tapestry®
storage at the speed of light
World Leader In Holographic Data Storage

- **2007** 1st commercial shipments of drive and media

- Spin off of Lucent’s Bell Labs
  - 170+ patents & disclosures in holographic material and recording technology
  - 515 Gb/in² aerial density demonstrated in 2006-Q2, highest of any technology

- ~125 employees extensive experience in world-class storage and holography

- Primary supplier of holographic media & test equipment to world-wide optical drive development companies

- Orders in-house from major end-users in storage services, government, broadcast

- Channel development underway
  - Signing OEM and VAR agreements

- Over $64 million in venture capital funding
  - Corporate investors: Hitachi Maxell, Bayer MaterialScience
Holographic Data Storage.....

*Unique in every way*

A blend of photography and digital recording

- The drive is a digital data-camera that records images of bits
- The media is film-like; but is only sensitive to a particular wavelength – blue laser (405 nm)
InPhase Technologies Milestones

The world’s undisputed leader in holographic data storage

- Now a provider of IP, media, and testing equipment to >95% of companies working on holography worldwide.
- World’s first broadcast from holographic storage – Turner Broadcast October 2005
- Passed magnetic disk aerial density -515Gb/sq. in., Q1 2006
- 65 patents & 105 applications/disclosures – 170 total
Holographic storage developers

• Inphase is primary supplier of media, test systems and consulting to other researchers of holographic storage (22 companies)

• Primary focus is on a consumer product

• Major optical companies now investing
  • Daewoo, pioneer, sony, toshiba, fujitsu, JVC, NHK, samsung, sharp, thompson

• Time to market is 3-5 years beyond inphase
Over 600% data growth 2006 – 2010

¼ is original – email, transactions, pictures, phone calls

¾ is replicated – emails forwarded, back-ups and archives, movies

Stack of books lined up for 1.1 billion miles; 6 round trips between the Earth & the Sun

2006

161 Exabytes

988 Exabytes

Stack of books lined up for 7.4 billion miles; round trip from the Sun to Pluto

2010

Source: IDC - The Expanding Digital Universe, March 2007
“One promising next-generation optical storage technology is **holographic** storage, which promises very stable long term storage in very dense packages. The first commercial holographic products should be available this year.” IDC
Archive applications in target markets

- **Health sciences**
  - x-rays, MRIs
  - surgical procedures
  - pharmaceutical trials
  - fixed content

- **Government**
  - national archives
  - copyright archives
  - space imagery
  - surveillance & security
  - fixed content

- **IT**
  - generic archive
  - check imaging
  - insurance claims
  - seismic data
  - weather models
  - fixed content data

- **Professional video**
  - acquisition
  - post production
  - digital intermedia
  - digital asset management
  - deep archive

- **Compliance**
  - SOX
  - SEC 17 a-3
  - email archives

  - HIPAA

  - US Patriot Act
Customer interest

Over 1200 leads are being qualified
Characteristics of a holographic storage customer

- Content is the company’s asset
  
  Examples: Geological and seismic data, movies, weather modeling, research data

- Creation of content is expensive
  
  Examples: Satellite images, movies, military surveillance, clinical trials

- Value of content often increases over time
  
  Examples: Satellite images, movies, medical history, research data

- Archive expectations are “forever”
  
  Examples: Satellite images, movies, news, sports, scientific data
Technology/Roadmap
Holographic Recording Is Optical Data Storage But In A 3-dimensional Format

1. Recording
   - Reference Beam
   - Signal Beam
   - The intersection of two beams creates an interference pattern of bright and dark regions.

2. Recording
   - A photosensitive medium records the interference pattern.

3. Recording
   - The hologram is the image of the interference pattern stored within the medium.

4. Reading
   - Light from one beam shining on the hologram reconstructs the data pattern.
A holographic data page (1.4mb) looks like this
How does holographic storage work?

- **How are data recorded?**
  The bits are encoded into an array of > 1 million pixels (page) recorded into the media via a laser.

- **How is capacity achieved?**
  Hundred pages are recorded in the same location in the media, each with its own angular address.

