perhaps most importantly, SSDs can provide the **required capacity at very low price points.**”*

PRESS RELEASE

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SANDISK LAUNCHES SOLID-STATE DRIVES AIMED AT HOT NEW CATEGORY OF ULTRA LOW-COST PCs
SanDisk pSSD Flash Memory Modules Are Positioned As Storage of Choice For Emerging “Must-Have” Market of ULCPCs or ‘Netbooks’

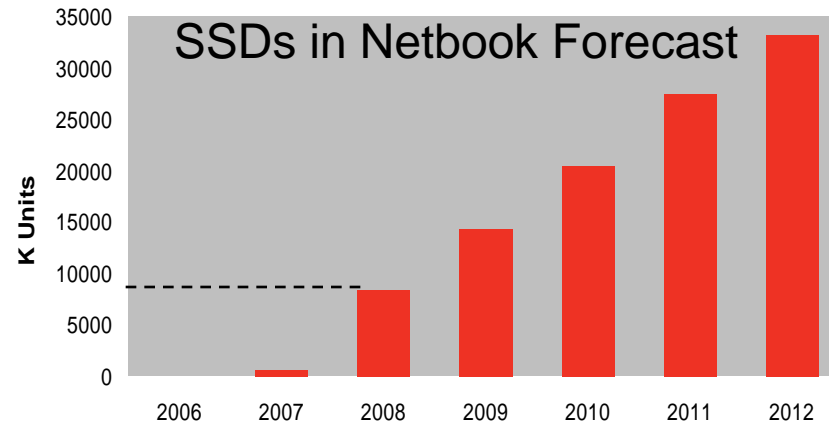


TAIPEI, TAIWAN AND MILPITAS, CALIFORNIA, June 3, 2008 –

...
According to Joseph Unsworth, Research Director at Gartner, The **opportunity for SSDs in the emerging market of ultra low-cost PCs is promising.”**

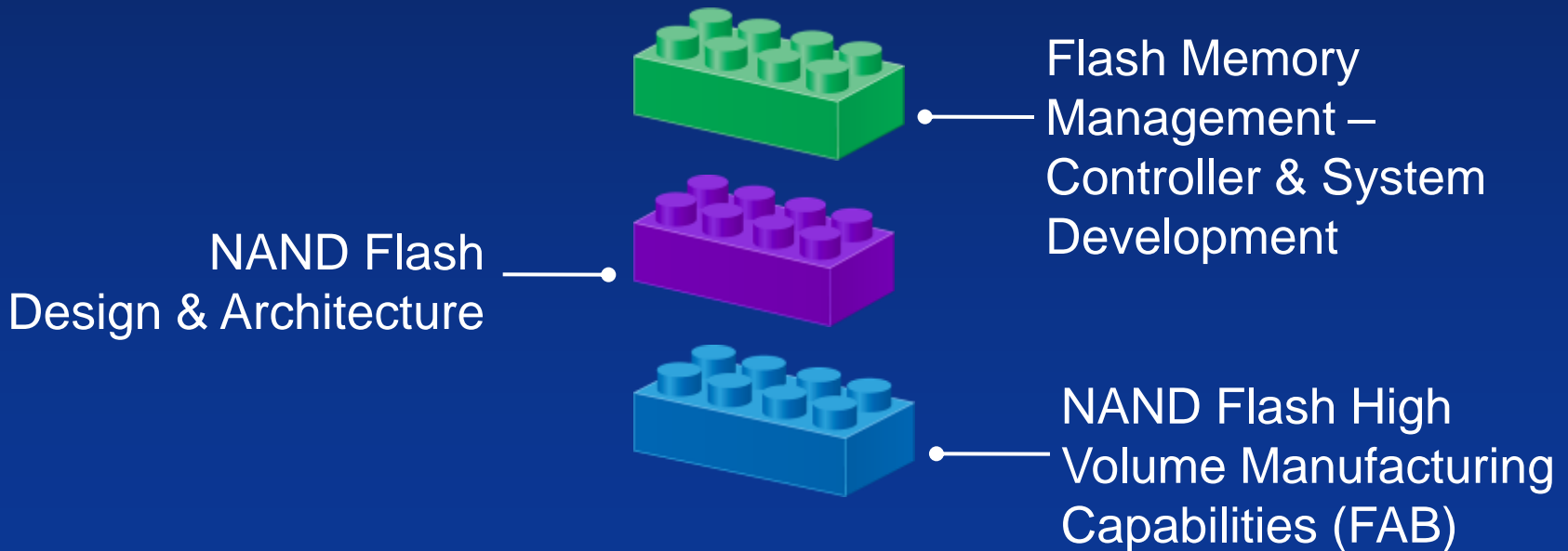
Gartner expects the low-cost SSD category to grow from 635,000 units in 2007 to **over 33 million units in 2012,**

