Embedded Storage

The Next Chapter, 2015 and Beyond!

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Embedded Storage

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SSD Markets Defined

	Client/Consumer	Embedded/Industrial	Enterprise/Datacenter
Examples			
Platforms	Desktops, Laptops, Ultra-books, Tablets, etc.	"Fixed Function" Compute Systems	Servers, Storage Arrays
Usage	Mostly Read (70/30), 8hr Duty cycle, 10 to 50˚C 1 – 3Yr Service Life	Wide range of mixed Work loads, 24/7 Duty cycle, -40 to 85˚C, 8 - 10Yr Service Life	Read & Write Intensive, 1-5x DWPD, 24/7 Duty Cycle, 20 to 50˚C, 5Yr Service Life
Bottom Line	Price & Performance "Low Expectations"	Reliability, Endurance, LCM & TCO "Mission Critical"	Performance, Capacity, Green & Endurance "X Levels of Redundancy"

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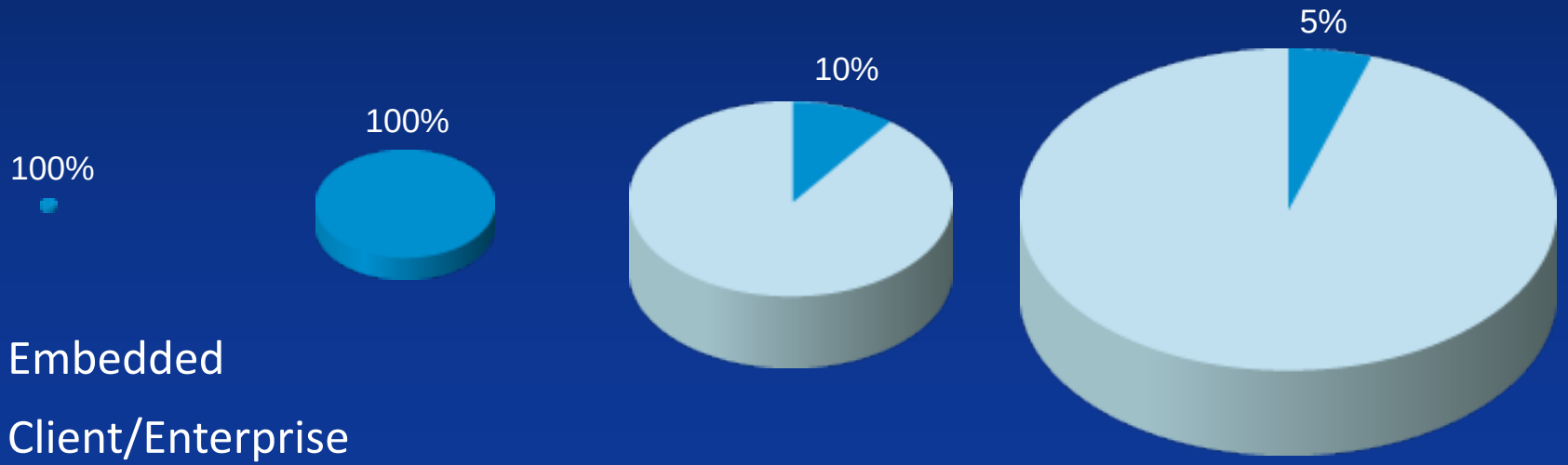
Historical Perspective

1992	2000	2010	2015
TAM $270M	TAM $10.6B	TAM $18.7B	TAM $30B (est.)
$22 / GB	$12 / GB	$1 / GB	$0.35 / GB



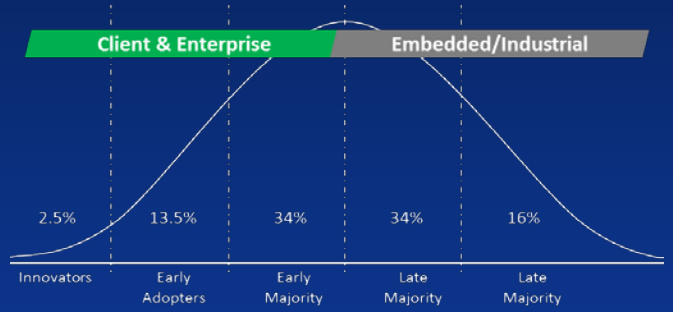
Embedded, A Closer Look

Embedded/Industrial Storage Market:

- Encompasses a broad range of applications and market segments
- Late Majority or Lag Consumer & Enterprise markets, in technology adoption from Interface to Form-factor to NAND technology
- Platform lifecycles (8 to 10 years) are not conducive to rapid changes in technology advancement
- Recent years show a steady, but cautious shift toward MLC NAND – driven by lower $/GB ASP

NetCom **Industrial**

Automotive



Key requirements are Reliability, Endurance, Lifecycle, Support and Cost

Reality Check?

Consumer/Client & Enterprise/Datacenter markets dominate the Global Storage market demand, and in turn, drive the technology available to support current and future Embedded Computing Storage applications.