- **How are transfer rates achieved?**
  The entire array (page) is exposed for ~ 2 milliseconds.
  The media does NOT move while data are being recorded or recovered.
Basic Drive Recording & Recovery Optics

Each Page has unique address “angle” within a book

Inverse read-out/data recovery

SLM data page of 1.4 mega pixels
Key Drive System Components

- Tunable laser 402-408nm
- Custom SLM, 1000 fps
- Custom shutter, 500Hz rep
- Custom CMOS camera, 485 fps
Drive Overview

- Electronics
- Optical mechanical assembly (OMA)
- Loader
System architecture - Write

52 mW

isolator + shutter

Laser @ 407nm

\[ \lambda/2 \]

POLYTOPIC FILTER

\[ \lambda/2 \]

\[ \lambda/2 \]

disk

SLM

CAMERA
Tapestry™300r

drive
- capacity - 300GB
- page size - 1.48 millions bits
- book size - 320 pages
- pages per disk - 4.4 million
- laser wave length 405 nm
- transfer rate - 20MBps or 160 Mbps
- avg exposure per page - 1 millisecond
- avg seek time - 250 ms
- bit error rate (BER) <10^{-18}
- form factor: W:5.75”, H:4.875”, L:27.5”

media
- write once
- 130 mm disc
- 3 yr shelf life prior to recording
- wave length sensitivity 405 nm
- >50 year archive life
- no special handling required
- 5.31” X 6” X .43”

list prices
- drive: $18,000
- media: $180
Recordable & rewritable roadmap

**worm**
- **2007**
  - Gen 1: tapestry™ 300r
    - 300 GB @ 20 MB/sec
  - Gen 2: tapestry™ 800r
    - 800 GB @ 80 MB/sec
  - Gen 3: tapestry™ 1600r
    - 1.6 TB @ 120 MB/sec

**rewritable**
- Gen 1: tapestry™ 300rw
  - 300 GB @ 20 MB/sec
- Gen 2: tapestry™ 800rw
  - 800 GB @ 80 MB/sec

**rw-drive backward read compatible with r-media**
**r-drive backward read compatible for 3 generations**
18 to 24 months between generations
theoretical maximum of 17 TB
Customer Interface Solutions

- SCSI Parallel (160/320) – High Density, 68 pin connector
  - HW/SW implemented
- Fibre Channel – 4 Gbps Optical
  - HW implemented
  - SW needs system level qualification
- Gig-E
  - HW implemented
  - SW needs system level qualification
- Serial Attached SCSI (SAS)
  - HW implemented
ISV Compatibility

- WORM, Magneto Optic
  - Pegasus: Investor4, Windows 2000 Platform, Adaptec HBA

- LTO
  - CA: BrightStor ARChive Backup
  - EMC: Retrospect v7.5
  - Oracle: Secure Backup
  - QStar: HSM
  - Software Architects: DataSaver Ver. 2.0.1
  - Veritas: Backup Exec

- NEXT
  - Bridgehead, Symantec, Masstech, Avalon, SGL Flashnet, Schlumberger, Commvault, Meditech, Chartmaxx and McKesson
Automation
Focus on the high end professional optical market

Provide libraries to leading companies worldwide

Credit lyonais, daimler chrysler, development bank singapore, deutsche bank, nestle, philips healthcare, siemens medical, swissair, t-mobile, and volkswagen
Disc library

- 200 to 2250 cartridges (675 TB)
- Focus on the high end professional optical market
- Provides libraries to leading companies worldwide
  
  Credit Lyonnais, Daimler Chrysler, Development Bank Singapore, Deutsche Bank, Nestle, Philips Healthcare, Siemens Medical, Swissair, T-Mobile, and Volkswagen

MSRP $56K to $208K
Disc library

software Support
- Compaq Tru64
- HP-UX
- IBM-AIX
- IBM OS/2
- Linux
- Macintosh
- WinNT/2000/2003
- Novell NetWare
- SGI Irix
- Sun Solaris

drive management ports
- custom serial port
- usb
- ethernet
- native protocols
- snmp functions enabled
- drive/media health checks
- commanded diagnostics
- statistics/error logs
Rackmount unit

- 15 slots
- Single drive (1st generation)
- Single picker (autoloader operation)
- LVD SCSI Interface
Holographic Library – TERASTORE