and that represents a five-year compound growth rate of 117 percent.³ “As semiconductor innovation enables more powerful functionality at lower prices, storage requirements will continue to be elastic, providing opportunities for companies that can command compelling low-cost SSD solutions,” said Unsworth.

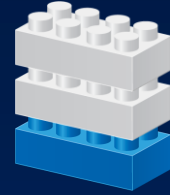
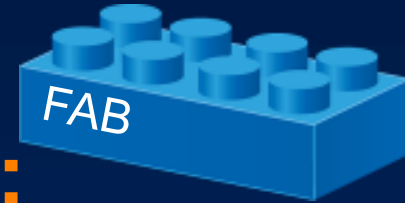


What Does it Take From Flash Vendors to Make SSD Adoption a Reality?

Vertical Integration Across Major Building Blocks



SSD Market Requires Assurance of Memory:

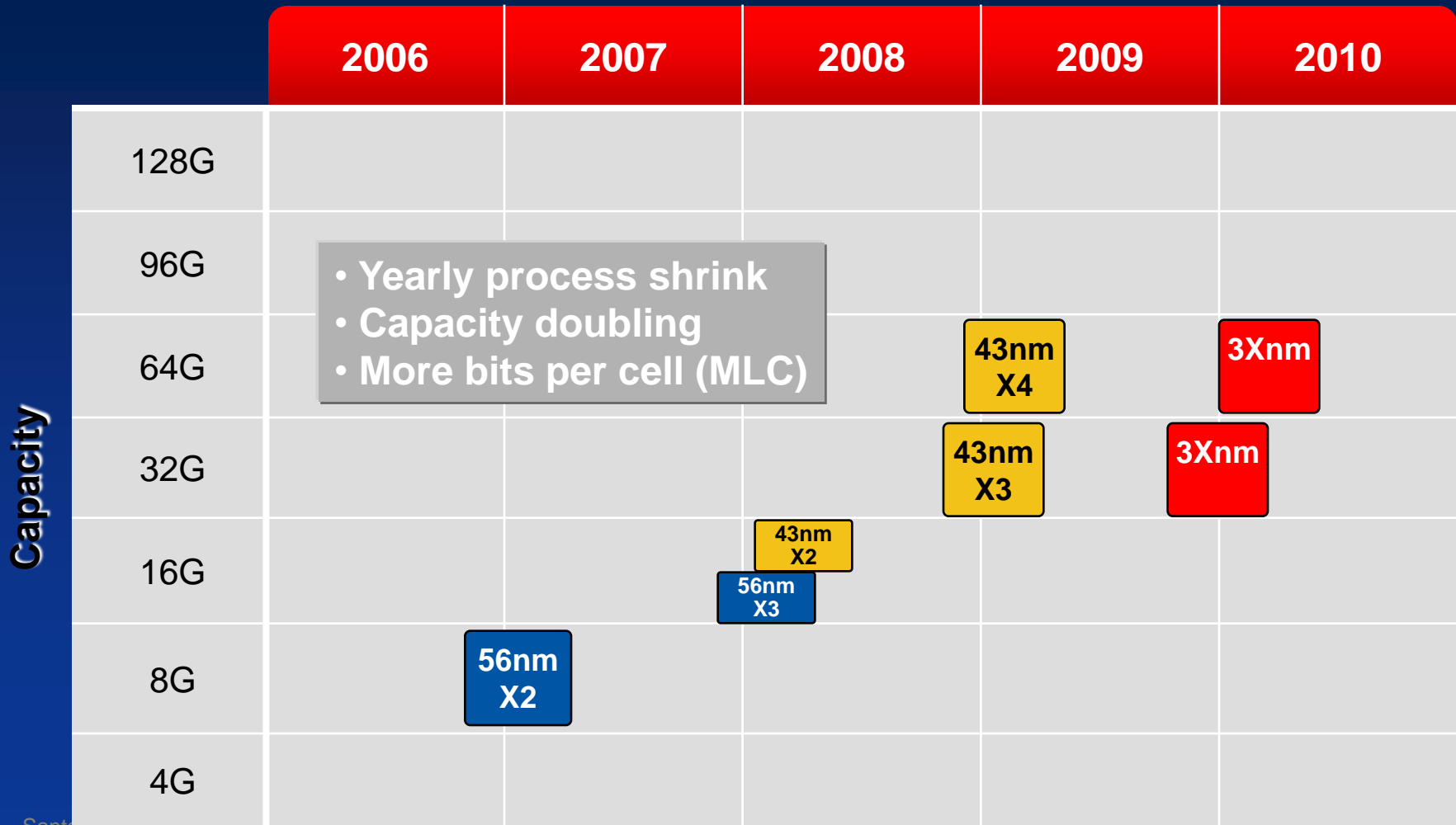
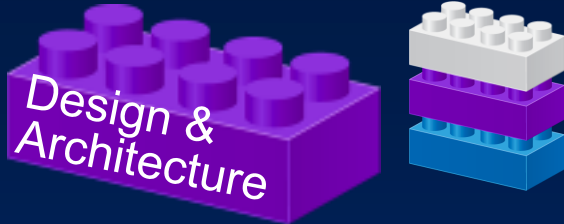


