Imation Invests in the Future of Data Storage

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James A. Goins
Senior Specialist, Magnetic Media

THIC Meeting - October 26 – 27, 2004
Imation is...

- A worldwide leader in removable data storage media for more than 50 years, since the introduction of the first data storage reel-to-reel tape in 1953 by IBM and 3M.
- Imation was created in 1996 as a result of the spin-off of several separate businesses, including those that comprised 3M’s Data Storage Division.
- Headquartered in Oakdale, Minnesota, with 2,800 employees globally and $1.163 billion in 2003 revenue, Imation’s products reach customers in more than 100 countries, with 60% of revenue from outside the U.S.
- Imation is the only US-based manufacturer of removable magnetic and optical data storage media.
- Listed on the NYSE under the ticker IMN.
To be the recognized leader in removable data storage media

The trusted source for digital storage of information important to consumers and businesses alike

The independent experts in data storage back-up, archiving, security and protection
Imation’s Discovery Technology Center

- Imation is the only US-based manufacturer of removable magnetic and optical data storage media.
- 423,000 square foot state-of-the-art technology development center focused on data storage removable media
- $15 million pre-production coater for next generation magnetic tape
- Next-generation optical media lab
- 300 scientists and more than 330 data storage patents in the U.S.
• State-of-the-art manufacturing facilities
• All plants certified to new ISO 9001:2000 standards
Imation’s Advanced Global Technical Centers

- Oakdale, Minnesota (HQ)
- Neuss, Germany
- London, Ontario, Canada
- Tokyo, Japan
- Beijing, China
Introducing Imation’s Tera Ångstrom Technology
Weatherford is the world's first terabyte-class tape facility built specifically for the development of next-generation tape products.

- $50 Million Investment in new Tera Ångstrom™ coating capability
- The single largest capital investment to date in Imation’s history
- Demonstrates our commitment to invest in leadership manufacturing technology capabilities
- The path to Terabyte class media
- Cornerstone for the future development of terabyte-capacity tape media
Site Overview

Community
Weatherford Population - 10,000
Southwestern Okla State University - 5,000

2 Buildings
Frequent awards for environmental leadership from the State of Oklahoma
Located on 120 Acres
185,000 Sq. Ft.
   42,300 Sq Ft Class 10,000 Cleanroom
   46,200 Sq Ft Coating
   29,400 Sq Ft Warehouse
   24,000 Sq Ft General Production
   21,500 Sq Ft Support
   21,000 Sq Ft Office
Core Technologies

- Milling
- Thin Film Coating
- Thin Film Slitting
- Servo Writing
- Failure and Defect Analysis
Weatherford Facility Expansion

- 12/15/02 construction begins
  - 365,000 construction hours
  - 140,000 engineering hours
- 12/1/03 building complete
- 2004 qualification and commercial production
Weatherford Quality Systems

Modeled after International Standards Organization (ISO)

<table>
<thead>
<tr>
<th>Certification</th>
<th>Number</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO Certification</td>
<td>9002</td>
<td>1991</td>
</tr>
</tbody>
</table>

**Key Elements:**
- Quality Management System
- Management Responsibility
- Procurement
- Manufacturing Operations
- Measurement, Analysis & Improvement
- Customer Satisfaction
Quality is Core

• Quality management begins with raw materials
• Imation’s Total Quality and Process Management leverages:
  – New product and process development discipline
  – Statistical process management
  – Six Sigma principles and tools
• FADA lab (failure analysis/defect analysis)
• Easy access to data - online use of control charts
Automated Raw Material Charging

Technology Highlights:

- Automated Material Batch Charging
- Consistent / Repeatable Additions
- Recipe Driven / Data Logging
- Dedicated Raw Material Bins
- Segregated Travelling Scales by Layer
Technology Highlights:

• Consistent w/in Batch Milling
• Narrow Particle Distributions
• Closed Loop Control
• Minimal Retain
• Dedicated RM Delivery Systems
• Portable - “Clean in Place” Kettles
• Dispersion Delivery Sized for Small Diameters / High Velocities
Coater Cleanroom Design

Technology Highlights:

- Minimal Human Influence in Process
- Easy Access for Maintenance
- Smaller Volumes to Keep Ultra Clean
- Cascading Pressurization
- On-Line Particle Monitoring
The Demand for Storage is Increasing

More Data will be created in 3 years than in the previous 40,000 years combined!

1 Petabyte = 1024 Terabytes
Source: UC Berkeley, School of Information Management and Systems.
Why Tape?

- Magnetic Tape has been around for over 50 years.
- End Users continue to demand more storage.
- Magnetic media is still the most cost-effective storage method.
- More data is being generated and storage is required.
- For example...

