Process Challenges in the Hard Drive Industry

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HDD Industry Dynamics

- Continuing push on Areal Density
  - TPI increasing
  - BPI Increasing
  - Fly Height Decreasing
  - Transition to Perpendicular

- Increased presence in CE sector
  - Increased mix of Form Factors – no longer Niche for sub 2.5 inch (0.85, 1.0, 1.8)
    - Process Capability and Flexibility
    - Cost vs Competing Technologies

- Increasing Quality Targets
  - Increased focus on DPPM and reliability for major integrators
    - 1000 DPPM in ’03 with a target of < 200 DPPM in ’06
  - Existing Test Philosophies being challenged for CE sector
    - Contradiction between low cost and increased environmental demand

- Cost under increasing pressure
  - Process Time
  - Cost of Ownership
  - CE Presence
Xyratex

Technical Capability

Machine/system Efficiency

Operational Efficiency and Scale

Customer

Process capability

Quality Products

Time To Market

Competitive costs

Flexibility and agility

Growth capability

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HDD Process Overview - Production Test

- Wafers
- Head Fabrication
- Head Gimbal Assembly
- HGA Test
- Head-stack Assembly

- Substrate
- Media Manufacturing
- Burnish & Glide
- Certification

- Motor & Coating

- Head-Disk (HDA)
- Servo Track Writing
- Final Assembly
- Production Test
- Pack & Ship

- Head

- Disk

- HDD

- HDA
Production Test - Thermal Performance

<table>
<thead>
<tr>
<th>~1998</th>
<th>~2002</th>
<th>~2006</th>
</tr>
</thead>
</table>
| **Shared Environment**  
**Air cooled system**  
- Range 35 → 55 °C  
- Accuracy ~ ± 5 °C | **Single Environment**  
**Water cooled system**  
- Range 25 → 70 °C  
- Accuracy ~ ± 2 °C | **Single Environment**  
**Thermo Electric Cooling (TEC)**  
- Range -10 → 85 °C  
- Accuracy ~ ± 1 °C |

Production Test - Vibration Performance

<table>
<thead>
<tr>
<th>~1998</th>
<th>~2002</th>
<th>~2005</th>
</tr>
</thead>
</table>
| **Hard coupled matrix of slots**  
**Hard ‘wedge’ mounted drives**  
- Crosstalk became an issue for new drives  
- 0.09 Rad/s/s @ 500Hz | **Individual Hard mount**  
**Constrained layer springs**  
- Less Crosstalk  
- System vibration effects becoming an issue for new drives  
- 0.02 Rad/s/s @ 500Hz | **Individually isolated soft mounts**  
**Offset Pivot Technology**  
**Vibrationally Decoupled Fans**  
- Servo-fill capable – in automated system  
- 0.006 Rad/s/s @ 500Hz |
Production ‘Test’ – Process Evolution

120 Drives

>2000 Drives

HDD Process Overview - Servowrite

Head

- Wafers
- Head Fabrication
- Head Gimbal Assembly
- HGA Test
- Head-stack Assembly

Disk

- Substrate
- Media Manufacturing
- Burnish & Glide
- Certification
- Media Writing

HDA

- Servo Track Writing
- Motor & Coating

HDD

- PCB Assembly
- Final Assembly
- Production Test
- Pack & Ship
Servo Writer Technology

Xyratex Hi-Speed / Hi-Density ServoWriter CORE Technology

Xyratex

Hi-Speed / Hi-Density ServoWriter
CORE Technology

200MHz

400MHz

600-800MHz

Xyratex High Performance Conventional Servo Writer Systems

Self Servo / fill systems

Rack and media writer

Disk Automation & Optics

Customer IP

Customer IP

Customer IP

Media Writers

Printing

Disk Automation
Optics

Partnering

HDD Process Overview - Disk Certification

Motor & Casting

PCB Assembly

Final Assembly

Production Test

Pack & Ship

HDA

HDD

HDA

HDD

Wafers

Head Fabrication

Head Gimbal Assembly

HGA Test

Head-stack Assembly

Substrate

Media Manufacturing

Burnish & Glide

Certification

Servo Track Writing

Xyratex Confidential
**Optical Certification – Xyratex Solution**

*Differential Scanning Fabry-Perot (DSF)*

Based on standard Laser Technology

Non Contact Optical Probe

- 0.5 mm above surface
- 4 um spot size
- 20Mbit sampling rate
- 10,000 rpm

100% surface coverage in 40 seconds

[Prototype Heads]

**Optical Certification - Scratch**

Substrate Scratch

AFM Scan:

- 0.33 um wide
- 12.2 nm deep

[Xyratex Scan]

Small pre-sputter defects easily detected

Compromise between scan speed and defect resolution
**Media Test Time Trends**

### Media Certification Times

<table>
<thead>
<tr>
<th>Legacy Workcell</th>
<th>MGA Workcell</th>
<th>XTA</th>
<th>X700</th>
<th>Dedicated Automation</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 Spindles/WC</td>
<td>8 Spindles/WC</td>
<td>12 Spindles/WC</td>
<td>4-6 Spindles</td>
<td>1 Spindle/WC</td>
</tr>
</tbody>
</table>

**HDD Process Overview - Precision Cleaning**

- **HDA**
  - Motor & Casting
  - Head-Drive Assembly
- **HDD**
  - PCB Assembly
  - Final Assembly
  - Production Test
  - Pack & Ship
- **Disk**
  - Servo Track Writing
  - Head-Disk Assembly
- **Head**
  - Wafers
  - Head Fabrication
  - Head Gimbal Assembly
  - HGA Test
  - Head-stack Assembly
  - Pre-sputter Clean
  - Burnish & Glide
  - Certification
  - Rough & Fine Polish Clean
Production ‘Clean’ – Tool and Process Evolution

1985
Single Standalone Scrub

240 DPH

2005
Fully Automated Multi-module System

2400 DPH

1985
Single Standalone Scrub

2005
Fully Automated Multi-module System

• 2000
  • Stainless Steel or PFA
  • 4-sided weir + QDR
  • 100 disk load
  • Frequency 950 KHz
  • Power in 3600 Watts

1994
• 50 disk load
• Stainless Steel
• 3 sided weir
  • Frequency 68 KHz
  • Power in - 600 Watts

~ 2006
• PFA
• 100 disk load

Sonic Clean
Performance Trends and most advanced tanks configurations

~ 2006
• PFA
• 4-sided weir + QDR
• 100 disk load
• Frequency 950 KHz
• Power in 3600 Watts
Advanced Cascade Scrubbing – 2400 DPH

Example of equipment extendibility

Media Manufacturing Requires Flexibility
Thank You
for your attention

Storage and Network Technology