- **Availability** – Petabytes of NAND for multi \$B market
- **Stable competitive price** – economy of scale will drive consolidation
- **Quality** – vertical integration for internal feedback loop



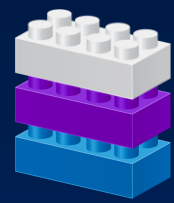
Petabyte = 2^{50} bytes

NAND Technology Roadmap





Not All MLC Is Created Equal



- New vendors just entering MLC market
- MLC history:
 - 1992 - First MLC Patent - Eli Harari
 - SanDisk-Toshiba Partnership
 - 2001 - First NAND MLC Product
 - 2002-2008 - 6 generations of MLC

US05089344A

United States Patent [19] [11] Patent Number: **5,095,344**

Harari [45] Date of Patent: **Mar. 10, 1992**

[54] **HIGHLY COMPACT EPROM AND FLASH EEPROM DEVICES** *of the IEEE International Electron Device Meeting, Dec. 1984, pp. 480-483.*

[76] Inventor: **Eliyahu Harari**, 2320 Friars Ln., Los Altos, Calif. 94022 *Y. Mizutani and K. Makita, "A New EPROM Cell with a Side-Wall Floating Gate for High-Density and High-Performance Device", 1985 IEDM Technical Digest, pp. 635-638.*

[21] Appl. No.: **204,175** *F. Masuoka et al., "A 256K Flash EEPROM Using Triple Polysilicon Technology", Digest of Technical Papers, IEEE International Solid-State Circuits Conference, Feb. 1985, pp. 168-169, p. 335.*

[22] Filed: **Jun. 8, 1988** *A. T. Wu et al., "A Novel High-Speed, 5-Volt Programming EPROM Structure with Source-Side Injection", 1986 IEDM Technical Digest, pp. 584-587.*