Cartridge type library - InPhase tapestry300r™ drives

<table>
<thead>
<tr>
<th>Model</th>
<th>Capacity</th>
<th>Configuration</th>
<th>Layout</th>
<th>$/GB*</th>
</tr>
</thead>
<tbody>
<tr>
<td>7100</td>
<td>56 – 70TB</td>
<td>2-10 drives</td>
<td></td>
<td>1.8</td>
</tr>
<tr>
<td>7200</td>
<td>182 – 196TB</td>
<td>2-10 drives</td>
<td></td>
<td>1.1</td>
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<tr>
<td>7300</td>
<td>283 – 297TB</td>
<td>2-10 drives</td>
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<td>0.7</td>
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<tr>
<td>7400</td>
<td>398 – 423TB</td>
<td>2-16 drives</td>
<td></td>
<td>0.7</td>
</tr>
<tr>
<td>7500</td>
<td>518 – 540TB</td>
<td>4-16 drives</td>
<td></td>
<td>0.7</td>
</tr>
<tr>
<td>7600</td>
<td>648 – 666TB</td>
<td>6-16 drives</td>
<td></td>
<td>0.7</td>
</tr>
</tbody>
</table>

* $/GB is calculated using the list price of the library and tapestry300r drives – media is not included
Pricing
Frequently asked questions

- MBTF of drive?
  - 100,000 hours
- Drive load/unload cycles?
  - 250,000
- Cartridge loads?
  - 20,000
- Avg. access latency in library (mount request to data access)?
  - 8-11 seconds, dependent on library size
FAQ continued

- Is access time longer with LTO emulation?
  - No
- Can Gen 2 drives read Gen 1 cartridges at the higher speed of 80 MB/Sec?
  - Yes
- Do you experience tape like “shoe shining” during non-streaming operations?
  - No
- How can you physically destroy the media?
  - CD shredder or incineration
Competitive Landscape
# Competing technologies

Blue boxes with a ✓ indicate the technology is competitive in archive market

<table>
<thead>
<tr>
<th>attribute</th>
<th>tapestry</th>
<th>blue laser optical*</th>
<th>data tape</th>
<th>hard disk</th>
<th>video tape</th>
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<tbody>
<tr>
<td>capacity roadmap</td>
<td>✓✓✓✓</td>
<td>✓✓✓✓</td>
<td>✓✓✓✓</td>
<td>✓✓✓✓</td>
<td>✓✓✓✓</td>
</tr>
<tr>
<td></td>
<td>✓300GB - 1.6 TB</td>
<td>15 – 100 GB</td>
<td>✓ 100GB – 1.6 TB</td>
<td>✓ 18GB -&gt;1.5 TB</td>
<td>1 – 251 GB</td>
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<td>✓✓✓✓</td>
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<tr>
<td></td>
<td>✓ 20 – 120 MB/s</td>
<td>4-12 MB/s</td>
<td>✓ 20 – 120 MB/s</td>
<td>✓ 40-150 MB/s</td>
<td>3 – 25 MB/s</td>
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<td>media archive life</td>
<td>✓✓✓✓</td>
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<td>✓✓✓✓</td>
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<tr>
<td></td>
<td>✓ 50 yrs</td>
<td>✓ 20 yrs</td>
<td>7-10 yrs</td>
<td>5 yrs</td>
<td>7 yrs</td>
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<tr>
<td>low media price</td>
<td>✓✓✓✓</td>
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<td>✓✓✓✓</td>
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<tr>
<td></td>
<td>✓ $.06-.20/GB</td>
<td>$1.00/GB</td>
<td>✓ $.25-1.00/GB</td>
<td>&lt;$3.00 GB</td>
<td>$1- 3.00/GB</td>
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<tr>
<td>media handling issues</td>
<td>✓✓✓✓</td>
<td>✓✓✓✓</td>
<td>✓✓✓✓</td>
<td>✓✓✓✓</td>
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<tr>
<td></td>
<td>✓ office environment</td>
<td>✓ office environment</td>
<td>Temp &amp; RH controls</td>
<td>Must spin-up drive periodically</td>
<td>Temp &amp; RH controls</td>
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<tr>
<td>physical WORM</td>
<td>✓✓✓✓</td>
<td>✓✓✓✓</td>
<td>✓✓✓✓</td>
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</tr>
<tr>
<td></td>
<td>✓ Yes</td>
<td>✓ Yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
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<td>✓✓✓✓</td>
<td>✓✓✓✓</td>
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<tr>
<td></td>
<td>✓ Yes</td>
<td>✓ Yes</td>
<td>no</td>
<td>✓ Yes</td>
<td>no</td>
</tr>
<tr>
<td>head contact on write/read</td>
<td>✓✓✓✓</td>
<td>✓✓✓✓</td>
<td>✓✓✓✓</td>
<td>✓✓✓✓</td>
<td>✓✓✓✓</td>
</tr>
<tr>
<td></td>
<td>✓ no</td>
<td>✓ no</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>hw security features</td>
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<td>✓✓✓✓</td>
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<tr>
<td></td>
<td>✓ optical encryption</td>
<td>none</td>
<td>none</td>
<td>✓ Yes</td>
<td>none</td>
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</table>

