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P3 Holographics

Technology transfer experience

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Holographic storage: the properties anticipated

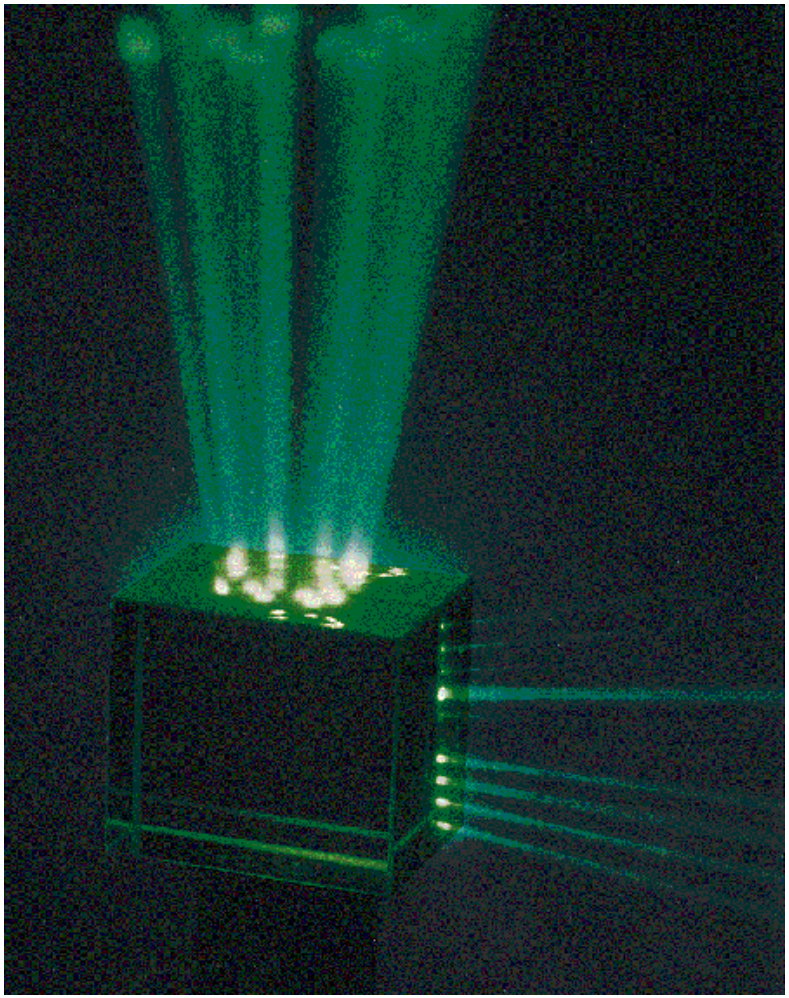


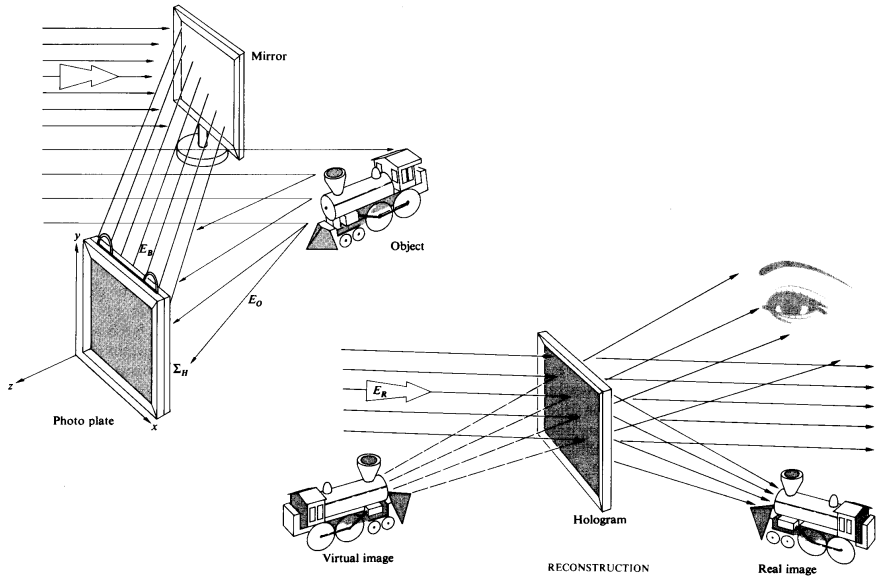
photo credit: IBM

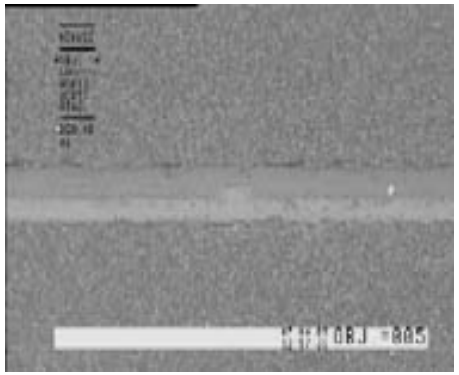
- fast access, μs
- high data rates, Gbit/s
- huge data storage density
- low latency before data stream commences

Photorefractive composites

A re-recordable holographic material

- **High performance**
  - Stable
  - Reliable
- **Patent granted**
  - US, Europe and Japan
- **Processable by:-**
  - Spin coating
  - Drop casting
  - Doctor blading
  - Roll to roll laminating?

