End to End NAND Flash Solution Selection and Configuration

Minimizing The Challenge of Embedded NAND SSD Implementations

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Overview

- The Challenge of Embedded SSD Implementation
  - Usage Model Variance
  - Untraditional usage models
  - Longevity/Reliability under Dynamic Change
  - Common Mistakes in Solution Selection
- 3 Areas of Solution Selection
  - NAND Configuration
  - Firmware/Setting Configuration
  - Host Setting Configuration
- Take Away Points

Usage Model Variance

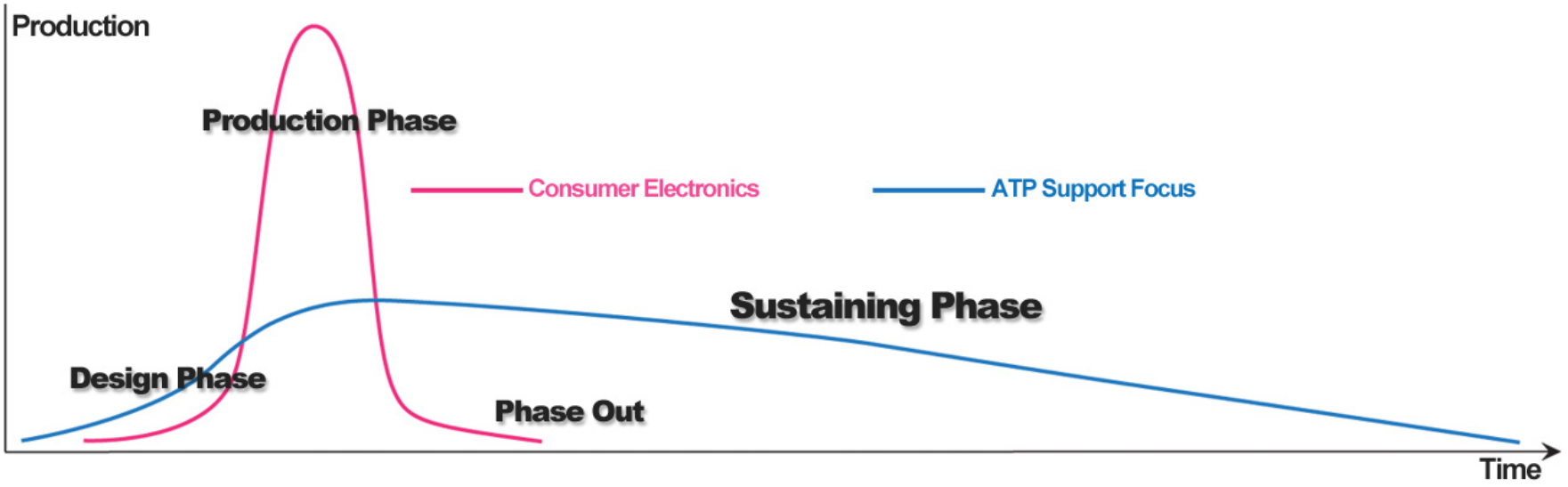
- Embedded SSD projects all vary in terms of:
  - File read/write Usage Model
    - File sizes
    - Static versus dynamic data
    - Examples
      - Boot Device: Read Only
      - Data Logging: Cyclic, small file write
  - Intended Environmental Conditions
    - Operating or Storage Temperature gradient/cycling
    - Humidity
    - Cold start
    - Vibration/Shock
  - OS/File system (often custom)
  - MISC Application Requirements
    - Fixed versus removable form factor + Frequency and manner of insertion
    - Power Cycling Requirements
    - Bandwidth/performance requirements

Untraditional Usage Models

- Untraditional usage for NAND
  - Certain requirements of SLC, but density/cost requirements of MLC
    - Example: Endurance requirements between MLC/eMLC, but high requirement for data retention
- Untraditional usage for Industry Standards
  - Form factors and protocol schemes developed for consumer usage
- Example: In Vehicle Infotainment: Navigation Data
  - Removability is required for future map updates
  - This usage model:
    - Mostly read with very little to no write
    - Small amounts of data commonly read, remaining data intermittently read
    - Focus on reliability under long term data retention over a wide temperature range

Longevity/Reliability under Dynamic Change

- The NAND/DRAM industry is fast moving with continuous evolution of IC architecture and manufacturing process.
- Embedded/Industrial Applications typically require:
  - Longer term, more costly validation/qualification
  - Increased liability and strict requirements for DPM failure rate
  - Increased sensitivity to stability and control on BOM