[51] Int. Cl.³ **H01L 29/78; H01L 27/01; H01L 29/10; H01L 29/40** *G. Samachira et al., "A 128K Flash EEPROM Using Double-Polysilicon Technology", IEEE Journal of Solid State Circuits, Oct. 1987, vol. SC-22, No. 5, pp. 676-683.*

[52] U.S. Cl. **357/23.5; 357/23.1; 357/23.3; 357/41; 357/45; 357/53; 365/185**

[58] Field of Search **357/23.5, 23.1, 23.3, 357/23.4, 41, 53, 45**

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S. Tanaka et al., "A Programmable 256K CMOS

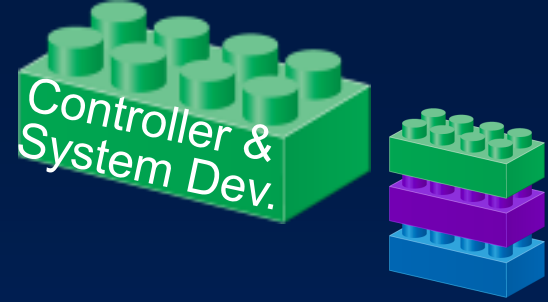
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ABSTRACT

[57] Structures, methods of manufacturing and methods of use of electrically programmable read only memories (EPROM) and flash electrically erasable and programmable read only memories (EEPROM) include split channel and other cell configurations. An arrangement of elements and cooperative processes of manufacture provide self-alignment of the elements. An intelligent programming technique allows each memory cell to store more than the usual one bit of information. An intelligent erase algorithm prolongs the useful life of the memory cells. Use of these various features provides a memory having a very high storage density and a long life, making it particularly useful as a solid state memory in place of magnetic disk storage devices in computer systems.

