

Rise of SSD in the Enterprise SSD Industry Report 2010

T A B L E O F C O N T E N T S

1 Executive Summary

1.1 Executive Overview

1.2 Storage Industry Dynamics

Computing Landscape – 1980 vs 2010

Closing the Price/Performance Gap in the Storage Hierarchy

Access Density: A Growing Problem

Memory Market Drivers

1.3 Market Status & Trends

Solid State Drives: Market Drivers

SSDs: When, Why and Where in the Computer Hierarchy?

SSD Today & Challenges

New SSD Market Segments – DRAM/SSD NVM vs. HDD/SSD Cache

1.4 Storage Market Segments & Product Requirements

Application Driven Enterprise Requirements

SSDs vs. HDDs: Features/Benefits, Competitive Pricing

Pricing Dynamics – Impact on SSD Market Demand

Price Driven SSD Market Demand Crossing over HDDs

1.5 Managing SSDs

Controllers managing BER, Endurance, LifeCycles, Wear ...

Emphasizing Total Cost of Ownership

1.6 Enterprise SSD Price Forecast

The Impact of Price Reductions

SSD Costs

Scale Out Model vs. Scale Up Models

1.7 Current Drivers & Inhibitors of SSD

Why SSD Acceptance is still limited

1.8 Emerging Technologies

MLC NAND, Phase Change

1.9 Futures

SSD Industry Roadmap 2010-2020

2 Market Drivers & Industry Dynamics

2.1 Customers requirements for NextGen Storage

2.2 SSDs: A shift in Data Storage

2.3 Killer Applications & Infrastructure for SSDs

2.4 SSD Myths & Facts

2.5 SSD vs HDD

Complexity of HDDs vs. Simplicity of SSDs

Real TCO - Leveraging SSD's advantage over HDDs

SAN TCO Savings using Intelligent Tiered Storage

Price & Capacity 2010

SSD vs. HDD Side/Side Comparison: Power Consumption, Performance, Total Cost of Ownership

SSD vs. HDD Side/Side Comparison: Replacement cost in Field Deployed System

2.6 SSD's Focus

Performance, Random I/O, Green,

- Replace/Coexist with HDDs as Primary Storage in Enterprise Apps
- 2.7 System Concerns & Mitigation**
 - Performance Concern
 - Endurance Concern
 - NAND Limitations
- 2.8 SSD Core Advantages**
 - Breaking the I/O Bottleneck
 - High IOPS, Lower Power Consumption, High Reliability/Non-Moving Structures
 - Avoiding Fragmentation Concerns
 - Latent Savings in TCO
 - Resistance to Environmental - Operating Temperatures, Shock & Vibration
- 2.9 Analysis by Key Metrics**
 - IOPS/\$/Watt
 - Performance: Response times, Random Reads vs. Random Writes
 - Impact of NAND cache on adoption of SSDs
 - Interfaces: IDE, ATA, USB, Fibre Channel, VME
 - Random Read Misses (RRM)
- 2.10 Futures**
 - The Holistic promise of SSDs: Critical Success Factors for NextGen SSDs
 - A new Growth Opportunity for Storage
 - March towards Commoditization - Gartner's HypeCycle 2010 vs 2007
 - NAND Prices/GB shot past DRAM in 2006, will catch HDD TCO by 2015
- 2.11 SSDs in PC Computing**
 - Evolution of Storage in Consumer Storage
 - Why consumer tiered storage ?
 - SSD Evolution & Penetration in Notebooks/NetBooks/iPads
 - NAND Flash as Cache
 - Significant improvement in boot time with new drive
 - Driving Factors: Power/Battery Life and Performance/Instant Boot Up
 - DIMM Packaging Simplifies FRU and User Experience
 - Cost of Ownership Analysis
- 2.12 SSDs in Enterprise Server Market**
 - Impact on Storage requirements from Virtualization, Multi-core Processors
 - Making SSD's Enterprise-Ready
- 2.13 Architectural Approaches in SSS**
 - What Applications really need from Storage?
 - Server Performance Comparisons – SSD vs HDD
 - SSD as caching and Hybrid Storage
 - SSD vs Flash vs HDD
 - SSD SATA-2 vs HDD: Overall Performance
 - SSD SATA-2 vs HDD in Application Loading, Gaming
- 2.14 Caching as a Solution**
 - Varying Response Times from differing SSD designs
 - Queue Depth
- 2.15 Tiered Storage Hierarchy**
 - Impact from SSD on Tiered Storage
 - SSDs Maximizing Bandwidth & Latency
 - Tier 0, 1 and 2
 - Managing Tiered Storage
- 2.16 Hybrid Storage**
 - Small SSD for performance, HDD for capacity
 - Economics of HDD vs. Tiered SSD/HDD solutions

