Challenges of Embedded/Industrial SSD Validation

Flash Memory Summit, 2014

8/7/14

Overview

- **The Challenge of Embedded SSD Validation**
  - Validation Strategy
  - The Factor of Industry Focus
  - The Factor Timing and Dynamic Change
  - The Factor of Usage Model Variance
  - Other Factors and Common Mistakes in Solution Selection

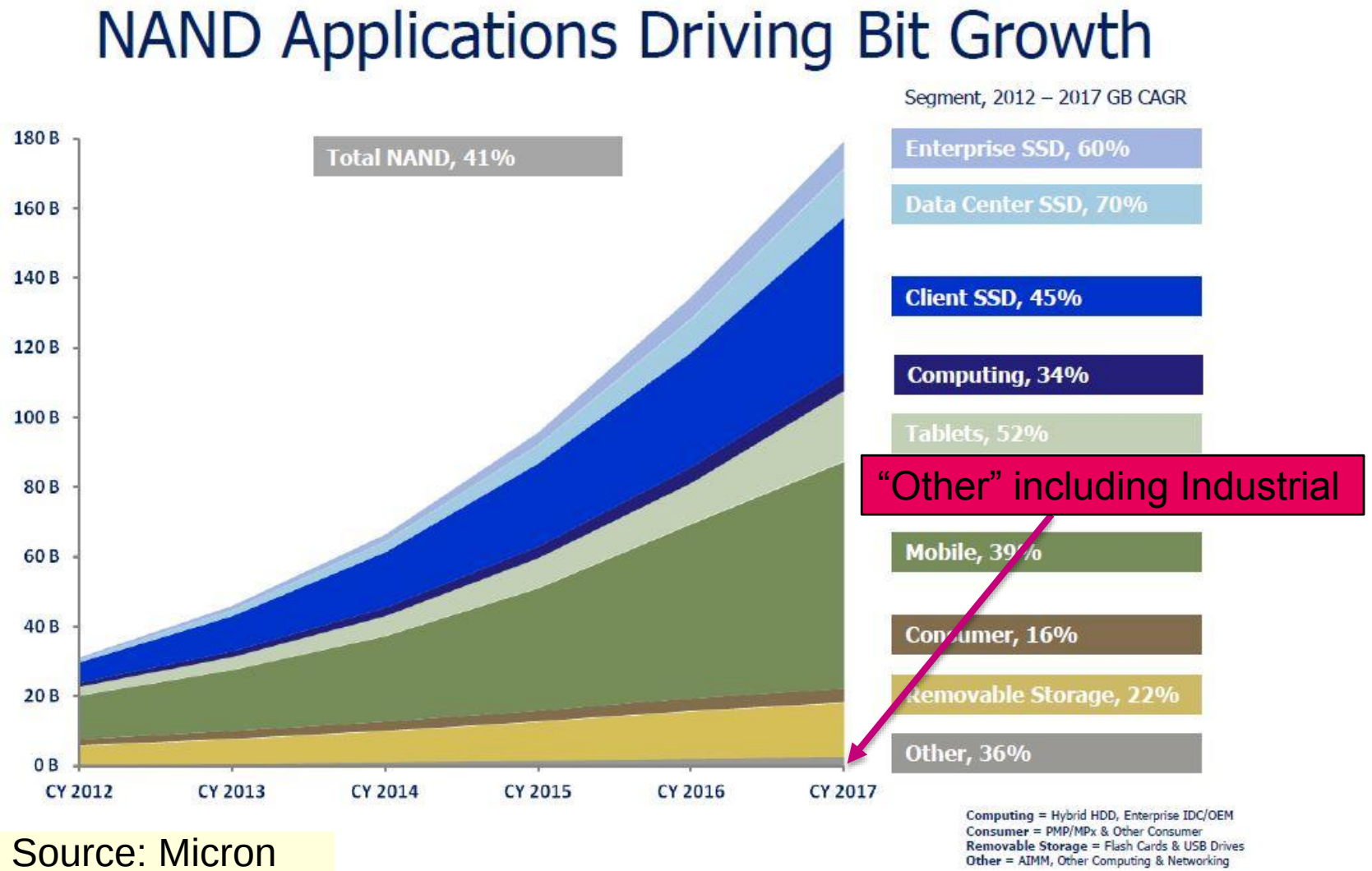
Validation Strategy

Finding the Right Balance

- Validation strategy is finding the balance of business and resource allocation
- For example, ***higher reliability applications*** typically means more resources, more time, and in turn… a longer term supply strategy
- Below is an example list of check and balances that need to be taken into account when coming up with a validation strategy