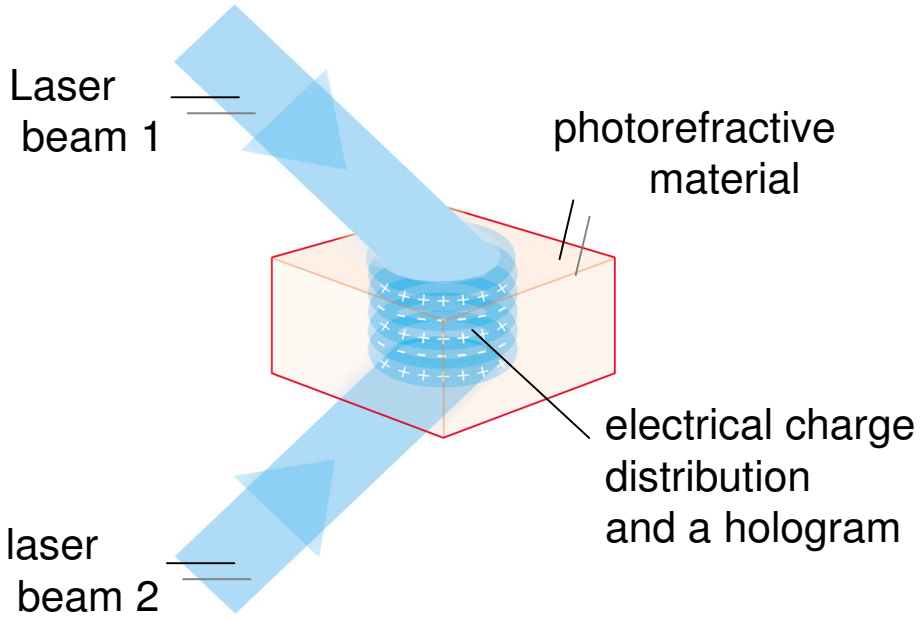




Outline of talk

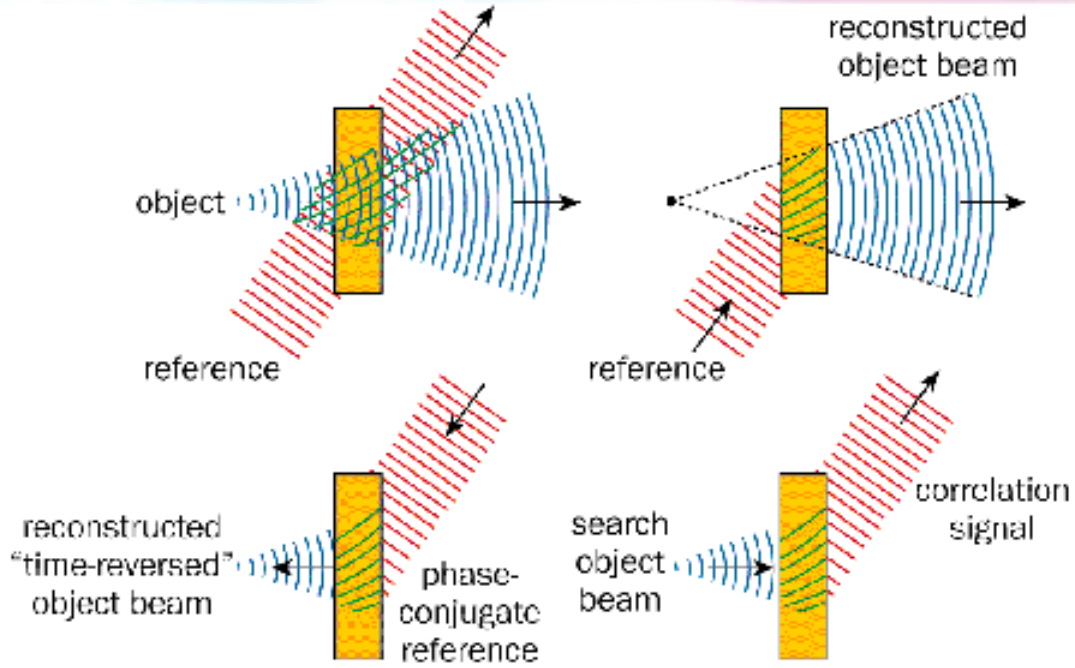
- idea of holographic storage
- more about P3 Holographics
- disc and bulk formats and the buffer hologram
- the impact of finance
- key lessons learned at P3 Holographics

Technology and history



- 1990 IBM Almaden first demonstrated photorefractivity within a polymer
- 1993 University of Arizona - complete diffraction effect surpassing the performance of $LiNbO_3$. IBM adopt this solution
- 1995 IBM publicly withdraw from this technology because of material instability
- 1996 Dr West's group at Manchester patent a stable diffractive polymer
- 1999 - Predictive capability developed