Positives	Negatives
↓ Cost	↓ Reliability
↑ Density	↓ Endurance
↑ Performance	↓ Power Fail Safety
↑ Technology Adoption	↓ Lifecycle Management

Reliability

Background: MLC NAND price point drives avg. 3 to 4x reduction in ASP, but is not without strings

1xnm MLC vs. 2xnm SLC NAND				
Block/Page Size	P/E Cycles	ECC Req.	Read Cycles	RBER
4x/2x greater	94% fewer	25% greater	10x fewer	1 x103 greater

Problem: Often effects of higher operating temps are overlooked in terms of data retention degradation

Solution Set: Firmware Features

1. Autonomous Background Media Scan
2. Read Retry
3. Adaptive control required to maximize
4. Health Monitoring via S.M.A.R.T.

Embedded Applications are not known for managed airflow

NetCom – better understanding

Industrial – designed for temp extremes, but for how long?

Automotive – looking for 105˚C

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Endurance

Background: Embedded SSD's must support a broad range of use cases – from Read-only to 70/30 Read/Write to Write-Intensive.

Problem: JESD 219 does not address the majority Embedded Storage applications for Workload & Operating Conditions

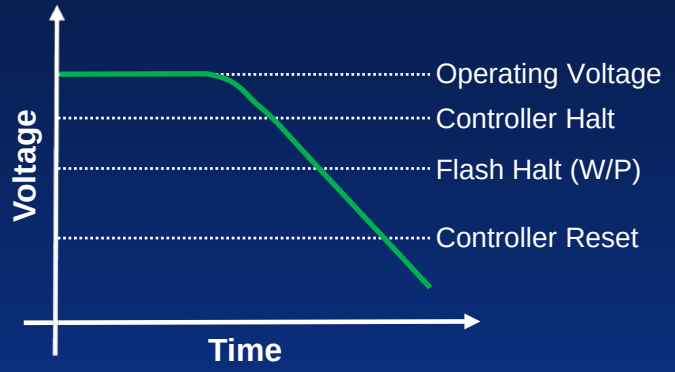
Solution Set:

1. Know the workload via analytical and/or empirical means
2. Not all Page-Mode FTL's are created equal (WAF)
3. Insure the behavior of the drive in last 3rd of life and beyond – UECC Management, Health Monitoring & Reporting and Fail Safe (Read Only with Read Refresh capability)

JEDEC JESD 219 Standard			
	Client	Embedded	Enterprise
Duty Cycle	8 hr/day (33%) @ 40˚C	??	24 hr/day (100%) @ 55˚C
Workload Random Sequential Repeated	24.36% 75.64% 0%	??	100% 0% 0%
Trim	Yes	Not Likely	No
Retention	1 yr @ 30C	??	.25 yr @ 40C
UBER	<1 sector in 10^{15} bits read	??	<1 sector in 10^{16} bits read

Power Fail Safety

Background: Embedded/Industrial applications require varying degrees of Surprise Power Failure tolerance – from minimal in-flight data loss ok to 100% no data loss.



Problem: MLC NAND (as compared to SLC) suffers from higher Read Disturb Sensitivity, Retroactive Data Corruption and Data Retention issues

Solution Set:

1. Managed Power Fail mitigation (inc. Host & Drive)
2. Optimized power down sequencing
3. Dedicated Pfail Circuitry

2015

- Embedded Flash Controller providers constantly challenged to improve both HW and FW features to enable lower cost media (NAND or other) solutions
- 2D planar NAND Development (SLC and MLC) has likely reached the end of the road
- 3D NAND is the new frontier to address Client/Consumer and Enterprise SSD markets, HDD Killer likely, but what about Embedded? If and When?
- SD, USB, eMMC, and SATA interfaces are primary choice for current platform design activity

And Beyond!

- Media – 2D transitions to 3D NAND for most applications, but Embedded will lag the greater market, …as usual
- Controller – ECC BCH (good enough), move to LDPC as required
- Supply Chain – Likely continued SSD supplier consolidation WW, know your Supplier/Partner AND their supply chain eco-system
- Form-factors – expect the trend to continue, follow the larger market lead - SATA, SD, eMMC, PCIe, UFS, …

Key Take-Aways

- The Semi's compete and serve the larger Consumer/Client and Enterprise/Storage markets, 3rd party Memory Module manufacturers are focused on the Embedded Storage Market

- MLC based storage solutions place greater responsibility on the Embedded System Designer to make informed decisions on the technology to be used

- Embedded Customers and Storage Solution providers must work closer to insure the selected storage solution meets the application needs throughout the intended service life

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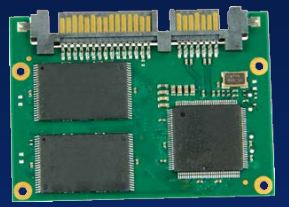
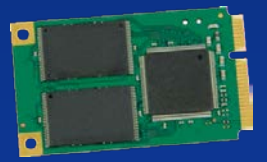
Quality is not an act, it is a habit.

Aristotle, 352 BC

Thank You!





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