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Intelligent Modeling And Control Of Disk Media Production

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***Abstract*—This work deals with optical system that can be used for improving the storage capacity of Removable Media Storage Devices (RMSD). It is modeled based on ultrahigh density multilayer disk recording by two photon absorption techniques. Fuzzy Logic Interference System is used to develop a controller which stimulates the intelligent system for disk media production evaluation. The Fuzzy Logic has two inputs; the Numeric Aperture and the Number of Layers, while the output is Desk Storage Capacity. The System was implemented by Mat lab simulation. A total disk storage capacity of up wards to six terabyte was realized.**

Keywords—Optical Data, Recording process, storage simulation.

1. INTRODUCTION

Disk is a flat shaped plate of a material specifically produced to act as a medium for the storage and retrieved of information. Such electronic system devices are classified as media. Thus disk media relates to those information storage and retrieval system devices that can be utilized in audio, video, and data applications. Prior to the advent of computer, most information storage devices were in the form of reels that are used in film projections or televise broadcast machines, video home sets (VHS) and audio cassettes. However, with the emergence of personnel computer, there has been a significant change in the requirements for removable media storage system devices (RMSDs). The first ever removable media storage device is the floppy disk. Subsequent developments in the RMSD are informed by improved storage and retrieval parameters including capacity, speed, access time, data transfer rate, data availability, backward compatibility, durability and convenience. Consequently the compact disk (CD) was introduced. The CD has a maximum storage capacity of 793 megabytes. The digital versatile disk (DVD) followed with an improved storage capacity of 15.9Giga bytes which is about eight hours of movies. Presently, the fluorescence multilayer disk (FMD) or the constellation three dimensional disk (C3D) are being developed. It has a capacity of one Tetra bytes which is equivalent of a 1000 CD capacity. Generally, the size of disk media is 120mm diameter and a thickness of 1.2mm. The technology applicable in the read and write data on RMSD includes; magnetic format that uses laser light and optical sensors, magneto-optical hybrid that uses a combination of magnetic and optical properties to increase storage capacities, holographic format that can write and read one million bits of data in a single flash of light.

Disk media production is indeed in a developmental process. The technology of RMSD is still evolving. With the rapid advancement of internet and computer technology, the demand of massive and inexpensive data storage tools has increased dramatically. For the last twenty years, optical disks, in particular read-only compact disks (CDs) and digital versatile disks (DVDs) have enabled us to replicate massive amount of data in an inexpensive removable formats. Optical disks are also popular as recording devices in the formats of compact-disc-recordable (CD-R) and compact disk-rewritable (CD-RW). Other formats, such as DVD-R and DVD-RW, are just emerging into the market of massive data storage. As the optical data storage technology evolves, the capacity of an optical disk increases (Tieke et al, 1999). The CD and DVD devices use the mechanism of far-field single-layer recording. A more advanced technology, which uses multiple layers on a single disk, is called volumetric bit-wise optical data storage. This disk media production can go a long way in improving the quality of removable media storage devices (RMSDS) in areas of storage capacity, speed and durability.

2. OPTICAL DISK DATA RECORDING PROCESS

The process of recording data onto an optical disk starts with the user input data stream converted to a current drive signal for the laser diode. Intense pulses from the laser cause physical changes in the surface of the recording medium as the disk spins, which result in spiral tracks of data marks. Retrieval of data marks on the disk is illustrated in Fig. 2.2, where the laser is used at a constant output power level that does not heat the data surface beyond its thermal writing threshold. The laser beam is directed through a beam splitter into the illumination optics, where the beam is focused onto the surface. As the data marks to read pass under the scan spot, the reflected light is modulated. Modulated light is collected by illustration optics and directed by the beam splitter to servo and data optics, which converge the light onto detectors. The detectors change light modulation into current modulation that is amplified and decoded to produce the output data stream.