Holograms



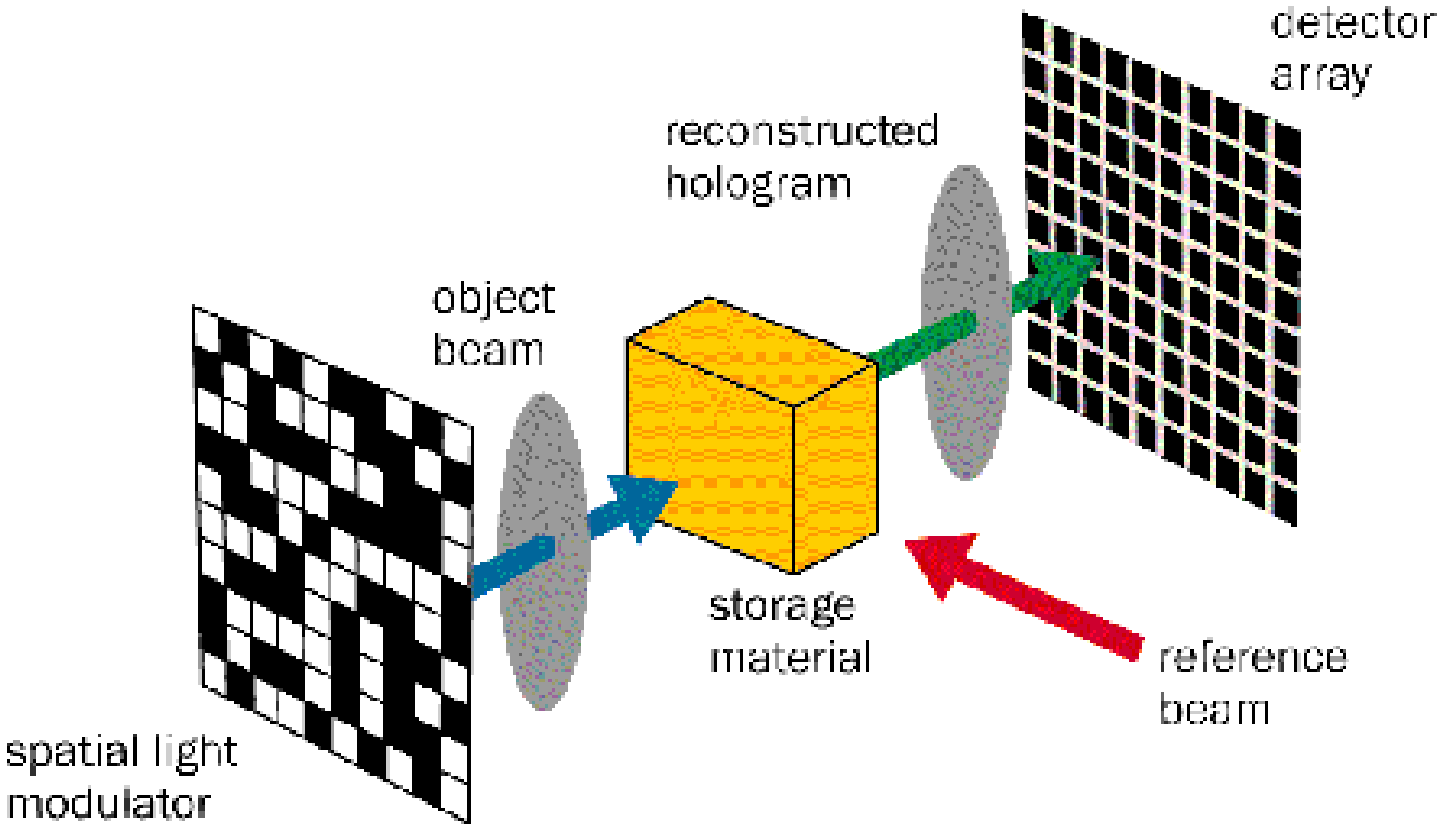
(a) Holographic storage of a single data bit.