3 Market Segments & Product Requirements

- 3.1 Real-World Application Workloads**
- 3.2 HDD vs. SSDs – Advantages & Issues**
- 3.3 Storage Requirements for PC and Enterprise Computing**
 - Consumer vs Enterprise Usage Expectations
 - Performance Requirements - Client vs. Enterprise SSDs

- When will SSD be in mainstream PC?
- 3.4 SSD Market Trends**
 SSD Technology Introductions over 10 years
 SSDs Enable New Growth In Enterprise Storage
 Enterprise Use Cases
- 3.5 “Enterprise Ready SSD”**^{©IMEXResearch}
 What is an “Enterprise Ready SSD”
 The continuum from Consumer to an “Enterprise Ready SSD”
 The metrics determining an “Enterprise Ready SSD”
 SLA Requirements for an “Enterprise Ready SSD”
- 3.6 Mainstream SSD Adoption in Enterprise Servers**
 Factors Impacting Server Performance, Reliability & Cost
 High Performance SSD & Benefit for Server Application
 Raw Media Performance
 Controller Performance Drivers
 Need for Pre-Conditioning
 Raw NAND Flash Media Reliability
 Reliability Management by Controllers
- 3.7 SSD Products Segmentation**
 Evolution of SSD Market Segmentation
 Hybrid SSDs
 Synergistic Integration of SSD & HDD
 SATA, PCIe Market Segments
 Access Bandwidth & Latency - Traditional vs. PCIe Attached SSDs
- 3.8 SSD Storage Fit in various Computing Environment**
 SSD as storage for SAN
 Blade Servers, Always-On Remote Logger, & Diagnostics
 Simple Plug-In SATA & PCIe Solid State modules & SSDs
 Distributed Flash Controllers Drive New SSD Topologies Economics of SSS
- 3.9 SSDs Performance in Horizontal Applications**
 OLTP: IOPS are key to OLTP & Database Transactions
 A Case for Flash Memory SSD overcoming HDD IOPS Crisis
 TPC-C Industry Benchmarks for OLTP - Read Only & Read Write TPS
 TPS change over time
 Mission Critical Applications
 Email/Exchange Applications
- 3.10 SSDs in Vertical Markets**
 Financial Databases, Government, Communications, Transportation
- 3.11 Application Workloads optimized using SSDs**
 Types of Clustered Storage
 Hybrid HDD/Flash Cache Economics
 Consumer Storage Opportunities Assessment
 Flash as Primary Store for 8x improvements for some workloads
 PCI-E versus SATA?
- 3.12 Real-Time, On Line Transaction Processing (OLTP) Systems**
 Banking - Charge Card Processing, Electronic Inter-Bank Transfers,
 Transportation - Reservations Systems,
 Financials/Wall Street -Algorithmic Trading, Currency Exchange and Arbitrage, Trade optimization,
 Other Real Time Transaction Processing Systems
- 3.13 E-Mail Servers**
 Internet Server Caching
- 3.14 Data Warehousing**
 Servers Requirements for Share and Share Nothing Data Warehouse Apps
 Database in Memory Architectures
 SSD Usage in Oracle - Exadata & Exascale/ IBM – Dataware & Netezza/ HP/ Teradata
 SSD Usage in Open Source Large Data Systems – MapReduce / Hadoop
- 3.15 High Performance Computing**
 Clustered Servers Requirements
 – Low Latency for Inter-Processor Communications & Lock-out

- High Bandwidth for Data Transfers
- SSD Usage for HPC Applications
- Data Modeling, Aerodynamics Design,
- Weather/Life Sciences, Nuclear Fission Models etc,
- Software Development

3.16 Web 2.0 Systems

Media Servers Video Production
 IP Video Surveillance,
 Video on Demand (VOD), HDTV
 Broadcast Video,
 Real Time Data/Feed processing,
 Contextual Web Advertising,
 Call Centers

