TeraStor's Near-Field Recording

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TeraStor Profile

- TeraStor Founded Dec. 1995, initial funding Feb. 1996
- 140 employees, 100,000 sq. ft. facility in San Jose
- Key Executives:

Gordon Knight*

Hossein Mogadam

Bill Dobbin*

Amyl Ahola

Rick Wilmer

Richard Walker

Louis Llamas

Skip Kilsdonk

- Jim McCoy* CEO (founder of Maxtor, co-founder of Quantum)
 - CTO (founder of Maxoptix & Optimem)
 - VP (founding CFO of Maxtor)
 - Pres, COO (past CEO LMSI, WangDAT, VP Seagate)
 - Sr. VP Eng (former CTO of Seagate)
 - VP Ops. (former VP of operations, Seagate)
 - VP Mktg (former worldwide marketing manager, HP)
 - VP Sales (former VP Western Digital, Seagate)
 - VP (former VP Maxtor)

* founder

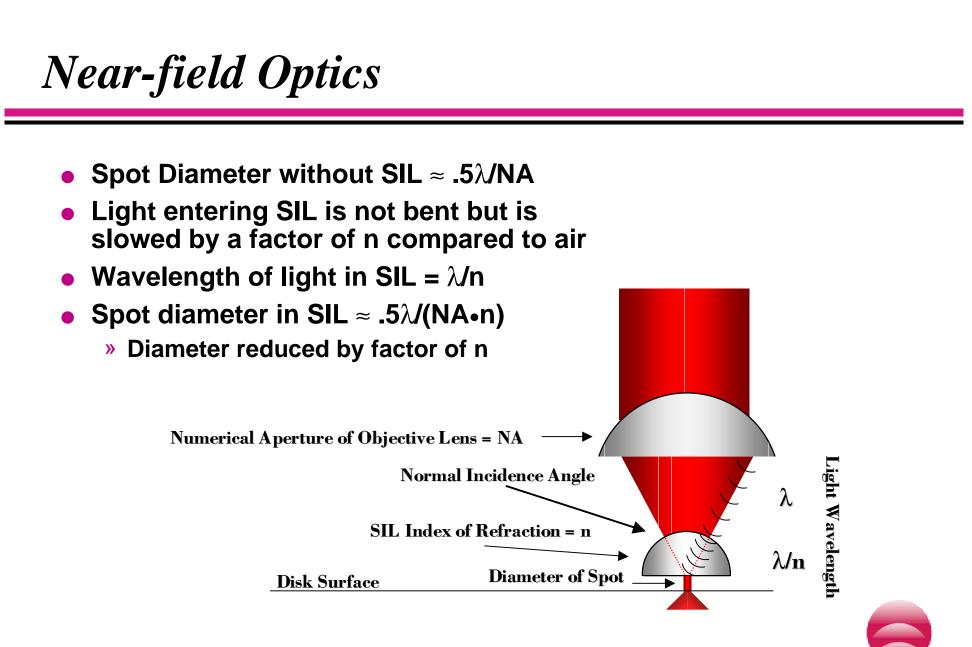


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Near Field Recording - Technology Evolution

- Optical flying head/First surface recording
 - » Basic technology developed by Digital.
 - Extensive patent portfolio (26 patents)
 - » Patents acquired by Quantum as part of their acquisition of the Digital storage business
 - » Co-exclusive patent rights granted to TeraStor by Quantum
- Solid Immersion Lens (SIL) technology
 - » Basic technology developed and patented at Stanford University
 - » Exclusive patent rights granted to TeraStor by Stanford





TERAS

Evanescent Coupling

- Provides energy transfer from the SIL to the surface of the media
 - » Unlike conventional magneto-optical products, the laser is not focused on the surface of the media, instead it is focused at the bottom of the SIL
- Well understood from Near-field Scanning Optical Microscopy
- Allows image of small spot inside SIL to be pulled to the surface of the media.