(b) The hologram is read out using the original reference beam

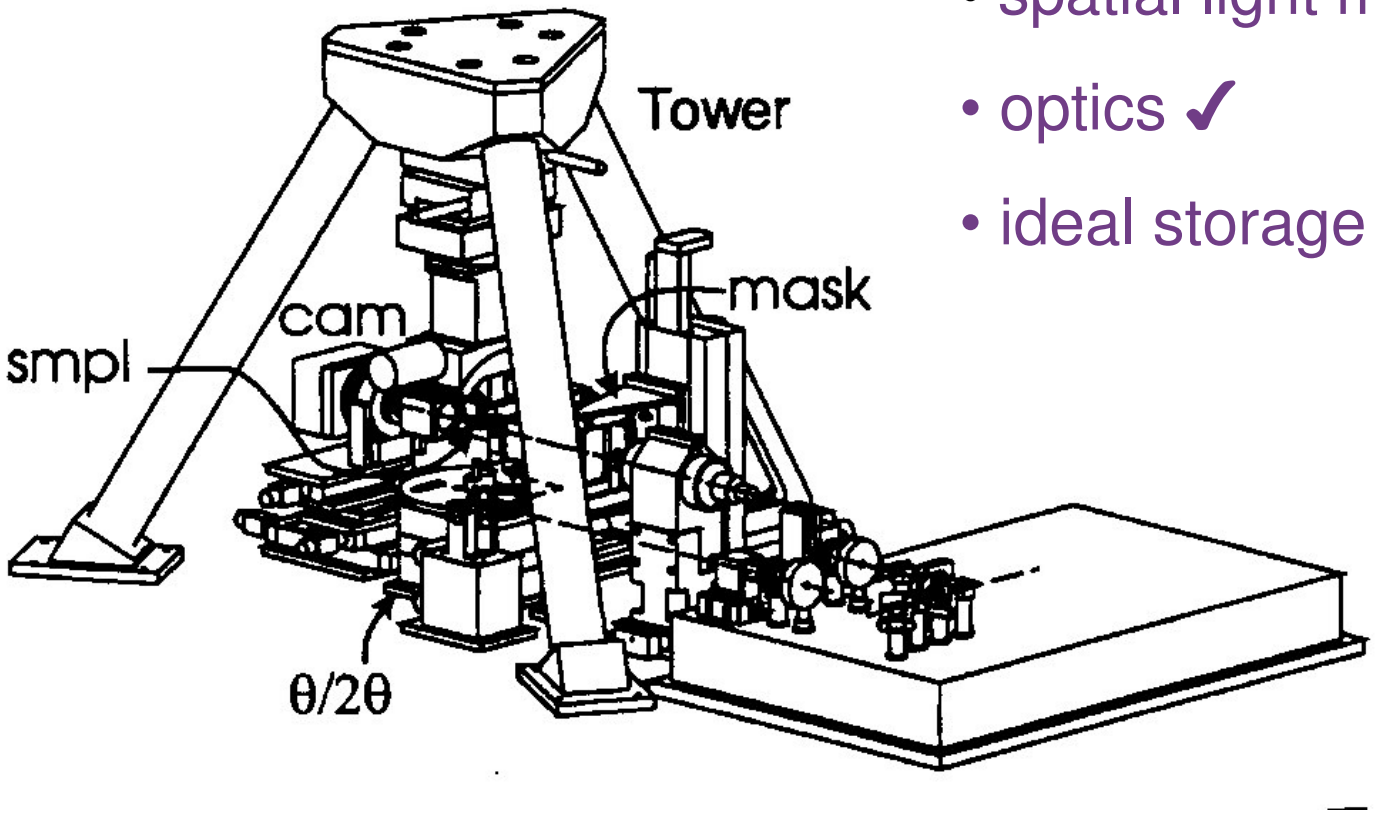
(c) The hologram can also be read out by illuminating it with a counter-propagating (or "phase-conjugate") reference beam. The phase-conjugate beam returns to its point of origin, where the bit value can be read without a high-quality imaging system.

(d) A third way to retrieve data involves illumination with a diverging beam called an object beam, which reconstructs the original plane-wave reference beam. This technique allows us to search the stored data according to its content, rather than its address. Source: Burr (IBM Almaden), Phys World 13(7) 2000

