



# The Evolving NAND Flash Business Model for SSD

Steffen Hellmold  
VP Business Development  
SandForce, Inc.

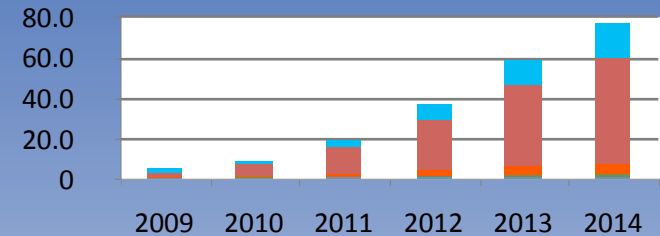


- SSD – Enabling Price Points are key!
- Reliability – Need adaptive ECC
- Reliability – Cluster Failure Mitigation
- Soft-interface Evolution for NAND
- Evolving NAND business model

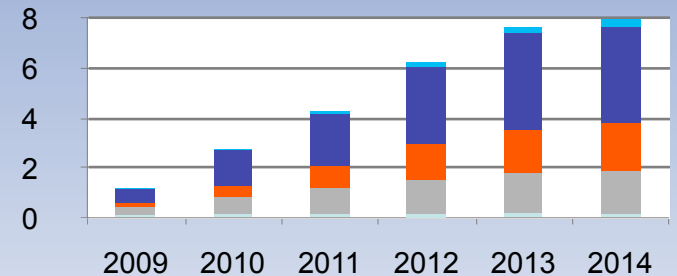
# SSD – Enabling Price Points are key!

- SSDs deliver a value proposition around \$/IOPS/W/in<sup>3</sup>, latency, form factor and robustness not \$/GB.
- **But enabling price points matter!**
- CY09: SLC Enterprise SSD less than \$20/GB => Storage Systems
- CY10: MLC Enterprise SSD less than \$5/GB => Servers
- CY11: MLC Enterprise SSD less than \$5/GB => Storage Systems
- CY12: MLC SATA SSD less than \$1/GB => Client Compute Systems

Mpcs



Industrial Storage Server Client  
NetBook  
B\$

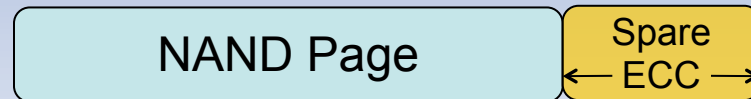


Industrial Storage Server  
Client NetBook  
Source: Gartner, August 2010

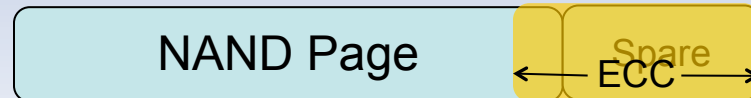
# Reliability – Need adaptive ECC

- SSD require highest reliability amongst NAND apps
  - Smaller lithography and increased MLC enabled NAND cost reductions, a side effect is a higher raw bit error rate
  - BCH based technologies reaching their technology scaling limits requiring increasing NAND spare area for ECC usage (>10%)
  - SSD processors are expected to support up to 80b/1kB ECC in order to enable reliable 20-nm class MLC SSD for Compute Apps
  - Adaptive Error Correction technology is required to enable scaling to application reliability needs from Client SSD to Enterprise SSD

**Conventional Error Correction:**  
Stores ECC in spare field



**Adaptive Error Correction:**  
Stores ECC in spare field and  
uses some of the NAND page



# Reliability – Cluster Failure Mitigation

- Scaling causes increasing probability of infant mortality, word-line, bit-line and other cluster failures in addition to retention failures
- NAND DPPM rates may exceed several thousand DPPM requiring compensation/mitigation to meet acceptable SSD AFR specs
- Some of the failures may be captured through NAND component and SSD level testing at the expense of increased test cost/time
- Compensating cluster failures in addition to ECC is required to achieve highest reliability for SSDs used in Compute Apps

“RAID on Silicon” will evolve from  
a nice to have to a must have!

NAND flash physics sensitive to e.g. location, temp, time and disturb must be compensated!

## §Read Compensation

1. Soft Information during Read will be required to maximize endurance life for e.g. Enterprise SSD

## §Write Compensation

- Soft Information used to adjust NAND writes will be required to adjust for physical cell location

## 1. Disturb Compensation

- Multi-dimensional scrambling is required to avoid disturb effects in NAND flash during writes

# Evolving NAND business model

- Increased complexity managing RAW NAND
- Proprietary soft-interfaces for NAND emerging
- NAND with ECC introduced, ClearNAND et. al.
  - Provides reliability at component level
  - Easier system integration and migration
- Question: What functionality is best served where?
  - Technical and business considerations impact decisions
- New NAND industry standards are needed to address diverging Consumer and Compute NAND needs

**Need a soft-interface NAND standard for optimal deployment of future NAND in SSD**



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  - SATA – Updates on SSDs, testing, and infrastructure equipment collaboration
- Stop by to enter our **free drawing** for one of three Corsair Force 120GB SandForce Driven SSDs
- See other SandForce Driven SSDs in our partners' booths as well

\*Random 4K transfers

Flash Memory Summit 2010  
Santa Clara, CA

