

Apacer

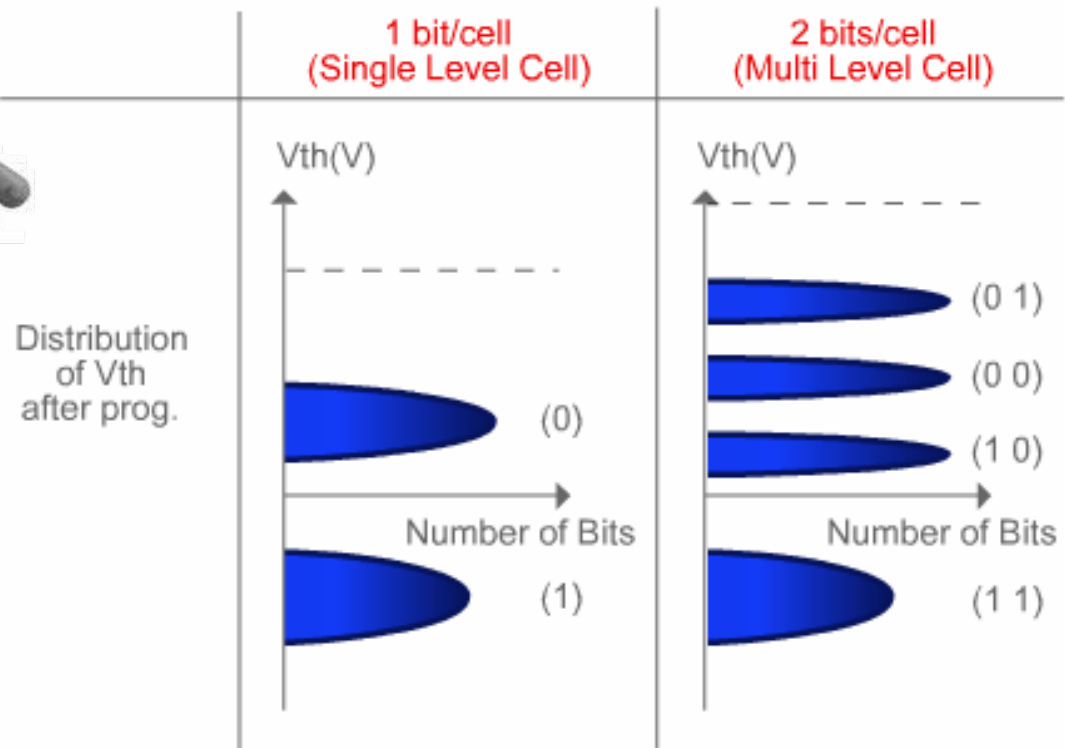
MLC-based SSD: Opportunities & Challenges

E-Flash Product Dept.