An holographic data storage system



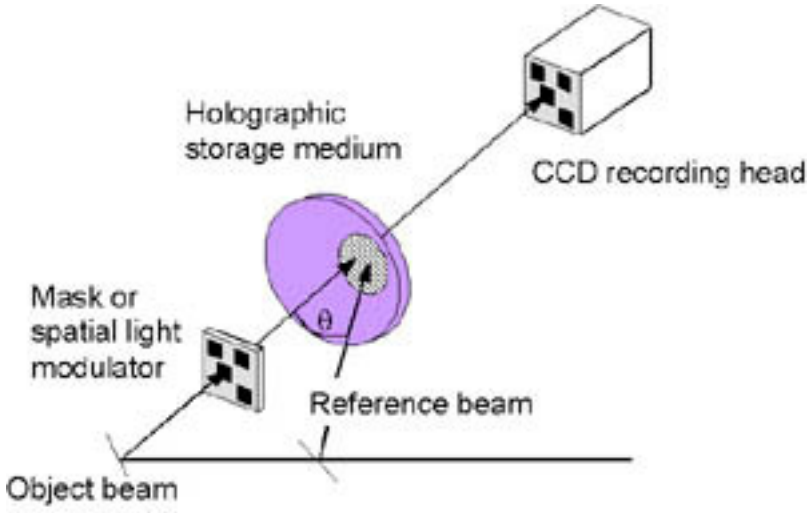
IBM Holographic Storage Tester

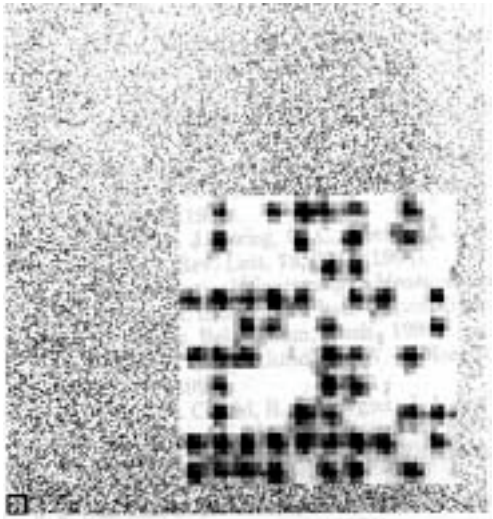


- spatial light modulators ✓
- optics ✓
- ideal storage medium ✗
  not yet

P3 Applications – holographic data storage

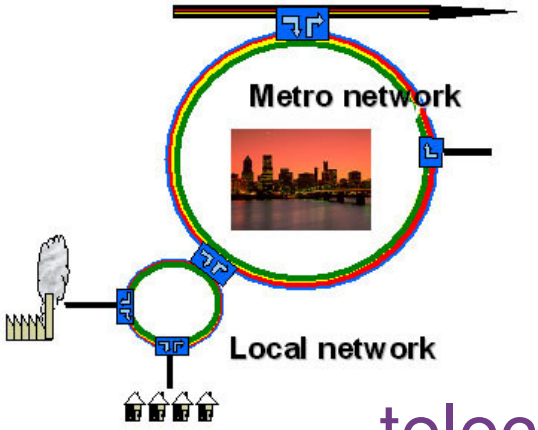
After the DVD?