Flash Management Know-How Required



New Flash Contains Bad Blocks

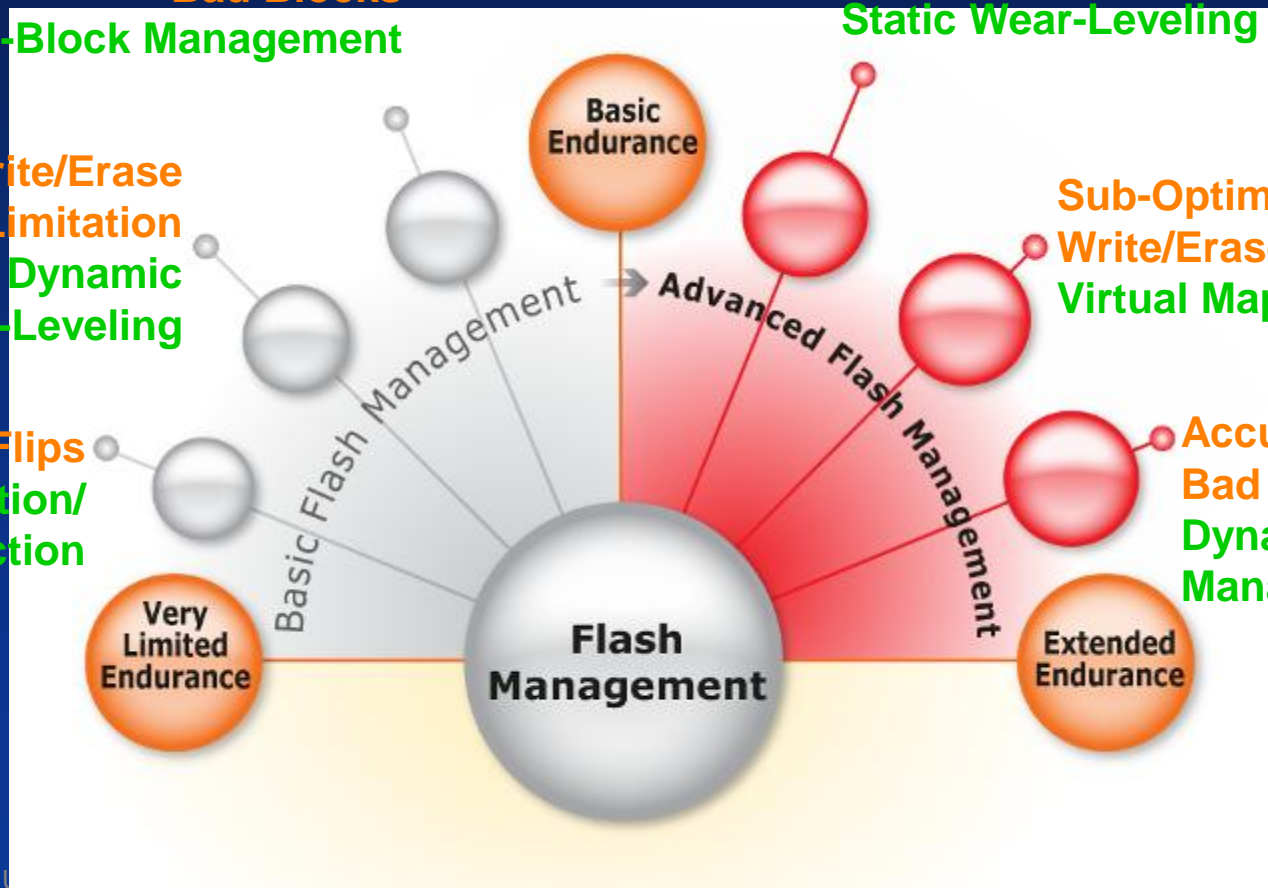
Likelihood of Flash Wear Depends on Use

Bad-Block Management

Static Wear-Leveling

Write/Erase Cycles Limitation
Dynamic Wear-Leveling
Bit Flips
Error Detection/ Error Correction

Sub-Optimal Write/Erase Ratio
Virtual Mapping
Accumulated Bad Blocks
Dynamic Bad-Block Management