NFR Components

• Solid Immersion Lens

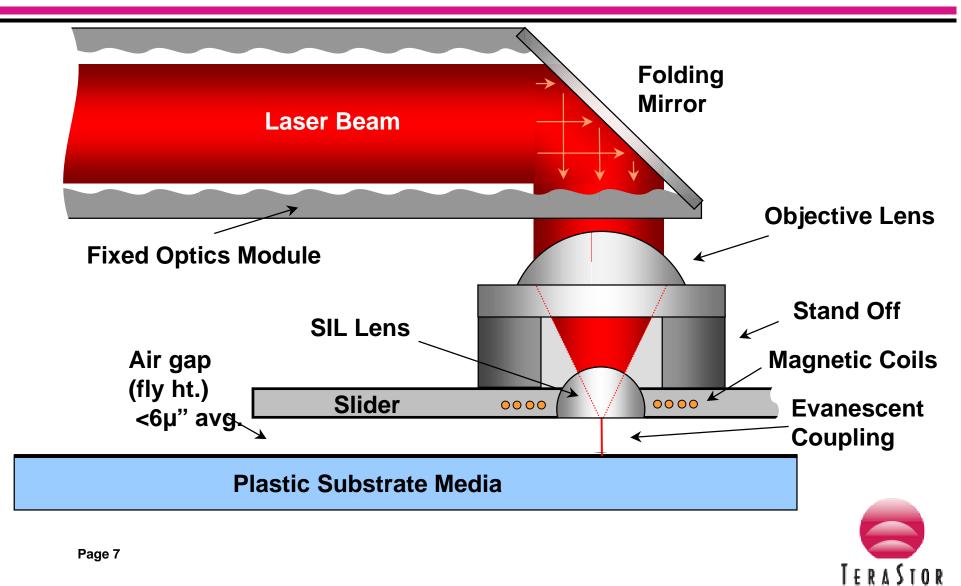
- » Based on liquid immersion microscopy
- » Allows Numerical Aperture of much greater than 1 by using high index of refraction material
- » Shape of the SIL allow for tighter focus of light spot

• First Surface Recording

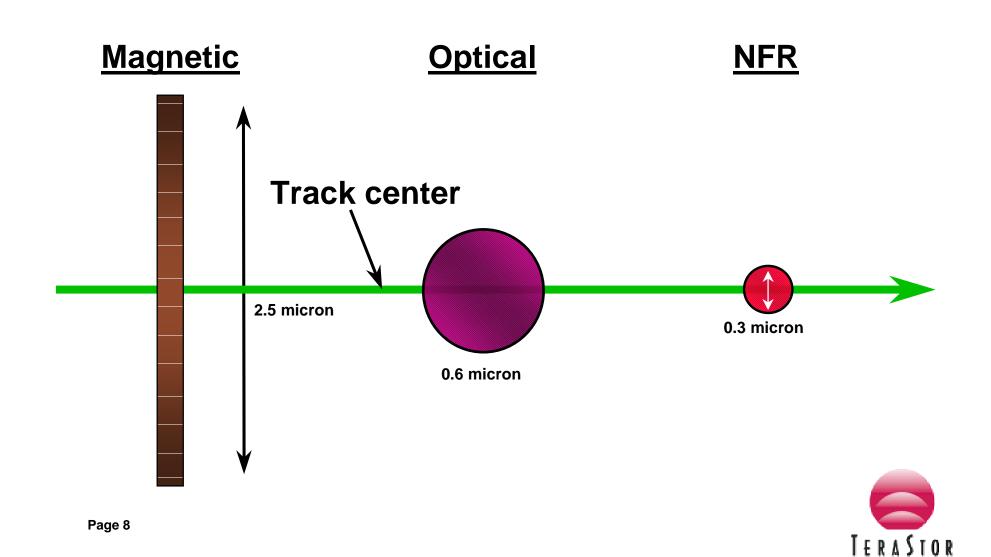
- » Places recording films in near-field proximity to the head
- Flying Optical Head
 - » Provides tight focus tolerances within the near-field and eliminates focus servo found in conventional magnetooptical products
- Crescent Recording
 - » Allows for bit densities of > 200,000 bits per inch with SIL



Architecture of TeraStor's Near-Field Recording Technology



Recording Area Compared

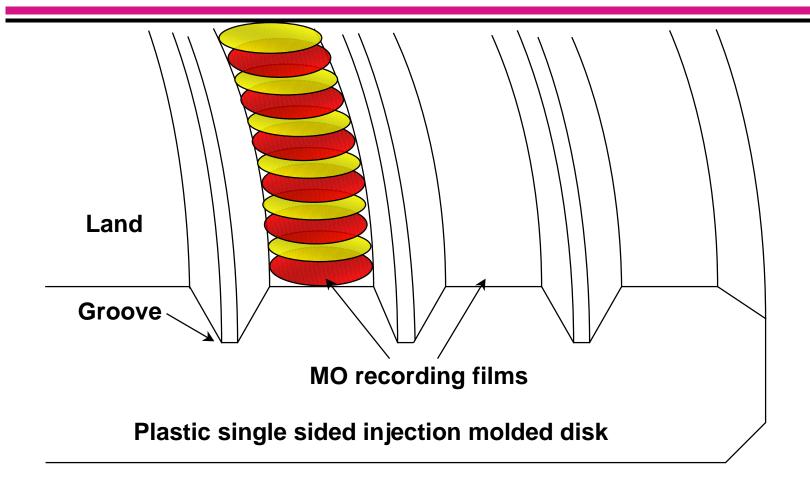


NFR Media

- Uses conventional MO recording films
- Stamped plastic substrate and first surface recording allows media costs to be competitive with tape
- Vertical magnetic domains allow for smaller spots than magnetic recording
- Proven domain stability, no super-paramagnetic effects
 - » Magnetic recording domains become unstable at room temperature somewhere between 20Gb/in² and 40Gb/in²
 - » Magneto-optical media has been proven stable at densities beyond the superparamagnetic "limit" (AT&T 1992)
- Long shelf life approaching that of conventional magnetooptical products
- Infinite rewrite passes, unlike phase change media