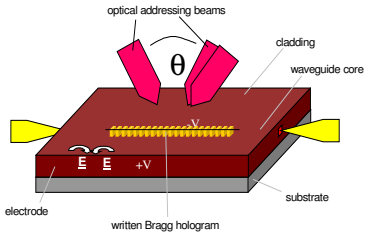


- Rewritable archive storage

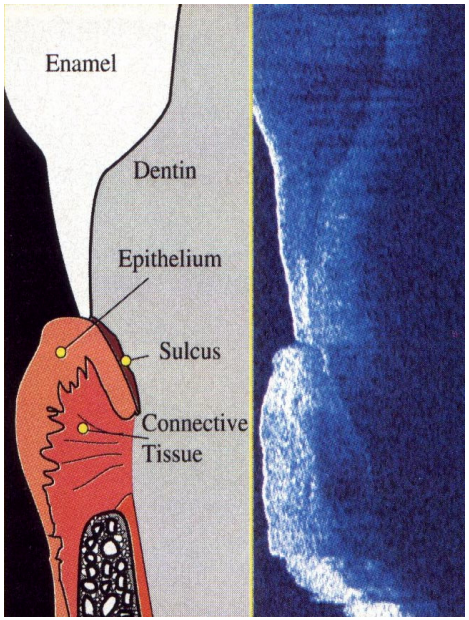
P3 Applications



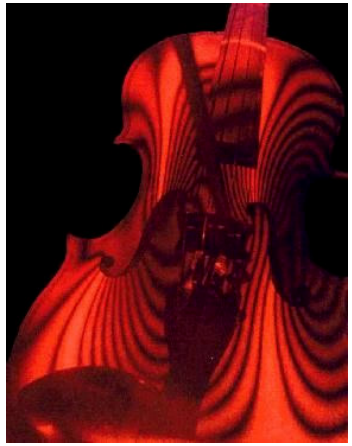
telecoms



OCT imaging e.g. dentistry



Biophotonics International



machine vision

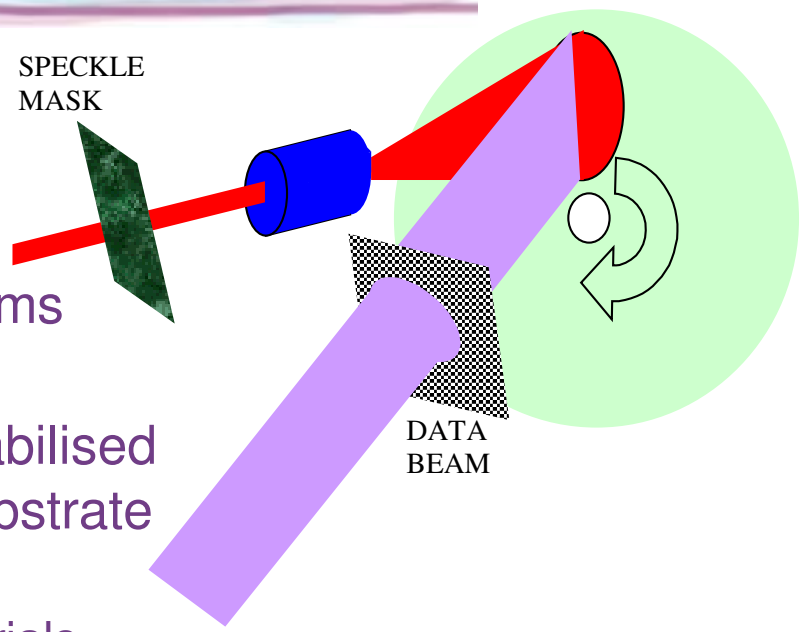
P3 holographics established

- IP landscape reviewed
- Market research done
- UCF investment - data storage work should ‘Piggy back’ on telecoms
- VC investment planned; £5m first round agreed

Holographic data storage market