25th March, 2009

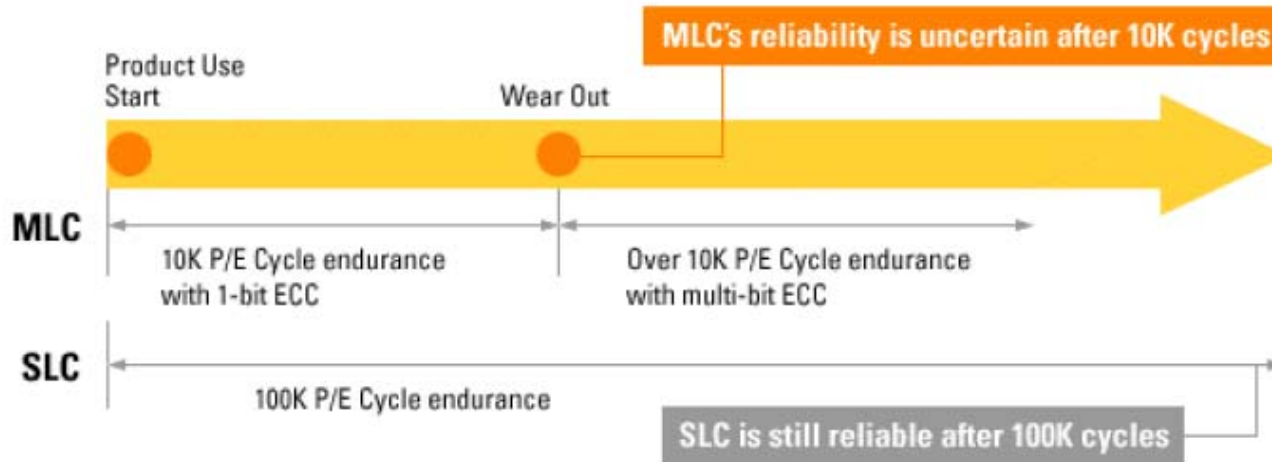
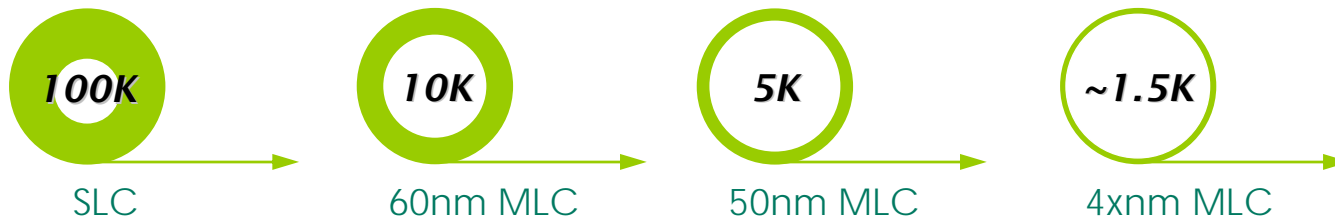
What's MLC?

- Multi Level Cell
 - 2 bits per cell (today)
 - 3 or 4 bits per cell (future)



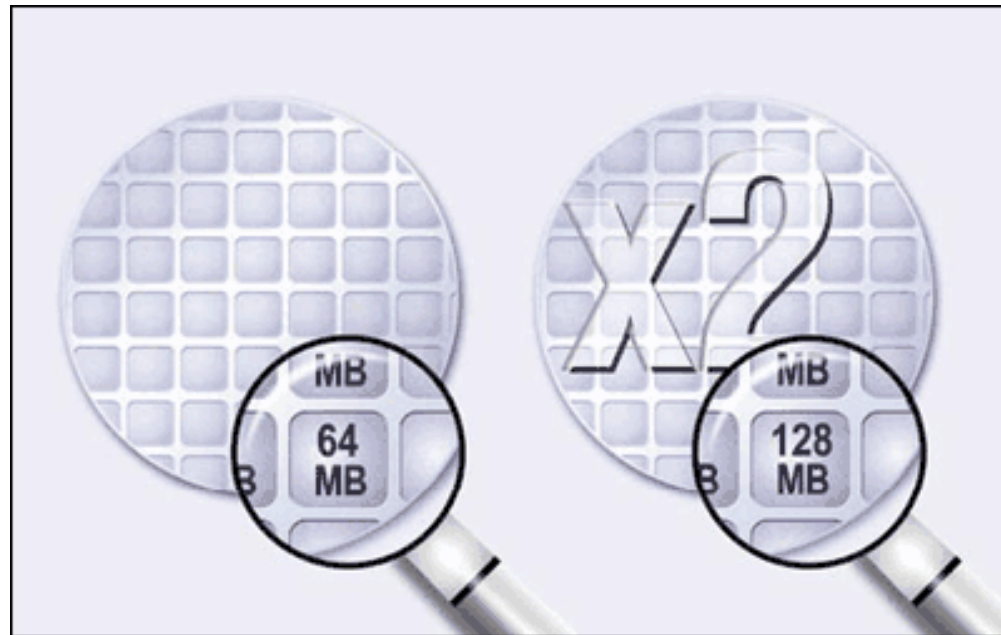
Endurance & Reliability

- Durability (NAND flash P/E cycles)