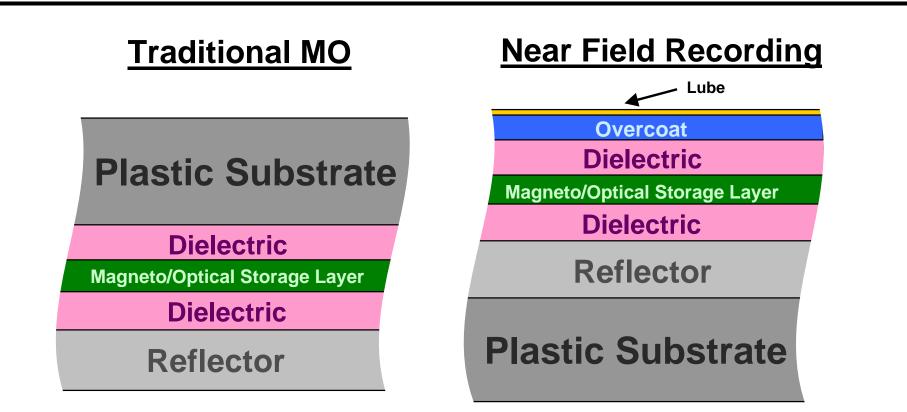


TeraStor Disk Structure





TeraStor Disk Structure





The Two Stage Servo

- Combines movements of a primary actuator and laser scanning
- Radial run out taken out with rotary actuator
- Instantaneous near track seeks with galvanometer mirror
- High bandwidth micro-mirror galvanometer allows for order of magnitude increase in track densities over magnetic recording
- Improved track acquisition capability
- Improved shock resilience



Technology Comparison

| | Recording Mechanism | Cyclability | Data Rate | Areal Density |
|------------------|--|--------------------------------|--|--|
| Near-Field MO | Vertical Magnetic Media | Infinite | >160 Mb/sec | > 10 Gb/in ² today => >200 Gb/in ² |
| Far Field MO | Vertical Magnetic Media | Infinite | ~48 Mb/sec | ~ 2 Gb/in ² today => <20 Gb/in ² |
| Phase Change | Amorphous Crystaline Molecular change | 10,000 to 500,000 cycles | ~ 24 Mb/sec today (slow process) | ~ 2 Gb/in ² today => <15 Gb/in ² |
| Magnetic | In-plane Magnetic Media | Infinite | > 200 Mb/sec today | > 4 Gb/in ² today => < 40 Gb/in ² |



Optical Comparisons

| | Conventional* | Near-Field | Blue Laser | Blue laser |
|---|---------------------|-----------------|-------------------|------------|
| | Magneto-Optical | Magneto-Optical | Conventional* | Near-Field |
| Laser Wavelength | 685 nm | 685 nm | 410nm | 410nm |
| Numerical Aperture | 0.65 | 0.65 | 0.7 | 0.33 |
| Index of refraction of SIL | n/a | 2 | n/a | 3** |
| Potential Spot Size | 0.53 micron | 0.26 micron | 0.29 micron | .07 micron |
| Maximum Areal Density | 4Gb/in ² | 16Gb/in2 | 13Gb/in2 | 238Gb/in2 |
| | | | | |
| Conventional optics products include CD, DVD, ASMO, MO, and OAW | | | ** SuperSIL shape | |



TeraStor Product Highlights

- High capacity removable cartridge drive
 - » Announced 10GB, 20GB and future double sided family
 - » Removable NFR media
 - » Average seek times < 18ms.</p>
 - » Volume production Q1 1999
- Announced automation solutions coming from:
 - » ATL Products » Exabyte
 - » DISC » Spectra Logic
 - » Overland Data » Plasmon IDE
 - » Others to follow
- Storage Management software commitments from 17 UNIX, NT, and Novell backup and nearline application developers



TeraStor Partners

• Strategic Technology Partnerships:

- » Media
 - Imation
 - Tosoh
 - Maxell
- » Heads
 - Yamaha
 - Second source under negotiation
- » Electronics
 - Silicon Systems Inc (Texas Instruments)
 - Hitachi
- » Optics
 - Olympus



TeraStor Partners

• Contract Manufacturing Partnership

- » Mitsumi Cebu Philippines
- Drive Manufacturing and Marketing License
 - » Quantum
 - ensure multiple sources of competitive drives
 - create de-facto standard products



Conclusions

- Near-field recording with a Solid Immersion Lens combines the best advantages of magnetic and optical recording
 - » many components from HDD vendors
 - » Low cost plastic media
- Near-field recording is practical today
- Conventional far-field optical recording has fallen behind magnetic recording and cannot keep up (even for DVD-RAM, ASMO, and OAW)
- NFR technology can maintain a significant areal density advantage over magnetic recording for both fixed and removable media products