Factor	Relationship	Notes/Other Contributors
Cost/Manpower vs Validation Coverage	Exclusive	- Population size of samples/prototypes, and in turn the number of engineers needed to debug failures in validation - A larger population size offers stronger validation coverage against DPM reliability/Quality (not to be confused with endurance)
Time to Market vs Validation Coverage	Mutually Exclusive	- Length of endurance testing to validate NAND/SSD P/E Cycle specification - Amount of preconditioning on the NAND to allow for validation of other endurance factors such as read disturbance - A longer validation period will reflect a longer requirement for supply chain longevity
Focus of validation	N/A	- Number of usage cases on platform to be validated - Performance vs environmental reliability vs endurance P/E, etc.

The Factor of Industry Focus

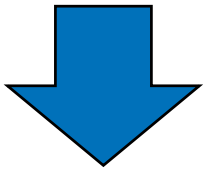


Source: Micron

The Factor of Industry Focus

NAND Industry Focus

- **Trend Controller/NAND Design:** Focus on maximizing P/E Cycle on the newer process node
- **Trend Controller/SSD Level:** Validation focus on Enterprise/Client Usage Cases
- **General Trend:** Less attention to reliability characteristics over wide temperature
- **General Trend:** Less attention to usage cases sensitive to retention and read disturbance

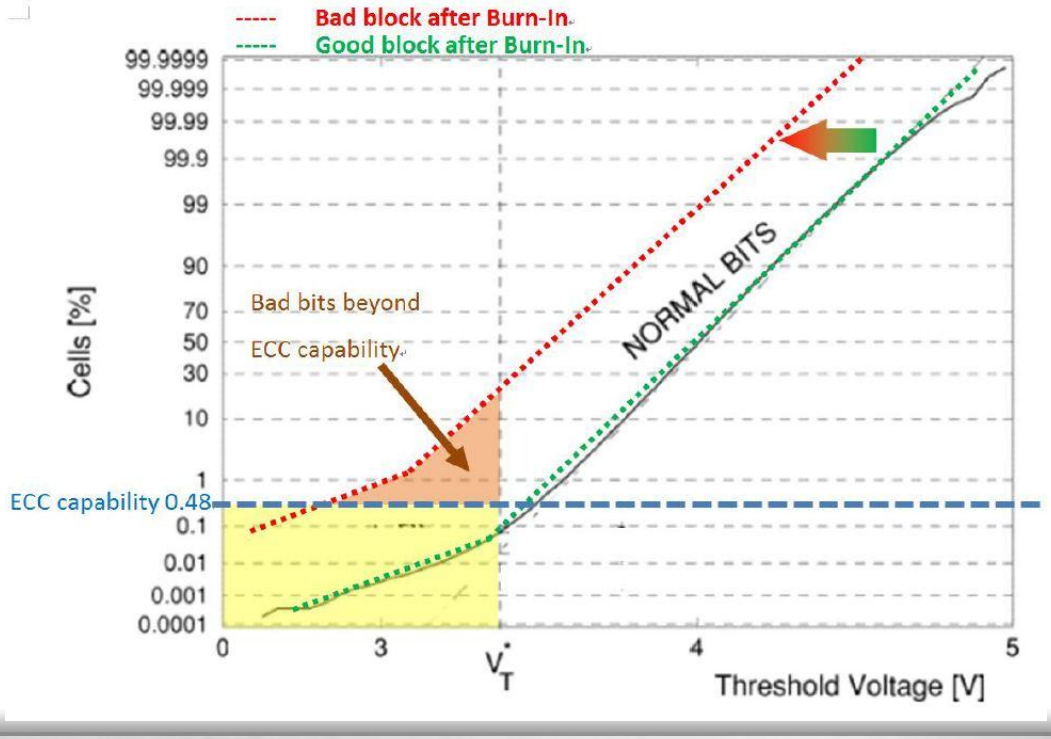


- **Take away:** The focus of the general NAND industry is **not aligned** with specific requirements of many embedded/industrial applications
- **Take away:** Despite the large resurgence of “industrial” SSD products made available, a traditional validation approach to simply integrating controller + NAND is **not sufficient**