### Tape Storage Progression

<table>
<thead>
<tr>
<th>Year</th>
<th>Model</th>
<th>Storage Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980's</td>
<td>3480</td>
<td>54” of tape stores a 500 page novel</td>
</tr>
<tr>
<td>1990's</td>
<td>3590E</td>
<td>24,900 books on a cartridge with 2,070’ of tape.</td>
</tr>
<tr>
<td>2000’s</td>
<td>Ultrium 2</td>
<td>124,500 books on a cartridge with 2,000’ of tape.</td>
</tr>
<tr>
<td>2000+</td>
<td></td>
<td>622,421 books on a cartridge with approximately 4,000’ of tape.</td>
</tr>
</tbody>
</table>
The Evolution of Magnetic Tape Technology
Greater than 1TB Capacity Cartridges

• What do we need to increase capacity?
  – Increase bit density
    • smaller pigments
    • smoother surfaces
  – Increase track density
    • Dimensional stability
    • Read/ write element dimensions
    • Tape transport
  – Increase tape length in cartridge
    • Thinner substrates
    • Thinner coatings
    • Dimensional stability
Three critical technology advancements need to occur to increase capacity of tape technology.

<table>
<thead>
<tr>
<th>Technology Advancements</th>
<th>Level of Advancement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Track Density</strong></td>
<td></td>
</tr>
<tr>
<td>• Precision in servo writing/slitting processes</td>
<td>~ 265-400%</td>
</tr>
<tr>
<td>• Track following: tape path design</td>
<td></td>
</tr>
<tr>
<td><strong>Bit Density</strong></td>
<td></td>
</tr>
<tr>
<td>• Media Output, SNR, Low Errors</td>
<td>~ 200-240%</td>
</tr>
<tr>
<td>• Data Channel Encoding/De-cording Efficiency</td>
<td></td>
</tr>
<tr>
<td><strong>Length of Tape per Cartridge</strong></td>
<td>~ 25%</td>
</tr>
<tr>
<td>• Thinner Substrate</td>
<td></td>
</tr>
</tbody>
</table>

*Increased bit and track density are enabled by smaller consistent particle sizes that are precisely orientated and tightly compressed to fit more bits on a set length of tape.*
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Single Layer MP-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150 nm, 1500-1700 Oe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dual Layer MP-2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 nm, 1800-1900 Oe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dual Layer MP-3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75-90nm, &lt; 2600 Oe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Dual Layer MP4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60 nm, 2500-2700 Oe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dual Layer MP5 - Development</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40-45 nm, &lt;2700 Oe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dual Layer MP6 - Research</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-35 nm, &lt;2200 Oe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thin Film Sputter Deposition (MTS) - Research</td>
<td></td>
<td></td>
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</tbody>
</table>

A generation of technology is defined by improvement in Signal to Noise Ratio of 2-3 dB
MP Size Migration

MP1: Average length 0.15 micron

MP2: Average length 0.10 micron

MP3: Average length 0.075 micron

MP4: Average length 0.06 micron
## Media Requirements Migration Path

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>MP 2</th>
<th>MP3</th>
<th>MP4</th>
<th>MP5</th>
<th>MP5/6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Max Native Capacity</strong></td>
<td>GB</td>
<td>100</td>
<td>200</td>
<td>400</td>
<td>1 TB</td>
<td>2 TB</td>
</tr>
<tr>
<td>Mag Layer Caliper</td>
<td>Nanometres</td>
<td>12</td>
<td>120-180</td>
<td>120-180</td>
<td>70-80</td>
<td>30-45</td>
</tr>
<tr>
<td>Substrate Caliper</td>
<td>24ga</td>
<td>24ga</td>
<td>24ga</td>
<td>18-24 ga</td>
<td>12-18 ga</td>
<td></td>
</tr>
<tr>
<td>Substrate Material</td>
<td>PEN/PET</td>
<td>PEN</td>
<td>PEN</td>
<td>PEN/PET</td>
<td>Aramid?</td>
<td></td>
</tr>
<tr>
<td>Mag Surface Roughness</td>
<td>Ra nm</td>
<td>4-6</td>
<td>4-5</td>
<td>4-5</td>
<td>3-4</td>
<td>2-3</td>
</tr>
<tr>
<td>Bit Density</td>
<td>Kbpi</td>
<td>90 -180</td>
<td>180-220</td>
<td>200-250</td>
<td>250-300</td>
<td>&gt;300</td>
</tr>
<tr>
<td>Data Tracks</td>
<td>in 1/2&quot; wide</td>
<td>300-400</td>
<td>500-600</td>
<td>500-600</td>
<td>1000-2000</td>
<td>&gt;2000?</td>
</tr>
<tr>
<td>Write Track Width</td>
<td>Microns</td>
<td>27</td>
<td>15</td>
<td>15</td>
<td>7-10</td>
<td>&lt;7?</td>
</tr>
<tr>
<td>Read Track Width</td>
<td>Microns</td>
<td>12.5</td>
<td>7</td>
<td>7</td>
<td>3-5</td>
<td>&lt;2?</td>
</tr>
<tr>
<td>R/W Tape Speed</td>
<td>Meters/sec</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4-8</td>
<td>&gt;8?</td>
</tr>
</tbody>
</table>

Trending towards thinner substrates......
Imation’s Tera Ångstrom™ Technology achieves a surface smoothness and uniformity that allows for increased bit and track density to realize increased storage capacities. This revolutionary and proprietary metal particulate advanced coating formulation and process allows Imation to develop and manufacture high quality, high capacity media leading to terabyte-class storage capabilities.
1. Impingement process to reach nanometer size particles using >10,000 psi, high-pressure jets.