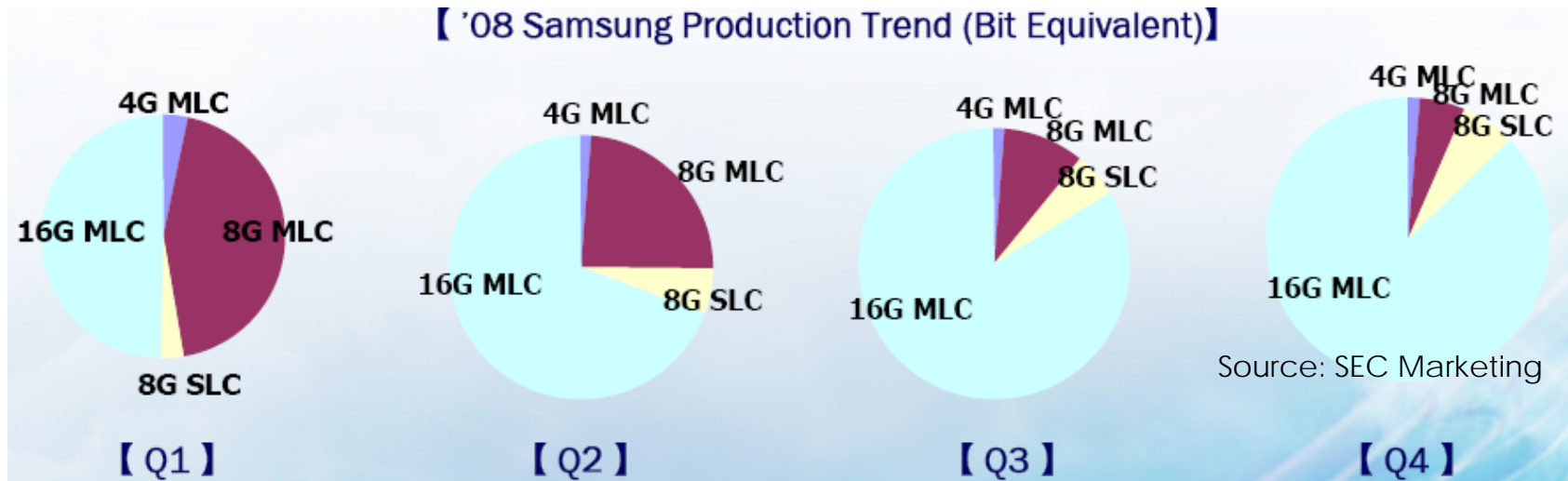
Why MLC?

- MLC has two times density on same chip size with SLC, that means MLC will always provide the lowest cost per bit.



Flash Supply Availability

- For example: Samsung Electronic Corp.
 - Total production of MLC is greater than SLC (only around 7% SLC out of total output in Q4, 2008)
 - MLC price varies with the rapid change in market demand, (ex. SLC: MLC = 1:2 → 1:3 → 1:4 → ?)



The Truth...

50nm Flash	SLC	MLC	Differences
Bits / Cell	1	2	MLC has 2 times density than SLC
Pages / Block	64	128	
Page Program	250us	900us	SLC provides ~2 times the write performance of MLC
Random Read	25us	50us	
Block Erase	2~10ms	2~10ms	
P/E Cycles	100K	5K~10K	Durability of SLC is typically 10 times better than MLC
ECC (detect/correct)	1~4-bits	4~16-bits	
Operating Temperature	Support wide range	Normal	SLC is more suitable to work under extreme environment
Data retention	High	Normal	
Power consumption	Low	Normal	SLC is better than MLC

Consideration for SSD Endurance

- NAND flash cycling endurance
 - SLC > 60nm MLC > 50nm MLC > 3-bit per cell MLC...
 - SSD density (the larger the better)

- Workload
 - Write speed, operation time (10MB or 10GB per day)
 - The less write times the better SSD life