- Dominated by *incumbent* companies InPhase (Lucent, IBM et al, US) & Aprilis (Polaroid et al, east coast US) with others rather weaker (Optilink in Denmark-Sweden-Hungary) all doing speckle pattern holography on thin discs
- Optostor attempted non-mechanical addressing
- Initially WORM: re-writable media would enter a second generation system

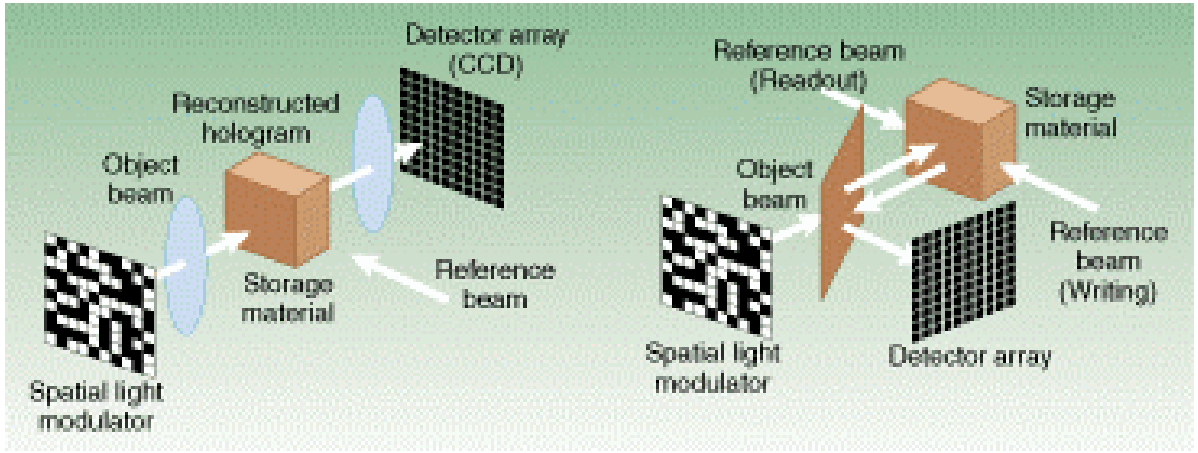
Speckle pattern holograms



- The photo-polymers used to record holograms exhibit optical scatter
- Materials change size when hologram is stabilised
  ⇒ use a thin polymer disc on a stiff substrate