4 Market Forecast & Shares

4.1 Market Trends impacting SSD Pricing

SSD Average Price Erosion \$/GB
 SSDs Enable New Growth In Enterprise Storage
 Enterprise Use Cases

4.2 Market Forecast for Handhelds, PCs and Servers (Units & Revenues)

4.3 SSD Market Forecast (Units, Revenues and GB)

Forecasts for HDDs vs. SSDs
 SSD Forecast for HHs and PCs (Units & Revenues)

4.4 SSD Forecast by Server Class by Environment

Server IOPS Requirements

- by size of Enterprise (Large/Midrange/Small)
- By Number of Employee in Enterprise

Enterprise SSDs Market Forecast

- Enterprise SSD Capacity Required by Servers & Storage Segments 2009-13
- Enterprise SSD Revenues by Servers & Storage Segments 2009-13

4.5 SSD Market Forecast by Horizontal Applications/Workloads

Latency & Bandwidth Requirements by Application
 SSD Market Forecast by Application (Units, Revenues, GB)
 Horizontal Applications mapped by IOPS and Bandwidth
 - OLTP, Business Intelligence, High Performance Computing, Web 2.0

4.6 SSD Market Forecast by Application Environment

Description of Applications
 Market Requirements by Application
 SSD Market Forecast by Application (Revenues, Units)

Computing/Data Processing

- PCs, Desktop, Notebook, Ultra-Portable
- Servers :
- Storage: DAS, SAN, NAS
- Networking: Routers, Switches, Base Stations

Industrial

- Process control (including subcategories)
- Test & measurement (including subcategories)

Military/Aerospace

- C3, Navigation, Weapons systems, Commercial aircraft

Communications

- High up-time applications

Consumer

- Set Top Box, Media Server, Video Servers

4.7 Markets for Non-NAND Solid State Products

- DRAM based Solid State
- NOR
- Impact on NAND SSDs

4.8 Special Niche Markets using SSDs unique features

- Low Power,

- Military,
- Reliability requirements,
- Size/Special Form Factor Requirements

5 Emerging Technologies & Standards

5.1 Flash Architecture

Anatomy, Resiliency, Pages, Blocks, Page States, Page becomes invalid
Flash Write: Reserve Capacity, Flash & Write Cache

5.2 Best Use of Flash, Flash and SP Write Cache

Best Practices: Flash Drives, EMC FAST Cache, EMC FAST, IBM

5.3 NAND in Computer Architecture

MLC and SLC Differences
NAND Reliability and Endurance
NAND Error Rate
SSD Reliability And Endurance
Endurance Factors, Wear-Leveling, Write Amplification
SSD Endurance Calculation, Capacity Effect on Endurance, Lifetime

5.4 Comparative Memory Cells

Micron 34nm, 32Gbit NAND
Rapid Scaling Driving Early Learning
NAND Will Adapt to the Market

5.5 Interface Optimization: Performance Comparison

5.6 SSD Block Diagram

5.7 Hybrid SSD Technology

Hybrid Wear Leveling Result
Standards
The Hybrid SLC+MLC Concept
Global Wear Leveling Technology
SMI SLC + MLC Hybrid Technology

5.8 Technical Issues

Managing the SSD – payload performance
Parts that make SSD enterprise grade?
Tracking Statistics for Endurance Monitoring & Life Prediction
NAND vs NOR, NOR vs Floating Gate
Multi-Level Cell Storage Cost Advantage
Erase Mechanisms
Code Flash Roadmap
NAND Bit Size Trend
Array Architectures
Scaling Challenge
SSD Interfaces: - IDE/PATA, SATA, Fibre Channel, SAS, PCI express

5.9 Overcoming SSDs' Quirks

Minimum Write Size
Slower Writes Than Reads
Inconsistent Performance

5.10 Standards

Building Standards for SSDs
Standards Help Improve Performance
Recently Developed SSD Interface Standards
NAND Optimizations: ONFI 2.0 HS-NAND

6 Ecosystem & Competitive Analysis

6.1 Ecosystem

Components, Boards, Drives, Controllers, Subsystems, Storage Systems, Distribution Channel,
Money Flows & Profit Margin Analysis:

