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# A CRITICAL EVALUATION OF NEWLY EMERGING HOLOGRAPHIC DATA STORAGE

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## ABSTRACT

This article presents an assesment of the long awaited holographic data storage technology and its possible impact on data processing.Despite some doubts,three dimensional holographic memory appears to have a serious potential to increase current storage capacities significantly at commercially realistic price levels.

**Key Words: Holographic** data storage, three dimensional storage, spatial light modulator, HVD, content distribution.

## 1. INTRODUCTION

The demand for storing larger and larger quantities of digital data is increasing rapidly and it is estimated that total storage capacity is now doubling every year. After more than thirty years of research and development work, first holographic disks and disk drives are scheduled for release in late 2006.A DVD sized holographic computer disk is planned to have 300 gigabytes of storage capacity, with a 20 megabyte per second transfer rate. According to the developers, next generation products will push up the storage capacities to 800 gigabytes and then to 1.6 terabytes (Johny, 2006).

The advertised capacities will make it possible to store millions of pages of information and high definition multimedia data in a small, inexpensive disk. It has already been demonstrated that, hundreds of movies or a million books could be digitally stored in a small volumetric space (Huang, 2005). These expectations are far beyond the limits of the current technology, which is based on magnetic storage of bits on two dimensional surfaces.

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There also are some doubts about commercial and technological success of holographic memory in the near future. This article evaluates the pros and cons of the latest developments in holographic data storage technology and its possible impacts on the future of data processing.

## 2. HOLOGRAPHIC DATA STORAGE TECHNOLOGY

Classical harddisk systems, CDs and DVDs store data bit by bit on a magnetizable surface. However ,the storage technologies behind these products are close to upper physical limits of data density(Thompson and Best,2000).The main problem is the following: As storage capacity increases , the magnetic grains that hold data get closer together in a limited area. Eventually, magnetic fields of the neighboring grains begin to interfere, which reduces the quality and reliability of stored data (Burr et.all,2001). Optical storage technology also suffers from similar problems related to the limited size of the recording light beams.

Holographic storage technology is based on writing data bits vertically instead of horizontally. The advantage is that, the entire volume of recording media is used for storing information. The actual storage takes place in a light-sensitive crystal material .The interferance of laser light is utilized for storing millions of bits at a time. During this process, a single laser beam is split into two beams: The signal beam and the reference beam. The signal beam carries the data and a hologram is formed when these two beams cross each other, creating an interference pattern in the recording medium. The signal beam travels through a spatial-light-modulator (SLM) that translates electronic data of zeros and ones into an array of light and dark pixels. When the two beams meet, the interference pattern that is created stores the data as a hologram image. The chemical reactions that occur during the process, cause the holographic image to be recorded in the light-sensitive storage medium. An important characteristic of this technology is the ability to store multiple holographic images in the same volumetric space. This can be achieved by varying major components of the system such as the beam angle, laser wavelength and media position, Data retrieval also is based on the same mechanism: When the data in a hologram is needed, the reference beam is sent into the material in the same way as when it was written. This process reconstructs the original signal beam, whose data contents can be converted into computer readable form by using a special digital camera system. A critical element here is the angle of the reference beam. It must match exactly the original beam angle. Even a few thousandths of a milimeter

difference will result in failure to reconstruct the recorded data(Bonsar,2006). The choice of storage medium is very important for the success of holographic recording and retrieval systems. There have been considerable research and development work for obtaining suitable materials for this purpose. The materials that are used currently are inorganic crystal or special polymer. The final media products satisfy stringent optical quality and stability requirements of reliable holographic storage devices.

There are a number of companies working in various fields of holographic storage technology Two leaders in holography related research and development are InPhase Technologies Optware. The companies plan to ship their first productssoon. Both InPhase and Optware are suppurted by powefull multinational companies including; Bell Labs, Bayer, Mitsubishi,Fuji , Toshiba Hitachi, Maxell and others.

## 3. POTENTIALS AND PROBLEMS

Unlike current storage technologies that record one data bit a time, holograpy allows more than a million bits of data to be written and read in paralel with a single flash of light.High 3D storage densities, fast transfer rates and durable media make holography the most likely choice for next generation data storage and processing needs. Only magnetic tape can compete with holographic storage capacities to some extent,but tapes are less durable and harder to access. A prototype holographic system has lately been demonstrated to have a recording capacity of 515 gigabits per square inch,which is highest ever for any storage technology.By the end of 2006,the producer plans to introduce 300 gigabytes capacity on an ordinary DVD–size disk with a transfer rate of 20 megabytes per second.The prototype could store up to 150 million pages,which is more than the capacity of 60 DVDs or 1000 CDs.The speed also is about 10 times faster than conventional DVD recording.

An important advantage of holographic storage is that the system does not spin like a hard disk or DVD.But,although the light source and camera detector are fixed,the reflective mirrors and lenses have to move to change the beam angles.This requires extremely high precision positioning and movements of the components.Some other properties that make holographic storage attractive include the followings (MacKinnon,2006):

Per megabyte cost of the media is low.
The life expectancy of recorded data is more than 50 years.
Random acces to stored data is the standard method.
Capabilities for improving information security are higher than current Technologies.

The opponents of the holographic storage technology raise some doubts about the immediate success of end user products. Scepticisms focus especially on the following points (Miller,2006) :

Since the media is photosensitive, maintaining reliability will be difficult as both the drive and cartridge have to be lightproof for preventing exposure to light. The level of precision has to be extremely high for proper interoperability of complex optical, electronic and mechanical systems. For example, slightest vibrations could throw the intersecting beams off-target.

The cost levels are not yet competitive for large scale market acceptance of holographic memory products.

The expected shelf and archieval lifetime of the products are not well-known.The sensitivity of media varies over time and the light source power is difficult to keep stable.

Despite these and similar negative points, the researchers and producers of the holographic technology are confident about succes in the near future.

## 4. CONCLUSIONS

Considering all positive and negative aspects ,it is now almost certain that the holographic storage technology will be the winner among the competing ones.This will be the opening of a new era in data storage and data processing .Applications requiring and using unusually high storage capacities will revolutinize content distribution,mobile computing and global information security.Possibilities include more efficient querying ultradense databases,new kinds of displays,and ultrafast processors carved into holographic material.However,the technology still needs a few more years to offer common-place affordable products.

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