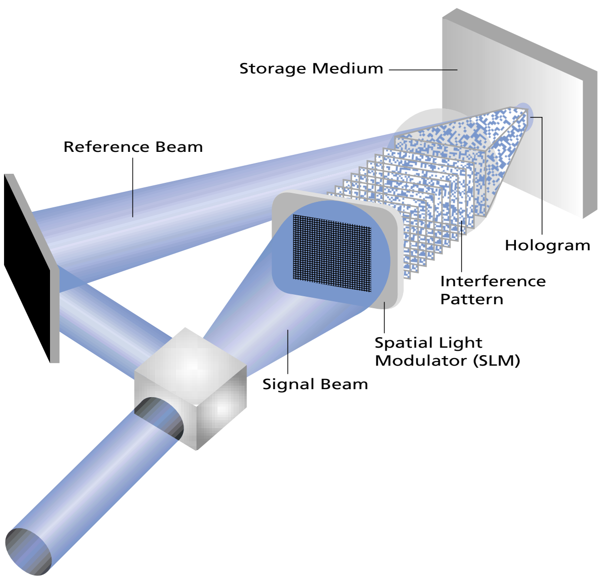
InPhase TECHNOLOGIES

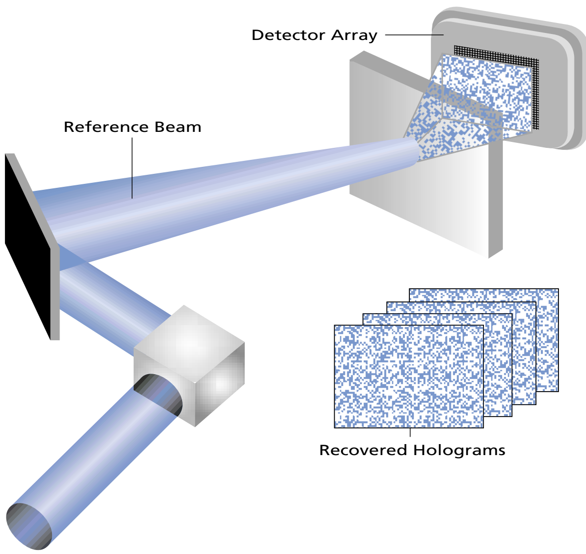
TECHNOLOGY TOUR

RECORDING DATA



In holographic data storage, light from a coherent laser source is split into two beams, signal (data-carrying) and reference beams. Digital data to be stored are "encoded" onto the signal beam via a spatial light modulator. The data or strings of bits are first arranged into pages or large arrays. The 0's and 1's of the data pages are translated into pixels of the spatial light modulator that either block or transmit light. The light of the signal beam traverses through the modulator and is therefore encoded with the "checkerboard" pattern of the data page. This encoded beam then interferes with the reference beam through the volume of a photosensitive recording medium, storing the digital data pages.

READING DATA



The interference pattern induces modulations in the refractive index of the recording material yielding diffractive volume gratings. The reference beam is used during readout to diffract off of the recorded gratings, reconstructing the stored array of bits. The reconstructed array is projected onto a pixelated detector that reads the data in parallel. This parallel readout of data provides holography with its fast data transfer rates (10's to 100's of MBytes/second).

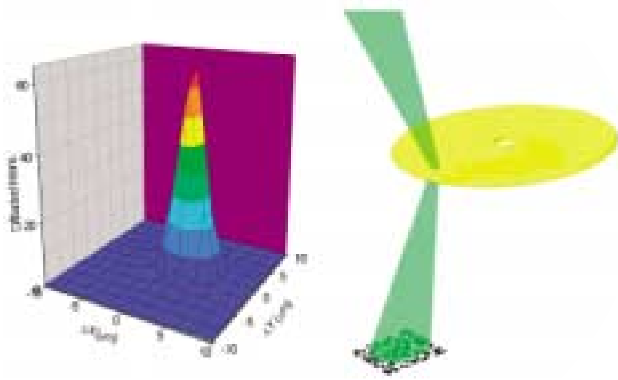
The readout of data depends sensitively upon the characteristics of the reference beam. By varying the reference beam, for example by changing its angle of incidence or wavelength, many different data pages can be recorded in the same volume of material and read out by applying a reference beam identical to that used during writing. This process of multiplexing data yields the enormous storage capacity of holography.

In the past, the realization of holographic data storage has been frustrated by the lack of availability of suitable system components, the complexity of holographic multiplexing strategies, and perhaps most importantly, the absence of recording materials that satisfied the stringent requirements of holographic data storage.

Recently the development of practical components for holographic systems has rekindled interest in this technology. While the development of the needed components has been accomplished for non holographic markets, the volume of these markets is expected to lead to low-cost, reliable components for holographic data storage. DVD-R (red 680nm) and DVD-B (blue 405-407nm) have been developed for the optical storage market place. These recording sources have the desired characteristics for holographic storage and are attractive due to their small size, ruggedness, and low cost. Digital micro-mirror devices appearing in new types of displays are ideal spatial light modulators with their large numbers of pixels (~ 1 million), fast frame rates (2000 Hz), and high optical contrast. The CMOS active pixel detector arrays emerging in digital photography exhibit the rapid access and data transfer properties required for holography.