– - Components>Devices>Subsystem>System>System Integrators>VARs>End Users

6.2 Basis of Competition/Positioning

- Technologies Deployed
- Product Lines and Capabilities by CAPSIMS Metrics
 - Capacity, Availability, Performance, Endurance, Scalability, Interoperability, Manageability, Security
- Manufacturing Capabilities
- Go-to-Market Channels of Distribution
- Financials (Rev, Margins, Profitability)
- 6.3 Supply Chain Ecosystem**
- 6.4 SSS based Systems by Usage by Manufacturers**
 - Consumers
 - Computer, Storage & Data Networking Systems
 - Communications Systems
 - Industrial/Military/Aerspace Systems

7 Supplier Profiles

- 7.1 Vendor Profiles**
 - Each vendor profile contains: Overview, Product Offerings, Strengths/Weaknesses, Outlook, Business Model, Competitive Positioning, Product Offerings, Key Markets, Revenue Estimate, SWOT Analysis, Product Line, Est. shipments by form factor
- 7.2 SSD Components Suppliers**
 - TSMC,
- 7.3 Semiconductors/ASICs**
 - Powerchip Semicon, ...
- 7.4 Flash Memory/SSD Device Manufacturers**
 - Hynix, Intel, Numonyx, Micron, Samsung, Toshiba ...
- 7.5 SSD Controller Manufacturers**
- 7.6 SSD Plug-In Modules**
 - Kingston, SMART Modular/Adtron,
- 7.7 SSD based Storage System Manufacturers**
 - WD/SilconSystems, SuperTalent, OCZ, Seagate, Texas Memory Systems,
- 7.8 SSS Integrators Profiles**
- 7.9 Military Industrial Systems using SSD**
 - Applications: Curtiss Wright, Raytheon, Datalight, Lockheed-Martin,
- 7.10 SSD Vendor Profiles (98 Vendors)**
 - Adesto, Adtron, Apacer, Atmel, ATP, SilconSystems, Avalanche, Axon Technologies, BAE Systems, Bit Micro, Celis, Ciprico, Contour Semicon, Crocus, Cypress, Elpida, Everspin Freescale Semicon, Fujitsu, Grandis, Harris, Hewlett-Packard, Honeywell, Hynix, IBM, IMEC, Inc., Infinite Memories, Innovative Silicon, Intersil, Macronix, MagIC, MagSil, Matsushita, Maxim, Microchip, msystems/SanDisk, Nanoco, Nanosys Nantero, NEC, Northrop Grumman, NuPGA, NVE, NXP, Oki, ON Semicon(Catalyst), Ovonyx, P-Flash/Chengis, , QsSemicon, Ramtron, Renesas, Rohm, Samsung, Samsung, SanDisk, SanDisk, Schiltron Sharp Semicon , Simpletech, Smith Industries, Solexis, Solvay , Sony, Spansion, Spin Transfer Techn, Spingate Technology, SST, STM, Symetrix, Targa, TEAC, Texas Instruments, Thin Film Electronics ASA, Tower Semicon, Transcend, UMC, Unity Semicon, Vision Technologies, White Electronic Designs, Winbond, Winstation, Wintek, Zetta

8 Go-to-Market/Channels of Distribution

- Critical Success Factors for SSD Business
- Demand Generation
- Revenues Flows in the SSD Supply Chain
 - OEMs
 - Channel: Distributors, System Integrators, VARs, VADs
- Gross Margins in the SSD Supply Chain by Level
 - OEMs
 - Channel: Distributors, System Integrators, VARs, VADs

9 Futures & Recommendations

9.1 The Road Ahead for Flash Memory/SSD Applications

A Fresh Perspective

Emerging Standards

NVMHCI – Coming Out From Behind the Curtain

The Holistic Approach to Storage

A new Growth Opportunity for Storage

March towards Commoditization - Gartner's HypeCycle 2010 vs 2007

NAND Prices/GB shot past DRAM in 2006, will catch HDD TCO by 2015

9.2 Recommendations

For Vendors (Components/Drives/Subsystems/Clients & Server Systems)

For Channel (Service Providers/System Integrators/VARs/Distributors)

For End Users By Applications (Horizontal – OLTP/Business Intelligence/HPC/Web 2.0 Apps)

For End Users By Vertical Industries (including specific needs by Verticals)

For Investments (VCs, Investment Banking)

9.3 Futures

Critical Success Factors for SSD Business

10 Méthodology & Appendices

10.1 IMEX Research Product & Market Segmentation Definitions