Common Mistakes in Solution Selection

- One dimensional cost evaluation, commonly cost per density/GB
  - TCO (Total cost of Ownership) of a solution should include:
    - Cost per TBW/endurance
    - Re-qualification costs
    - AFR (Annual Failure Rate)
- Insufficient re-evaluation of solution under die change
  - Solution/Density evaluation only under NPI, not under sustaining
  - Often sustaining level qualifications are simplified and inadequate
  - Densities and the solution itself often has to change upon die revision
- 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

3 Areas of Proper Solution Selection

- NAND Configuration
  - The first step is to select the right NAND + Controller solution with proper information exchange
- Firmware/Setting Configuration
  - With a hardware setup established, controller settings can be optimized and tested by project requirement
- Host Setting Configuration
  - In many cases, the host usage model or software configurations are fixed, but just as often there was simply a lack of information exchange on possible ways to optimize the host for more efficient and thus more cost effective usage of the storage device

NAND Configuration

- Information Exchange
  - Establish project reliability and performance hard requirements
  - Project usage model details must be communicated to the SSD vendor for analysis on WAI (write amplification index) efficiency
  - Project schedule and supply chain windows need to be established
- Evaluation of NAND options and density to establish cost effectiveness in terms of:
  - Cost per GB
  - Cost per Usage/TBW
  - Cost per longevity window
  - Satisfaction of project reliability and performance hard requirements

	TLC	cMLC	eMLC	IT MLC	SLC
Cost/GB	✔✔✔✔✔	✔✔✔✔	✔✔	✔✔✔	✔
Cost/TBW	✔	✔✔	✔✔✔✔✔	✔	✔✔✔✔
Data Retention	✔	✔✔	✔	✔✔	✔✔✔✔
tPROG	✔	✔✔	✔	✔✔	✔✔✔
Density Scalability	✔✔✔	✔✔✔✔	✔✔✔	✔✔✔✔	✔✔
Longevity Window	✔	✔✔	✔✔✔	✔✔	✔✔✔✔

Firmware/Setting Configuration

- Interface Mode
  - Many industry standards require support for different interface modes
  - Example: CompactFlash allows for UDMA/MWDMA/PIO, Fixed Disk/Removable modes.
  - Avoid a ‘trial and error’ scenario and establish the correct interface mode settings ONCE
- Density/Provisioning Settings
  - Duplication/content loading environment/requirements
  - Overprovisioning
- SSD Information Access
  - Usage/wear/health status
  - SMART command set settings for ATA devices
  - Special command set settings for other devices
- Special Algorithms or Functions
  - Special functions for encryption, serialization/keys, power cycling recovery
  - Special commands to trigger special SSD functions
  - Application specific special controller algorithms
  - eg. AutoRefresh techniques to combat data retention issues

Host Setting Configuration

- File Read/Write sizes
  - Page/block sizes continue to grow, but many embedded applications remain at very small file sizes.
  - The NAND flash/controller management unit size, block, and page sizes need to be communicated by BOM to allow for possible host optimization and improvement on WAI
- File System/OS
  - File systems and OS environments are often directly drafted over from a previous implementation on HDD and need to be revisited for SSDs.
- Host Response to SSD Health Status
  - Signal scheme to server or user based on SSD health status
  - Host usage mode response to SSD health status
- Avoid “Second guessing” the controller
  - Switching over from a discrete NAND implementation to a managed NAND solution often involves ‘deprogramming’ the host from trying to implement its own wear leveling and block level management algorithms

Conclusion

Take Away Points:

- With this increasing diversity of both NAND options and application specific controller setting/features, deeper considerations and additional information exchange should be included for the proper selection of a embedded NAND SSD. Factors that should always be discussed:
  - Usage model details
  - Project Longevity Requirements and sensitivity/cost to re-qualification
  - Cost metrics including Cost per TBW, Cost per longevity window, not only cost/GB.
  - Project NPI and ramp schedules
- Deeper collaboration with your embedded SSD vendor for proper information exchange for every ***qualification*** and even ***die revision***.
- Demand more active feedback from your embedded SSD vendor regarding your specific usage model and the appropriate most cost effective solution.

Conclusion

- **Follow up with ATP for more information on:**
  - Solution Selection Services:
    - Project TCO evaluation process which quantifies several solution options/densities.
    - Joint validation program involving joint testing processes at the system level
  - Information Exchange Services:
    - Quarter market updates and embedded SSD technology trends
    - NAND Validation/Testing Reports focused on embedded usage models, various environmental conditions and their associated NAND bit error rates
    - Solution whitepapers on specific failures encountered in the industrial and embedded application segments

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