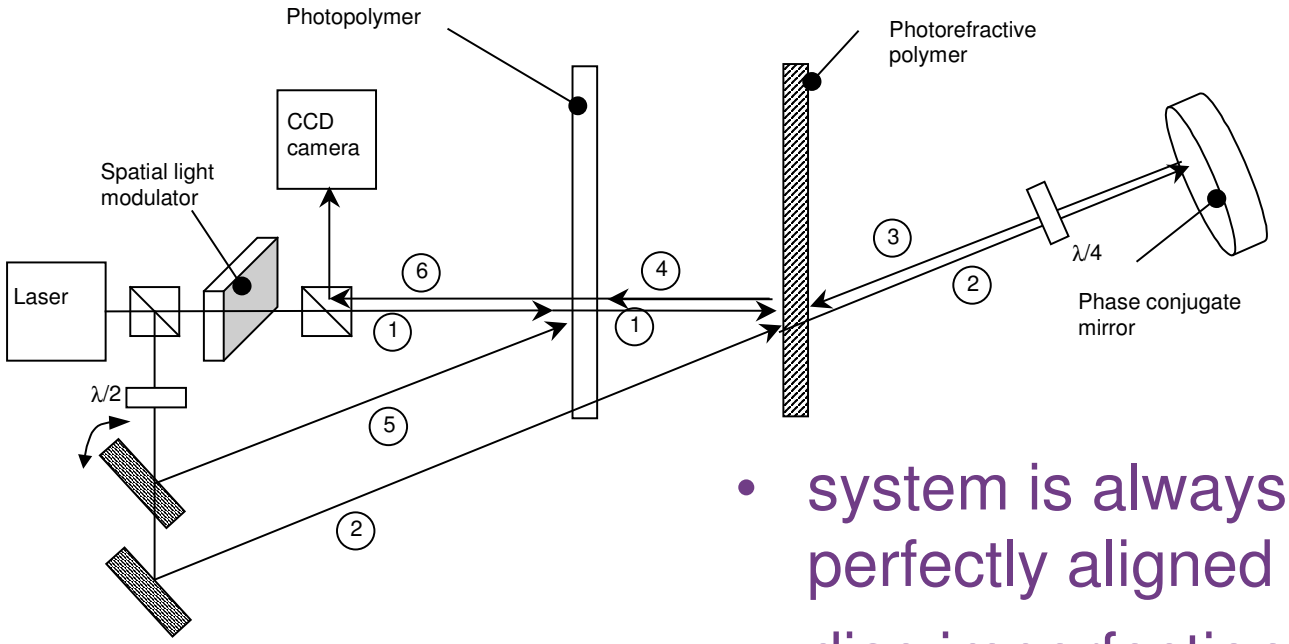
- large area holograms are needed with thin materials
- spin the disc to separate holograms for high capacity
- use a speckle pattern as reference beam
  ⇒ holograms can overlap almost completely
  ⇒ very accurate disc positioning is needed
- **RESULT: *high density and data rate, but long latency and expensive mechanics***

Reverse readout of thick holograms



- Different holograms have different reference beam angle only: no moving parts
- only one set of optics needed with reverse readout: less costly
- **RESULT:** ***low latency, high density and data rate, affordable, but readout erasure destroys the archive***

Buffer hologram concept



- system is always perfectly aligned
- disc imperfections compensated for
- lower quality optics
- nearly all optics on one side of disc

But ...

- Key tech problem is buffer is exposed through photopolymer
- Optostor, Optilink websites close, etc
- Bob Shelby at IBM concluded that Aprilis' system is very low but non-zero shrinkage: this will still be an issue

Dot.com crash, telecoms crash

- Over period of months P3 value fell from high to near zero
- VC funding reduced drastically
- inter-start up economy replaced as incumbents deal with incumbents
- InPhase establish entry barrier

Lessons learned at P3

- Holographic media technology is subservient to strategic position with major industry players
- Ambitious technology program for £5m stretched to DTI Smart and a scorched earth crossing - flawed logic
- Right to prioritise reliability and quality (e.g. Digilens)