**International Journal of Engineering Research and Development**
*e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com*
*Volume 10, Issue 9 (September 2014), PP.80-83*

# HVD Holographic Technology for Data Storage Disks

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**Abstract:-** Nowadays due to pervasiveness of using digital devices throughout all the world and Dramatic increase of digital data storage speed, transfer rate, quality of data, etc. these devices need to new infrastructures for handling and supplying data with high speed and volume. One of these devices that will change market of optical disks is HVD. HVD disk uses holographic technology for reading/writing data that causes higher volume of storage and data transfer rate toward other optical storages.

**Keywords:-** Holography, laser, servo data, HVD, optical Storage

## I. BRIEF HISTORY OF HOLOGRAPHY

Holography was first used by Denis Gabor in the 1940s with a mercury arc lamp. His discovery did not immediately attract much attention due to the 'incoherent' nature of the mercury light, and the resulting low quality results.With the 1960s invention of the laser (light amplification by stimulated emission of radiation), holography now had the 'coherent' light source needed to produce high-quality images. Coherent light is monochromatic, of a single wavelength, and from a single point source. In 1962 Emmett Leith and Juris Upatnieks create first laser transmission holograph of 3D objects. In 1962 Dr. Yuri N. Denisyuk makes it possible to recreate holograms with incandescent light. In 1968 Stephen Benton discovered a way of eliminating the so-called 'rainbow smear' effect. Using his method, only one color would be seen. This gave rise to the "rainbow" effect; as the viewpoint is moved vertically, the color of the hologram changes. Benton's discoveries made 'embossing' and mass-production of holographs possible[1].

## II. BASICS OF HOLOGRAPHY

The word "holo" in Greek means complete and gram means recording, so that a "hologram" is a complete recording of the wave scattered from an object. Holography uses both phase and amplitude distributions of the scattered light to record the image of the object[2].An essential condition for the successful fabrication of a hologram is the availabilityof a monochromatic light source with minimal phase fluctuations. The presence ofPhase fluctuations results in the random shifting of the interference pattern and thewashing out of the hologram. For this reason, a coherent light source (usually a laser)is a necessary part of the apparatus.Holography is able to record the phase of light waves from an object by interfering two light waves out of phase. The human eye cannot determine phase, but it can detect the phase difference between these two beams of light. The original object can be reproduced with a reconstruction beam used on the hologram, creating an apparently 3D image. This image is really just focused
light[3].

## III. SIMPLE HOLOGRAM SETUP

Fig. 1 illustrates a typical experimental configuration used to record a hologram and reconstruct the optical wave scattered from the surface of a physical object.Using a beamsplitter, laser light is split into two portions; one is used as the reference wave, whereas the other is scattered from the object to form the object wave[3]. When the two beams meet on film, they interact and cause an interference pattern. The film records this pattern through a chemical reaction that changes the index of refraction of the gratings inside the film [3].

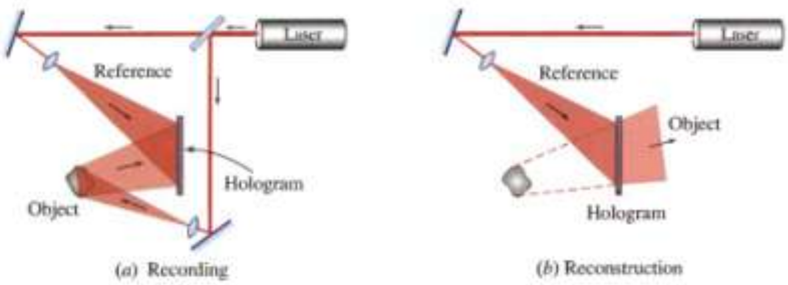


**Fig. 1: Holographic recording and reconstruction**

**Fig. 2: Holographic Versatile Disc (HVD)**

**What is Holographic Data Storage?**

Three dimensional or "holographic" data storage involves using the entire media for storage, not just a few layers like we currently use today. The process is accomplished by using two laser beams, instead of one, to write/read data to/from the disk[4].