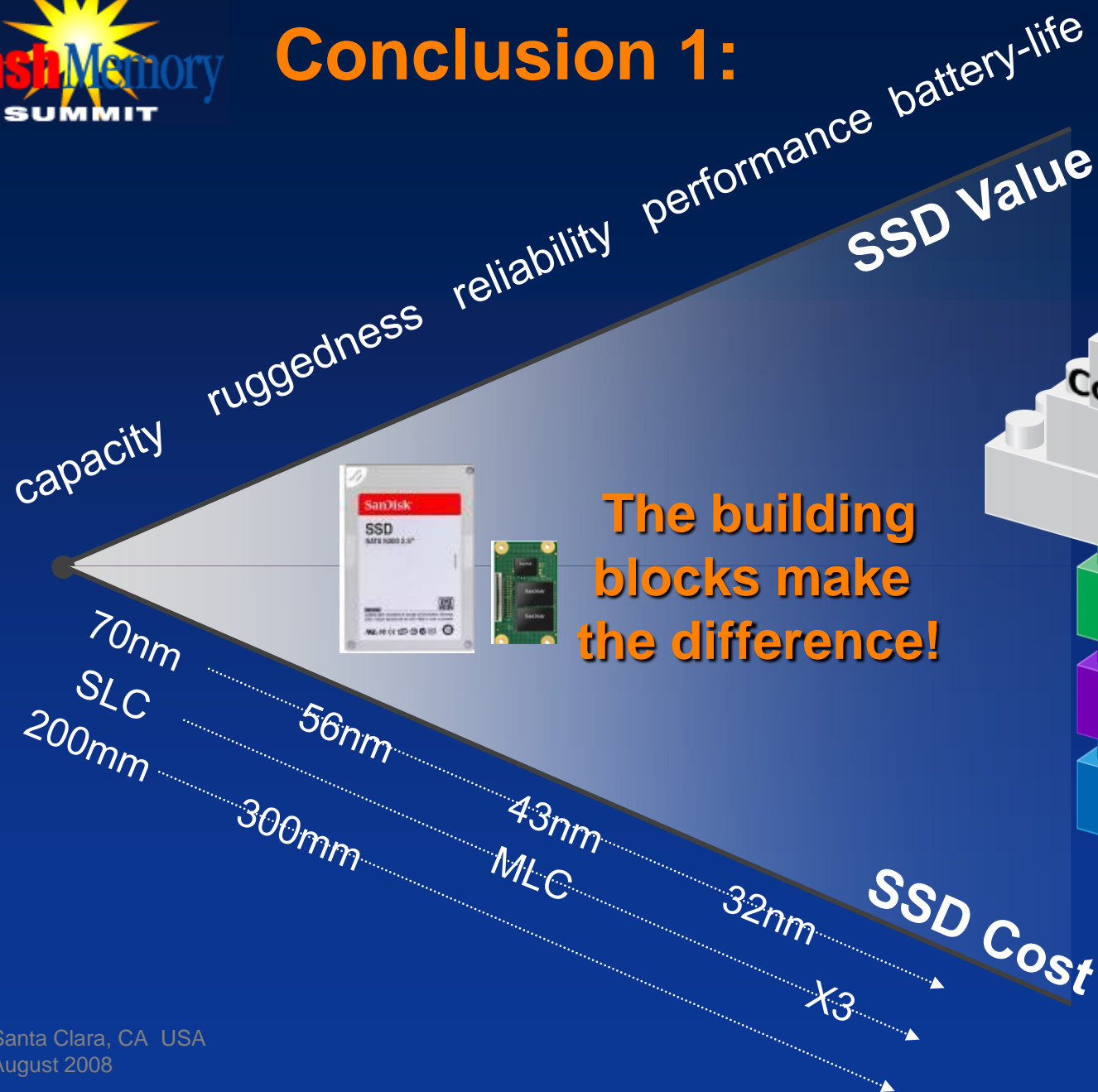


Note: Challenge increases as process shrinks



Summary: SSD Adoption Where When How?

Conclusion 1:



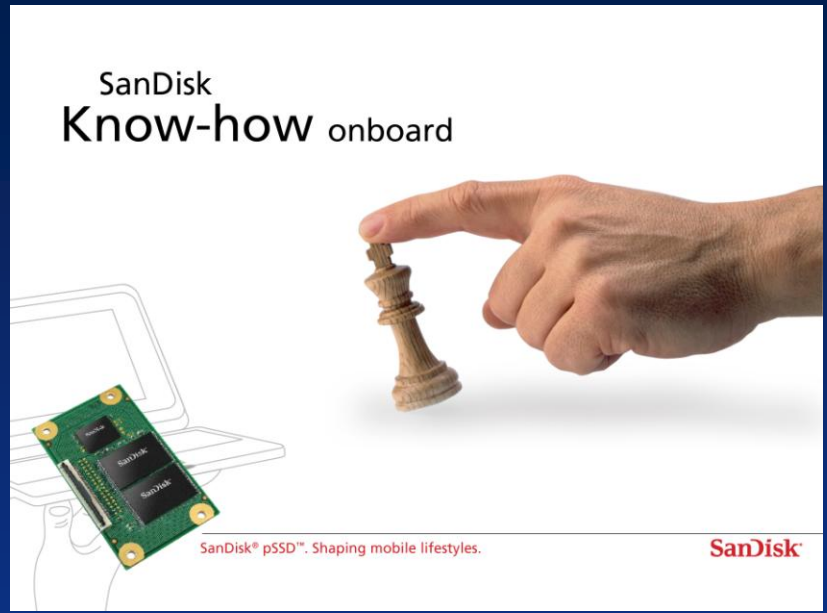
Conclusion 2:

SSD value answers Netbook needs today



Bottom Line

SanDisk
Know-how onboard



SanDisk® pSSD™. Shaping mobile lifestyles.

SanDisk

Rugged
and reliable



SanDisk® pSSD™. Shaping mobile lifestyles.

SanDisk

Affordable,
solution



SanDisk® pSSD™. Shaping mobile lifestyles.

SanDisk

Lightweight,
small form factor



SanDisk® pSSD™. Shaping mobile lifestyles.

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