The InPhase Technology team has invented several multiplexing techniques that yielded a simple, easily implementable architecture for holographic storage systems. Spurred by this development, we focused on the long-standing problem of the lack of suitable storage materials and invented new high-performance recording media with demonstrated high density data storage capabilities. Our work serves as the foundation for a practically realizable, high capacity storage system with fast transfer rates and low-cost, removable recording media

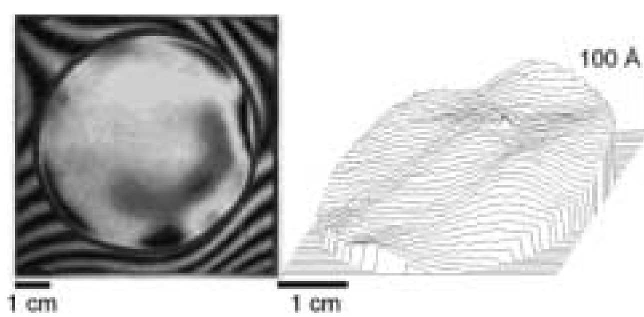
BREAKTHROUGH - NEW MULTIPLEXING METHODS



The methods used to overlap or multiplex holograms determine the complexity and architecture of the recording system. Bell Labs researchers developed several new methods of multiplexing holograms that increase the capacity, performance, and simplicity of the drive. In addition, several recording procedures have been developed that maximize the potential of InPhase's unique photopolymer recording materials.

Drive architectures and multiplexing methods have been developed for several concepts. These include very small form factor recordable PCMCIA drives, and new replication and drive technology for low cost, high performance ROM distribution.

BREAKTHROUGH - NEW POLYMER RECORDING MEDIA



One of the major challenges in the area of holographic data storage has been the development of suitable storage materials. Holographic media must satisfy stringent criteria, including high dynamic range, high photosensitivity, dimensional stability, optical clarity and flatness, nondestructive readout, millimeter thickness, and environmental and thermal stability.

InPhase has designed Tapestry™ media, which is a new "two chemistry" photopolymer that yields high response, high photosensitivity media in millimeter-thick, optically flat formats. The media exhibits the highest dynamic range of any holographic material, and currently represents one of the few recording systems appropriate for high density digital holographic storage applications.

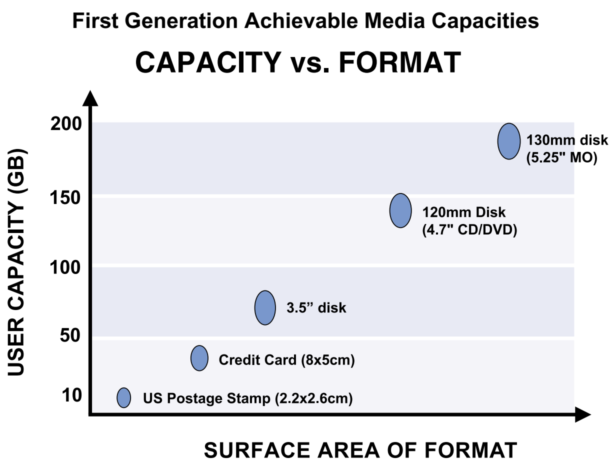
BREAKTHROUGH

The media is fabricated from mixtures of two independently polymerizable yet compatible chemical systems. Recording disks are formed by an in-situ polymerization of one of the components to form the matrix or support of the medium. The other component, which is photosensitive, remains unreacted and dissolved in this matrix. Recording of holograms occurs through a spatial pattern of polymerization of the photosensitive species that mimics the optical interference pattern generated during holographic writing. The concentration gradient that results from this patterned polymerization leads to diffusion of the unpolymerized species which creates a refractive index modulation that is determined by the difference between the refractive indices of the photosensitive component and the matrix. Our approach allows us flexibility in tailoring the media to the particular needs of high density holographic data storage.

In these materials, a storage densities of 31.5 Gbits/in^2 (a density that would yield ~45 Gbytes on a 5 1⁄4" disk) have been demonstrated by recording and retrieving >3000 digital data pages. Newer "two-chemistry" materials and custom optics we have developed have the capability to store >100 Gbits/in^2 densities with very fast transfer rates. With these photopolymer materials meeting the critical performance requirements for holographic mass storage, we believe they have removed much of the risk associated with the development of holographic technology.

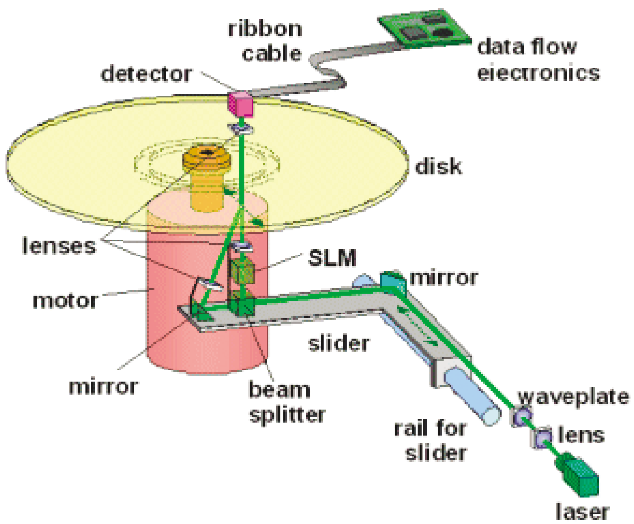
InPhase is developing a rewritable material and system to expand the technology into more traditional data storage markets.

CAPACITY VERSUS FORMAT



The system implementations of this technology do not require very fast rotation of the media to get very high transfer rates. Depending on the application, small form factors can have very high capacity and performance. A chart of capacity vs. media format using a blue laser and simple recording techniques is shown.

EXAMPLE DRIVE



We believe the substantial advances in recording media, recording methods, and the demonstrated densities described here coupled with the recent commercial availability of system components remove many of the obstacles that previously prevented the practical consideration of holographic data storage and greatly enhance the prospects for holography to become a next-generation storage technology.

InPhase Technologies is also applying the technology developed to other markets. We are forming relationships with partners in both optical component and optical communication market places.