**Structure of Holographic Versatile Disc (HVD)**

Many disk prototypes have been looked at over the years, however, the industry standard has now accepted having the HVD disk include a reflective layer in order to be backward compatible and to assist with tracking of the write beam. HVD also includes servo data. The servo beam in the HVD system is at a wavelength that does not photosensitize the polymer recording medium. In the HVD test system, the servo data is carried in a red (650-nm wavelength) laser. The size and thickness of an HVD is also compatible with CDs and DVDs. The structure of the disc places a thick recording layer between two substrates and incorporates a dichroic mirror that reflects the blue-green light carrying the holography data but allows the red light to pass through in order to gather servo information[5].

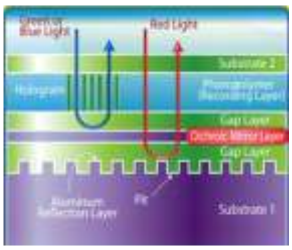


**Fig.3: HVD Layers**

**The HVD System: Writing Data**

A simplified HVD system consists of the following main components (Fig. 4):

- Blue or green laser (532-nm wavelength in the test system)
- Beam splitter/merger
- Mirrors
- Spatial light modulator (SLM)
- CMOS sensor
- Photopolymer recording medium

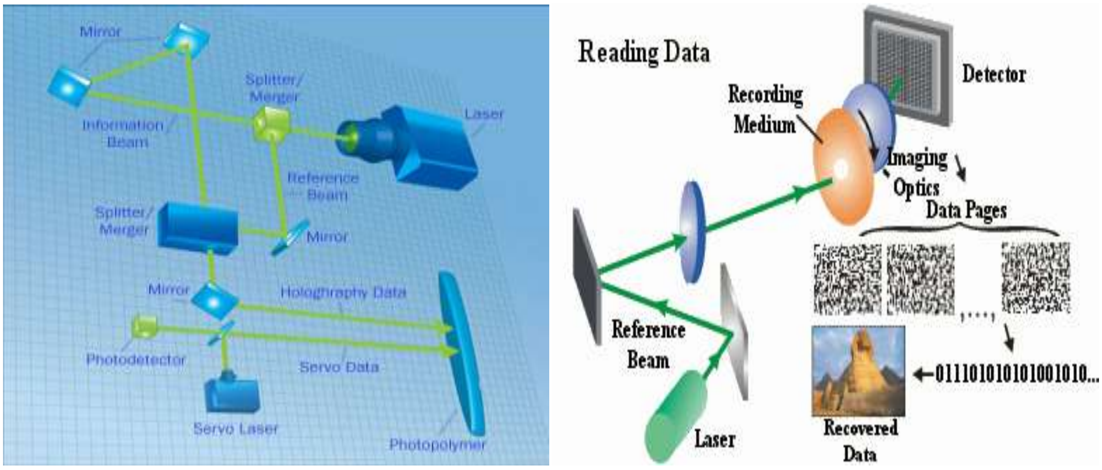


**Fig.4: HVD System(Write)**

The process of writing information onto an HVD begins with encoding the information into binarydata to be stored in the spatial light modulator (SLM).Pixels of the spatial light modulator filter (block or allow) the light thus encoding the data into the laser beam.These data are turned into ones and zeroes represented as opaque or translucent areas on a "page" .this page is the image that theinformation beam is going to pass through.

Once the page of data is created, the next step is to fire a laser beam into a beam splitter to produce two identical beams. One of the beams is directed away from the SLM.This beam becomes thereferencebeam. The other beam is directed toward the SLM and becomes the information beam. When the information beam passes through the SLM, portions of the light are blocked by the opaque areas of the page, and portions pass through the translucent areas. In this way, the information beam carries the image once it passes through the SLM.

When the reference beam and the information beam rejoin on the same axis, they create a pattern of light interference, theholography data. This joint beam carries the interference pattern to the photopolymerdisk and stores it there as a hologram.