2. Quiescent drying process with low air velocity and magnetic coils to achieve high degree of particle orientation

3. In-line calendering process to achieve surface smoothness on the order of Ångstroms.
1. Impingement Process
Impingement Process - Nanometer Particles

More uniformity and smaller size with I-MUF technology

Cumulative Particle Concentration (#/ml)

Size (micron)

Lower Detection Limit (10 counts)
Dispersion and Viscosity Control

- IMUF Impingement Process in Parallel with Imation’s Proprietary Dispersion Delivery System
  - Uses high-pressure (>10,000 psi) impingement jets to force particles against each other blasting apart the magnetic clusters to separate them into nano-sized elements.
  - Accurately controls time between high shear impingement process and coating application
  - Close proximity to coating head
  - Provides consistent viscosity to coating
  - Eliminates the need for pumps which cause
    - flowrate & pressure disturbances leading to downweb thickness changes
    - Stagnation and Contamination

Magnetic Dispersion Viscosity as a Function of Time after Exposure to the Impingement Process and the Magnitude of the Shear Rate

<table>
<thead>
<tr>
<th>Shear Rate</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.18/sec.</td>
<td>+/- 5.0</td>
</tr>
<tr>
<td>11.7/sec.</td>
<td>+/- 0.3</td>
</tr>
<tr>
<td>118/sec.</td>
<td>+/- 0.06</td>
</tr>
<tr>
<td>1,170/sec.</td>
<td>+/- 0.04</td>
</tr>
</tbody>
</table>
2. Quiescent Drying Process

Quiescent Drying
Low turbulence drying chamber creates uniform particle orientation

Magnetic coils orient particles

Magnetic coated base film
2. Quiescent Drying Process

**Quiescent Drying**

Low turbulence drying chamber creates uniform particle orientation

Magnetic coils orient particles

Magnetic coated base film

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Patent #: US 5813133  
Issue Date: 29 Sep 1998  
Title: Coated substrate drying system with magnetic particle orientation

Patent #: WO 9957499 A1  
Issue Date: 11 Nov 1999  
Title: Controlling float height of moving substrate over curved plate

Patent #: US 6134808  
Issue Date: 24 Oct 2000  
Title: Gap drying with insulation layer between substrate and heated platen

Patent #: US 6256904 B1  
Issue Date: 10 Jul 2001  
Title: Controlling float height of moving substrate over curved plate
Imation LTO2 sample with Quiescent drying & magnetic coil orientation; OR 3.3

Competitive LTO2 product; OR 2.2

SEM Images: 40,000x
3. In-line Calendering Process

Ultra-smooth Calendering Rolls with <200 Å surface finish

Compresses the media to achieve Ångstrom scale surface smoothness
AFM Image of Imation LTO2 POR

**Ra:** 4.0 nm

AFM Image of Imation 1 TB target media using Advanced MP Coating Technology in Discovery pre-production facility

**Ra:** 2.4 nm

100 µm x 100 µm scans, vertical scale 100 nm/div
Smaller consistent particle sizes that are precisely orientated and tightly compressed.
Imation Tera Ångstrom™ Technology Advantage

- **Capacity**
  Increased capacity through bit and track density improvements

- **Transfer Rate**
  Increase capacity also demands an increase in transfer rate. Imation’s proprietary processes will help media/drive systems achieve 50-80MB/second transfer rates

- **Performance**
  High SNR and consistent signal strength ensures efficient processing time

- **Reliability**
  Surface uniformity (smoothness) and higher SNR allow for accurate data reading

- **Quality**
  State-of-the-art quality practices incorporated throughout the facility
Imation’s unique Tera Ångstrom™ technology is based on three proprietary techniques used to produce high-capacity tape products.

– The tape coating process begins with Imation’s proprietary impingement process. Imation’s process utilizes high-pressure (>10,000 psi) impingement jets to force particles against each other blasting apart the magnetic clusters to separate them into nano-sized elements.

– To enable precise particle orientation during the drying stage, Imation’s proprietary quiescent drying process creates a delicate environment using low air velocity and magnetic coils for precise particle orientation.

– The in-line calendering process incorporates a stack of rollers with an ultra-smooth finish to compress the tape to achieve surface smoothness on the order of Ångstroms.

– Imation Tera Ångstrom™ Technology enables increased bit and track densities to enable higher capacity tape technology with a faster time-to-market.
Imation is Focused on the Future

- U.S. headquartered media manufacturer
- Imation is investing in:
  - R&D
  - Manufacturing capabilities
  - Quality
- Imation’s Terabyte-Class tape manufacturing facility investment will support the tape industry into the next decade and beyond
Thank you!