Why Holographic Storage?

- **High Capacity & Performance**
  - Volumetric recording vs surface recording
  - Parallel records and reads(~1 mb) vs serial (1 bit)
- **Low Cost**
  - Lowest cost per gigabyte for storage
  - Inexpensive media manufacturing cost
- **Broad Design Flexibility**
  - Any format factor possible – cards, disk, etc.
- **Robust Content Protection & Security**
  - More difficult to pirate due to volume recording
  - Custom encryption
- **Long Archival Life**
  - 50 years
  - Very tolerant to dust, scratches, and surface defects
  - No special handling required

History of Holographic Storage

- **Many companies and many research projects over the last 30 years**
- **Biggest stumbling block had been creating viable storage media**
- **Bell Labs invented revolutionary Holographic Media Solution in 1997**
- **Why we succeeded**:
  - Integrated team, Unique system and material synergy
  - Tremendous technical depth of Bell Labs
- **Major Accomplishments of Bell Labs Team (now InPhase)**
  - Invented new multiplexing methods - 1994
  - Channel modulation schemes and alignment techniques - 1995
  - **Invented flat media manufacturing process - 1996**
  - **Invented concept of 2-chemistry material - 1997**
  - Recording techniques invented and 2-chemistries demo'd - 1998
  - Error correction codes simplified and material improved - 1999
  - Temperature compensation scheme invented and demo'd - 2000

InPhase Enabling Breakthroughs

Past Problems With Holography	InPhase Solution
• **Recording Material** - No suitable material, the fundamental problem.	➢ **Novel, "two-chemistry" polymer material** - Invented high-performance, proprietary materials with demonstrated high-density data storage capabilities. ➢ **Media manufacturing method** – Invented a flat media manufacturing process that allows inexpensive substrates to be used in a process similar to DVD.
• **Recording Methods** - Complex, difficult, and achieved only limited densities	➢ **New multiplexing methods** - InPhase has developed recording methods that enable a simple, compact storage system.
•**Temperature effects** – Limited operational window	➢**Invented compensation scheme** that allows wide operating temperature window.
• **Laser Sources** - Costly and unreliable	• **Commercially available sources** - Red diode lasers developed for DVD-RAM applications and blue lasers for DVD-Blue.
• **Detectors** - Costly and poor performance	• **Commercially available detectors** - CMOS active pixel sensor arrays
• **Spatial Light Modulators** - Exhibited slow frame rates and poor contrast	• **Commercially available modulators** - Digital micromirror devices, ferroelectric modulators.

InPhase Expertise

- Core Skills
  - Holographic Systems (100+ years experience)
    - Recording physics, multiplexing, scheduling, noise and channel issue, modeling, etc
  - Media & Material development & characterizations (100+ years experience)
    - Polymer chemistry and chemical engineering of polymers
    - Physical chemistry and analytical analysis of material
- Development skills
  - Optical design and system development
  - Laser development and characterization
  - Data channel and imaging processing
  - Mechanical Design
  - Servo Design
  - Electrical Design
  - Software/Firmware

Resulting in over 90 patents, applications, and disclosures

How does HDS work?

Capacity

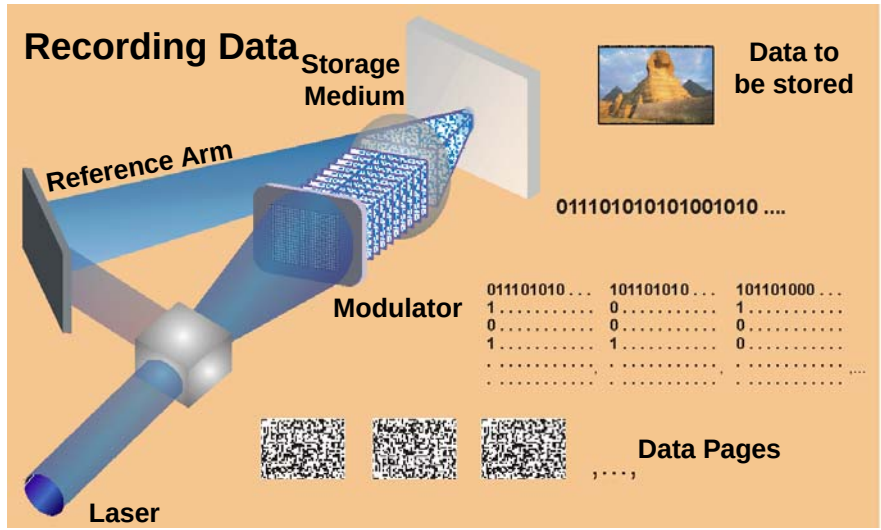
- Media Thickness
- Media Dynamic Range
- Multiplexing
- Wavelength

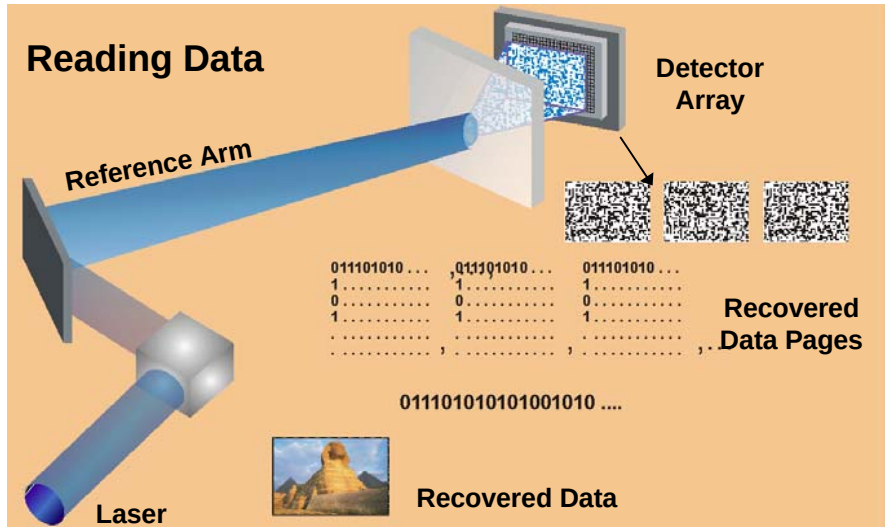
Transfer Rate

- Page size
- Media Sensitivity
- Media Dynamic Range
- Laser Power

Reliability

- No head/media interaction
- Data fixed after recording
- Media inert post recording





Sample Data Page –
1.3 million bits of data recorded in ~ 2 milliseconds