**The HVD System: Reading Data**

To read the data from an HVD, you need to retrieve the light pattern stored in the hologram.In the HVD read system, the laser projects a light beam onto the hologram, a light beam that is identical to the reference. The hologram diffracts this beam according to the specific pattern of light interference it's storing. The resulting light recreates the image of the page data that established the light-interference pattern in the first place. When this beam of light, the reconstruction beam, bounces back off the disc, it travels to the CMOS sensor. The CMOS sensor then reproduces the page data (Fig. 5)

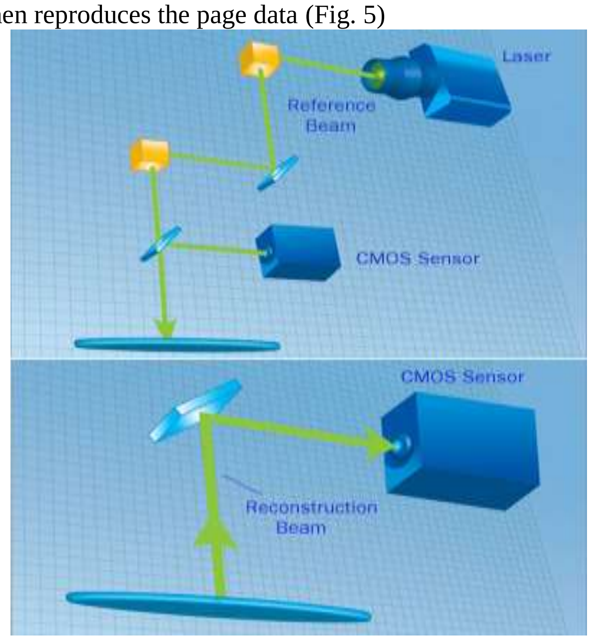


**Fig. 5: HVD System(Read)**

**Why the Interest interesting HoIographic Data Storage?**

- Increased storage capacity
- Increased read/write speed
- Longer storage life
- Security

**Increased-Capacity**

In today's world, digital media is becoming more and more common and is requiring more storage to meet the new demands. More industries are now using digital storage than ever before. 200 DVD's can fit on one 1 or (3.9) TB holographic disk with a future capacity of 6 terabytes.

IBM's test platforms can store up to 390 bits per square micron (a micron is a millionth of a metre). DVDs, by contrast, have a storage density of about five bits per square micron. Interesting Facts It has been estimated that all the books in the U.S. Library of Congress, could be stored on six (6) HVD's. The pictures of every landmass on Earth (Google Earth for example) can be stored on two (2) HVD's. With MPEG4 ASP encoding, a HVD can hold between 4,600 to 11,900 hours of video, which is enough for non-stop playing for a year. This property of HVD is partly due to HVDs storing holograms in overlapping patterns, while a DVD basically stores bits of information side-by-side. HVDs also use a thicker recording layer than DVDs, an HVD stores information in almost the entire volume of the disc, instead of just a single, thin layer (Table1) [6].

**Table 1: competitions optical disks**

| | **DVD** | **DVD** | **Blu-Ray** | **Blu-Ray** | **HVD** |
|---|---|---|---|---|---|
| **Number of Layers** | Single | Dual | Single | Dual | 200+/- |
| **Recording Capacity** | 4.7GB | 9.4GB | 25GB | 50GB | 3.9TB |
| **Data Transfer Rate** | 11.08Mbis | 11.08Mbis | 36Mb/s | 36Mb/s | 1GB/s |
| **Disc diameter** | 120 mm | 120 mm | 120 mm | 120 mm | 120 mm |
| **Laser wave length** | 650 nm(Red) | 650 nm(Red) | 405 nm(Blue) | 405 nm(Blue) | 532nm(Green) |

**Increased Speed**

Holography allows a million bits of data to be written and read out in single flashes of light, enabling data transfer rates as high as a per second (fast enough to transfer a DVD movie in about 30 seconds).

**Longer Storage Life**

HVD's have an estimated archival life expectancy of at least compared to CD/DVD archival life of 2 to 5 years (even though published life expectancies are often cited as 10 to 25 years or longer for optical media, it depends on the storage conditions and quality of the disks).

**Why is it taking so long?**

Low cost materials needed to come available which are just now happening due to other industries utilizing new technology. Developments of needed components, in fields outside the storage industry, have brought the cost down making it financially viable to proceed.

## IV. CONCLUSIONS

It is not far away that holographic technology in data storage, make a revolution causing higher volume of storage and data transfer ratein optical disks and become more common for saving data.

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