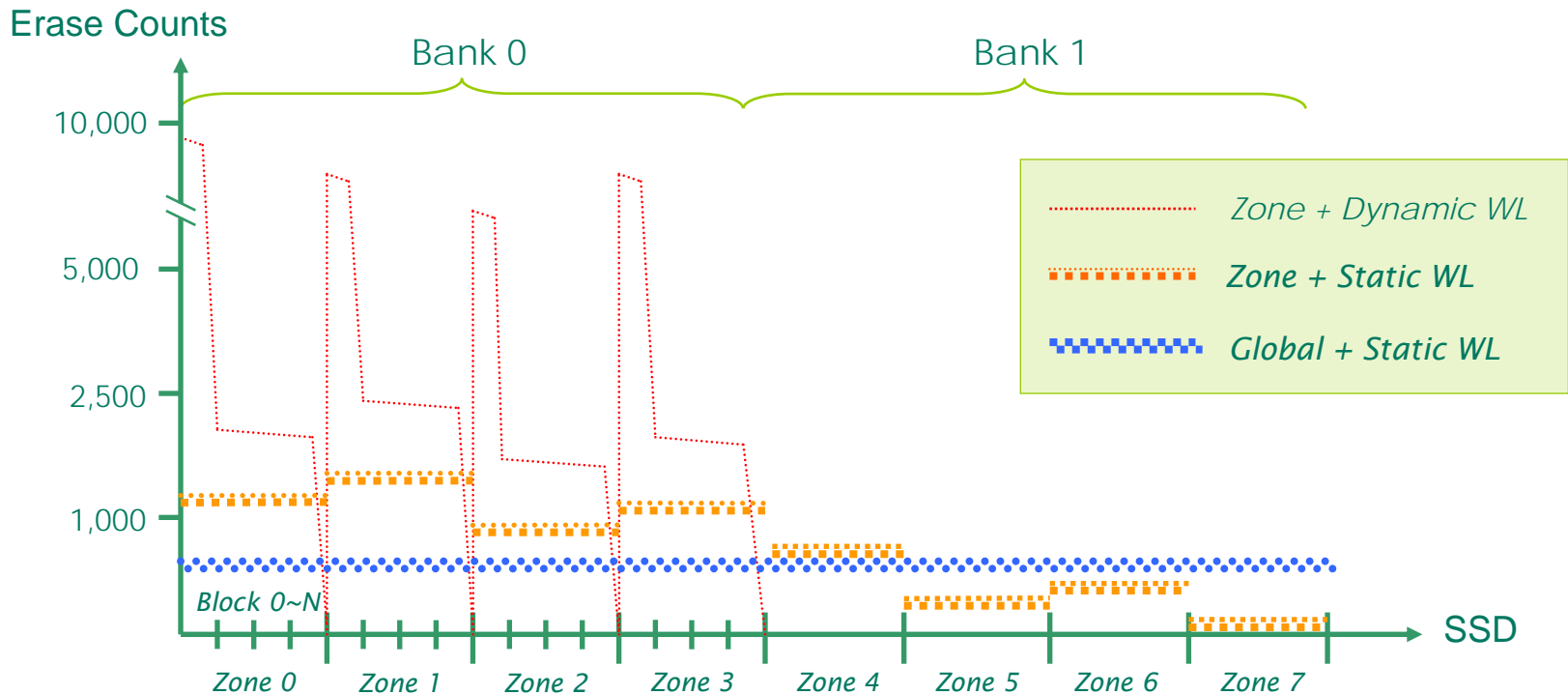
MLC Application	Capacity	Daily use scenario	Daily Workload
Digital Camera	2GB	200 shots at 10 Mpixel	1GB
MP3	4GB	150 songs at 256Kbps	1.2GB
Camcorder	16GB	1 Hour recording in DVD quality	2.4GB
SSD	16GB~	e-Learning, Entertainment, Internet browsing, E-Mail...	1~32GB

- WAF (Write Amplification Factor)
 - Additional write overhead due to the sector and block size mismatch: WAF = Flash writes / Host writes
 - Result varies from user's application
 - Better to minimize to get close to 1x

	WAF
E-learning	1.21
Video creation	1.07
Productivity	1.33
3D	1.16
Avg.	1.12

Source: Samsung Electronic

- WLF (Wear-Leveling Factor)
 - Wear-Leveling, a plus for SLC but a must for MLC
 - $WLF = (\text{Max. P/E Cycle}) / (\text{Avg. P/E Cycle})$
 - Global > Zone, Static > Dynamic



