Professional Optical Data Storage - As Viewed From A Consumer Electronics Perspective.

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Presented at the THIC Meeting at the STK Bldg 8 Auditorium, 1 Storage Tek Dr, Louisville CO 80027-9451
July 22 - 23, 2003
**Consumer & Professional Applications.**

<table>
<thead>
<tr>
<th>Static</th>
<th>Portable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical libraries (5¼”). HDTV editing.</td>
<td>HDTV camcorders. Data logging.</td>
</tr>
<tr>
<td>A/V recorders. PC drives.</td>
<td>Cameras/camcorders. PDAs/Laptops.</td>
</tr>
</tbody>
</table>

**The Data Storage Pyramid.**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Capacity</th>
<th>Access time</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary memory</td>
<td>Up to 4GB</td>
<td>RAM</td>
<td>Online memory</td>
</tr>
<tr>
<td></td>
<td>40GB-TB’s</td>
<td>HDD RAID</td>
<td>Near-line memory</td>
</tr>
<tr>
<td>Secondary memory</td>
<td>2.4GB-9.1GB</td>
<td>MO/WORM</td>
<td>Offline memory</td>
</tr>
<tr>
<td></td>
<td>650MB-8.56GB</td>
<td>CD/DVD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50GB-TB’s</td>
<td>MO/CD/DVD Optical libraries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TB’s</td>
<td>Tape libraries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;200 GB</td>
<td>External exchange media</td>
<td></td>
</tr>
</tbody>
</table>

**Professional Mass Data Storage Landscape.**

- Systems usually have to be transparent to users.
- Regulatory approval sometimes required.
- Reliability.
- Robustness.
- Long data retrieval lifetimes.
- Backwards compatibility.

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**The Professional Mass Storage System Model.**

<table>
<thead>
<tr>
<th>Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Integrator</td>
</tr>
<tr>
<td>Software house</td>
</tr>
<tr>
<td>Hardware Integrator</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drive</th>
<th>Media</th>
</tr>
</thead>
</table>
**Professional Mass Data Storage Technology.**

- **HDD RAID systems.**
  - Enterprise mirrors, high-medium cost/GB, fast data rates, faulty disks hot swappable, organically expandable (EMC Centera is eWORM, 4.8-153TB).

- **Automated optical libraries (-5.8TB).**
  - Enterprise back-up, high-medium cost/GB, medium capacities, slow data rates, faster media transport & seek times.

- **Automated tape libraries (1-50TB).**
  - Enterprise back-up, low-medium cost/GB, respectable data rates, slower media transport & seek times, media maintenance.

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**Storage System Price Trends.**

![Price Trends Graph](image)
Pressure on 5.25inch Optical Libraries.

- Higher density (increased capacity) required to compete with DVDpro and tape on cost/GB.
- Higher data rates (>200Mb/s) required to compete with HDD and tape.

Go Blue*: UDO and V-disk.

- UDO (Plasmon).
- 5.25inch disk in cartridge.
- 30GB per disk, 60GB & 120GB on road map.
- 8MB/s (64Mb/s) read, 4MB/s (32Mb/s) write.
- 80MB/s ultrawide SCSI interface.

- V-disk (Sony).
- 12cm disk in cartridge.
- 23.3GB per disk, 50GB & 100GB on road map.
- 11MB/s (88Mb/s) read, 9MB/s (72Mb/s) write.
- 160MB/s ultrawide SCSI interface.

*Blu-Ray associated technology.
Other Technologies.

- Multi-level.
- Multi-layer.
- 2DOS.
- SuperRENS.
- **DomEx (MAMMOS, DWDD).**
- Holography.

Applying DomEx to 5.25inch MO.

- **5.25inch MO technology delivers:**
  - “14x” 9.1GB disk capacity.
  - 50Mb/s data rate.

- **DomEx technology could deliver:**
  - Up to 150 GB* per disk (32days full body MR).
  - >200Mb/s* data rates.

*Demonstrated experimentally.
Blue First-surface MAMMOS* Recording.

*Magnetically AMplified MO System.

Writing at High Density with MO.

- LP-MFM: laser pumped – magnetic field modulation.
- Marks (much) smaller than given by the diffraction limit.
- Crescent-shaped domains written when laser pump rate increased.
- DomEx read-out schemes used for reading marks small marks.
**RF-MAMMOS – Mark.**

- Expansion layer
- Storage layer
- Collapse field

**ZF-MAMMOS read-back mechanism.**

- External magnetic field NOT required.
- Bit copied through exchange coupled trigger layer.
- Heat decouples trigger layer from storage & expansion layers.
- Expansion driven by balance of stray fields from neighbouring bits and demagnetising field from expanded domain.
- Collapse driven by stray field from current bit.
**Small Free Working Distance Actuated Head.**

- High bandwidth DVD actuator.
- Red NA 0.65 lens replaced with blue (\(\lambda=405\text{nm}\)) NA 0.95 lens.
- Thin film coil placed between lens and media.
- Lens wave-front aberration < 30\(\lambda\), rms.

**High Data Rate Integrated MFM Coil.**

- Optimal for 0.7<NA<0.95 lenses.
- Low inductance, good heat transport design.
- Magnetic field rise time 3.5 ns with coil driver.
**MO-PDIC.**

- Photo detectors integrated with pre-amplifier.
- 200MHz or 300 MHz bandwidths, 68 dB gain.
- 1.7ns expansion rise times measured.
- 100MHz (200Mb/s) read-back performed with 80nm carrier (200MHz b/w).

**ZF-MAMMOS Carrier Signals.**

- NA=0.95, λ=405nm.
- V_write=2.5m/s, V_read=6.0m/s.
- Signals low-pass filtered with 80 MHz BW.
Benefit of DomEx MO 5.25inch.

- Competitive cost/GB with DVDpro.
  - Due to >10Gb/in² density.
- Quadrupled data rates (>200Mb/s).
- Maintain:
  - Overwriteability.
  - Long term data stability.
  - Media access & file seek times.
  - Robustness
  - Cartridge compatibility.
  - Cartridge selling price.

Summary.

- Many alternatives exist for professional mass data storage.
- The 5.25inch optical library market is under pressure.
- DomEx MO could complement other technologies for future 5.25inch drives.

http://www.research.philips.com/technologies