* Blu-ray, HD DVD, UDO – source IDC
TCO for 500TB for 25 years

### Assumptions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Tapestry</th>
<th>UDO</th>
<th>LTO-4</th>
<th>T10000</th>
<th>D-5 Video Tape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>300 GB</td>
<td>30 GB</td>
<td>800 GB</td>
<td>500 GB</td>
<td>158 GB</td>
</tr>
<tr>
<td>Media Migration</td>
<td>2 times</td>
<td>2 times</td>
<td>4 times</td>
<td>4 times</td>
<td>4 times</td>
</tr>
<tr>
<td>Total Media used</td>
<td>3,333</td>
<td>33,333</td>
<td>2,500</td>
<td>4,000</td>
<td>12,660</td>
</tr>
<tr>
<td>Media Price</td>
<td>$180</td>
<td>$54</td>
<td>$150</td>
<td>$135</td>
<td>$250</td>
</tr>
<tr>
<td>Drives used</td>
<td>9</td>
<td>39</td>
<td>9</td>
<td>9</td>
<td>32</td>
</tr>
<tr>
<td>Drive Price</td>
<td>$18,000</td>
<td>$2,960</td>
<td>$8,2930</td>
<td>$32,000</td>
<td>$35,000</td>
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<tr>
<td>Data Migration$</td>
<td>$300K</td>
<td>$300K</td>
<td>$600 K</td>
<td>$600 K</td>
<td>$600 K</td>
</tr>
</tbody>
</table>
TCO for 500tb for 25 years

Assumptions | Tapestry 2 | UDO-3 | LTO-4 | T10000 -2 | D-5 Video Tape
---|---|---|---|---|---
Capacity | 800 GB | 120 GB | 800 GB | 1 TB | 158GB
Media Migration | 2 times | 2 times | 4 times | 4 times | 4 times
Total Media used | 1250 | 8333 | 2500 | 2000 | 12660
Media Price | $80 | $60 | $80 | $120 | $250
Drives used | 9 | 39 | 9 | 9 | 32
Drive Price | $6,000 | $4,000 | $4,000 | $32,000 | $35,000
Data Migration$ | $300K | $300K | $600 K | $600 K | $600 K
# Media archive & handling characteristics

<table>
<thead>
<tr>
<th></th>
<th>video and data tape characteristics</th>
<th>tapestry™ media advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>archival life</strong></td>
<td>3 – 10 yrs</td>
<td>50 yrs</td>
</tr>
<tr>
<td><strong>head/media interaction</strong></td>
<td>media wear out</td>
<td>media has no physical contact with head</td>
</tr>
</tbody>
</table>
| **special handling** | 1) Store at recommended temp  
2) Keep evenly wound  
3) Store upright  
4) Fasten loose end to reel  
5) Rewind every 3 years  
6) Protect from magnetic field  
7) Allow 24 hours for climate change | store at room temperature |

Source: Sony, InPhase
Features meet customer requirements

• High capacity & performance
  • Massive data repositories; hundreds of TB to pbs per year; streaming data

• Long archival life
  • 50 -100 years

• Robust content protection & security
  • Write once read many (WORM) media
  • Drive based optical encryption

• Random access to data
  • Millisecond recovery; true near-line capability

• Excellent total cost of ownership
  • Low cost media
  • Reduced migration frequency
  • Low power consumption