True SSD Lifetime

- True NAND flash P/E cycles, workload, WAF & WLF must be accounted for when calculating SSD lifetime
 - Assumes a perfect wear-leveling actively on 50nm MLC-based SSD
 - Assumes data access is 50% random
 - Assumes WAF=1.8, WLF=1.04 (common user profile)
 - Lifetime = $\frac{\text{SSD capacity} * \text{NAND P/E Cycles (50nm, MLC)}}{\text{Daily workload} * \text{WAF} * \text{WLF}}$

$$(4\text{GB} * 5\text{K}) / (8\text{GB} * 1.8 * 1.04) = 1,335 \text{ days (3.6 years)}$$

Are MLC safe for enterprise appl.?

Apacer suggest **not** to:

- Install OS on MLC SSD with small capacity
 - Life Time Consideration
- Adopt MLC on specific application that is intended for high performance (especially for random write)
 - Performance consideration
- Store important data on MLC for long-term data storage
 - Data retention consideration

Apacer MLC Solution - Industrial

- Product lines
 - PATA: AFD VI (TBD)
 - SATA: Mini SAFD25MII, SAFD254, SAFD181
 - CFC: Commercial series
- Capacity: 1GB~128GB
- Warranty: 2 years (4GB and below only 1 year)
- Long-term supply with fixed F/W & H/W assurance
- Implement one cycle of entire flash blocks scan to early screen out inferior flash before MP



Add-on Values - SMART

- S.M.A.R.T.
 - Self Monitoring Analysis & Report Technology, is part of ATA standard
 - Receiving SSD attribute threshold from controller
 - The way to monitor SSD's health before SSD crash
 - Back-up data
 - To do timely replacement before SSD crash
 - call for Apacer's instant support

Warning!

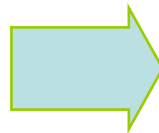
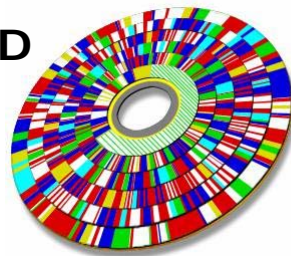
Call for Help!



Add-on Values - SSD⁺Optimizer

- SSD⁺ Optimizer
 - InvisiTasking™: only idle system resource are utilized
 - Combined benefit of HW & SW, particularly optimized for Apacer SSD's architecture
 - Keep system performance at optimal status at any time
 - Prevent performance decline from file fragment
 - Defrag disk on the fly, but no waste of available erase cycles in overall review
 - Real-time Optimization

Before: HDD



Market Segmentation

- PC, NB & Netbook for consumer applications are price sensitive market
- Data Server, IPC, Thin Client, POS... for industrial applications require high performance with reliability

Requirements	Industrial		Consumer (MLC-based)
	SLC-based	MLC-based	
Higher performance (Read & Write)	★ ★ ★		
Greater reliability (Cycling / RBER)	★ ★ ★		
Component level product control	★ ★ ★	★ ★ ★	
Support wide temperature range	★ ★ ★	★	
Data retention	★ ★ ★	★	
Add-on values (SMART, Quick Erase, etc.)	★ ★ ★	★ ★ ★	
Lower cost / GB		★ ★	★ ★ ★
Greater density reach		★ ★ ★	★ ★ ★

Cost/GB

High



Low

Consumer Appl.

- Module/Drive type, **MLC**



Military, Medical, Financial Appl.

- Chip/Module/Drive type, **SLC**



Military

Data Center



Medical



ATM



High-end NB



NAS...

Gaming PC



Netbook, UMPC

Thin Client



IPC



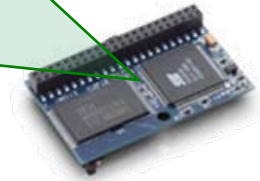
KIOSK



POS

Industrial Appl.

- Module type, **SLC > MLC**



Low → High

Performance

High ← Middle

Reliability



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