The Factor of Timing and Dynamic Change

NAND Process Maturity

- Increasing difficulty of new process node ramp
- Variance of NAND RBER (Raw Bit Error Rate), and ELFR (Early Life Failure Rate) as process matures
- Variance in the same factors by wafer production lot/date code



The Factor of Timing and Dynamic Change

NAND Process Maturity

- **Take Away:** NAND and SSD validation should take into account the state of NAND process maturity. Along with the normal tolerance definition to account for NAND quality variance, there should be the proper production level screening mechanisms to ensure quality

NAND Process Change/Die Revision

- Not only do many characteristics of performance, reliability, and endurance change on the NAND component, but due to new management feature and ECC requirements, a new NAND controller is also commonly required along with the NAND change.
- In turn, with die changes many of the same aspects of initial qualification during NPI will need to be performed again during sustaining level qualifications.
- **Take Away:** It is a common mistake for sustaining level qualifications to underestimate the amount of affected change SSDs go through with a die revision. Under any such change, there should be open and transparent communication regarding product changes and possible effects to the host usage model.

The Factor of Usage Model Variance

Performance Validation

- Performance evaluation is another area which requires special consideration for embedded/industrial applications as compared to client/enterprise.
- Where enterprise/client SSDs benefit from a higher CE (chip enable) count and the greater ability to multiplex, embedded/industrial application SSDs trend towards **lower/middle densities** and a lower CE count. Further, as the mainstream mono NAND density grows to 128Gbit, lower/middle density SSDs are seeing a reduction in performance through revision change.
- Workload/usage model variation will also be a key factor in resulting SSD performance.

- **Take away:** For performance validation, the specific usage model should be evaluated at the specific density SSD and not by general datasheet. Under sustaining qualification, this needs to be re-evaluated assuming NAND/configuration + controller change

The Factor of Usage Model Variance

Endurance Validation

- NAND trending continues towards larger page size (8/16K) and embedded/industrial usage model are often utilizing much ***smaller*** file transfers. This can result in a very different write amplification factor and thus the endurance capability of the SSD.
- Further, many embedded applications are utilizing custom OS/host environments often without the benefits of TRIM/NCQ. Newer caching and DRAM features on the controller cannot be utilized to improve efficiency.
- Embedded/Industrial SSD applications are often read-only with little to no writing activity. In such situations, P/E cycling of the NAND becomes less of a concern and other factors such as data retention become more important.

- **Take away:** For endurance validation, the specific usage model should be evaluated specifically with a consultation back from the SSD vendor regarding strategies to maximize endurance.

Other Factors and Common Mistakes

Power Cycling/Stability Validation

- Data integrity under sudden down is relative.
- What type of data coverage features does an SSD employ? In flight data or only residual data? What are the recovery methods an SSD deploys and how this impacts performance upon the next power cycle?
- Don’t assume that a read only usage model does not have write activity to the NAND!

Reliability over Wide Temperature

- Many factors of endurance/reliability are dependent on temperature despite blanket operating temperatures stated on spec
- Data retention capability, read disturbance severity, and P/E cycling capability all vary by temperature.
- Other factors such as temperature ramp (rate of change) should also be considered

Other Factors and Common Mistakes

Common Mistake: One dimensional cost evaluation

- Commonly cost per density/GB is taken into consideration
- TCO (Total cost of Ownership) of a solution should include:
  - Cost per TBW/endurance
  - Re-qualification costs
  - AFR (Annual Failure Rate)

Common Mistake: Incorrect timing of BOM planning

- BOMs are often selected with recommended cost/availability timing during early NPI, but not ideal for later in mass production
- This may also result in redundant, multiple qualifications during NPI or even during mass production ramp

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