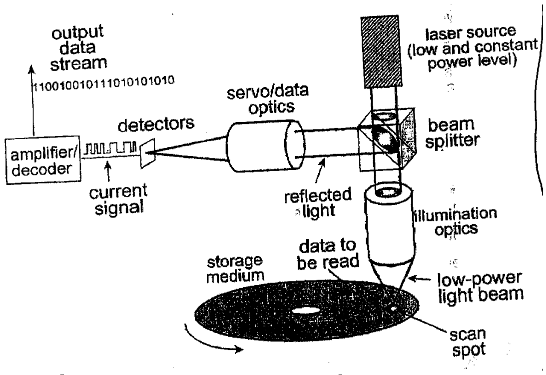

Fig. 2.1 Data Tract Readout Process

3. DEVELOPMENT OF MODEL FOR OPTICAL DATA STORAGE

The ultrahigh density multi-layer disk recording by two photon absorption model is assumed. In this model, a high Numerical Aperture (NA) objective lens (NA>1) with a long working distance (>100mm) together with a multilayer volumetric optical media provides an important direction towards the realization of ultra high density multi-layer recording by two-photon absorption. A high NA objective lens decreases bit size, increases the volumetric density, and reduces the recording laser power requirements for a given recording speed.

For increasing Disk Capacity, the parameters required for a 2-photon 3-D optical data storage disk, are:

Maximum (r_{max}) and minimum r_{min}) recording radius of the disk, $/_{bit}$ W_{pitch} is the bit size in the X-Y plane.

NA is the numeric aperture of the optical system.

The total area raw capacity is expressed as:

$$C_{areal} = \frac{\pi(r^2max - r^2max)NA}{1_{bit} X W_{pitch}} \quad 3.1$$

The volume raw capacity of a 2-photon 3-D optical data storage disk is:

$C_{total} = C_{areal} * N_{layer}$

$$C_{areal} = \frac{\pi(r^2max - r^2max)NA \text{ X } N_{layor}}{1_{bit} X W_{pitch}}$$

Hence

The storage capacity = volume raw capacity

Storage capacity = C_{areal} X N_{layer}

3.2

$N_{layer} = T_{disk}/S_{layer}$ is the number of layers.

T_{disk} is the thickness of the disc;

S_{layer} is the layer separation

Generally, T_{disk} should be smaller than the working distance of the objective lens.

For Ultra high density multi-layer disk readout, during readout, fluorescence is emitted in 4n radians. The substrate of the disk is n1 = 1.492. The critical angle affects the maximum solid angle that can be collected. Total collection efficiency is the ratio of the collected solid angle to 4n radians:

NA = n1sinθ ens.

N = refractive index in image space θ = marginal ray angle in image space.

Radius of beam width r = 0.61λ/NA

Wavelength (λ) = 460nm

Numerical aperture (NA) = 0.2 to 1.8

Pulse repetition rate = 76MHz

Pulse width = 200 per second

Bit length per bit = 1.22λ/NA

Bit size = 1 bit x w pitch = 1.2 x λ

Demonstration of the Model on Optical Data Storage by Simulation

Below is the model parameter for the 2 –photon 3-D optical data storage disk.

$r = (r^2_{max} - r^2_{min}) = 0.61\lambda$, $r^2 = (0.61\lambda)^2$.

$\pi = 22/7$

n1 = 1.492

No of layers = 1 0

For equation 3.1, the simulated data from the numerical aperture used is as shown in table 3.1

Table 3.1: Variation of Storage Capacity with increasing NA

Numerical Aperture (NA)	Area (surface) Capacity: TB
0.2	0.8819
0.4	1.7638
0.6	2.6457
0.8	3.5275
1.0Z	4.4094
1.2	5.2913
1.4	6.1732
1.6	7.0551
1.8	7.9377

For equation 3.1 the simulated data from the numerical aperture used for collection efficiency is also shown in table 3.1

Table 3.2: variation of Collection Efficiency with increasing NA

Numerical Aperture (NA)	Area (surface) Capacity: TB
0.2	0.0451
0.4	0.1830
0.6	0.4221
0.8	0.7795
1.0	1.2893
1.2	2.0288
1.4	3.2714
1.6	5.000 – 1.9366i
1.8	5.000 – 3.3745i

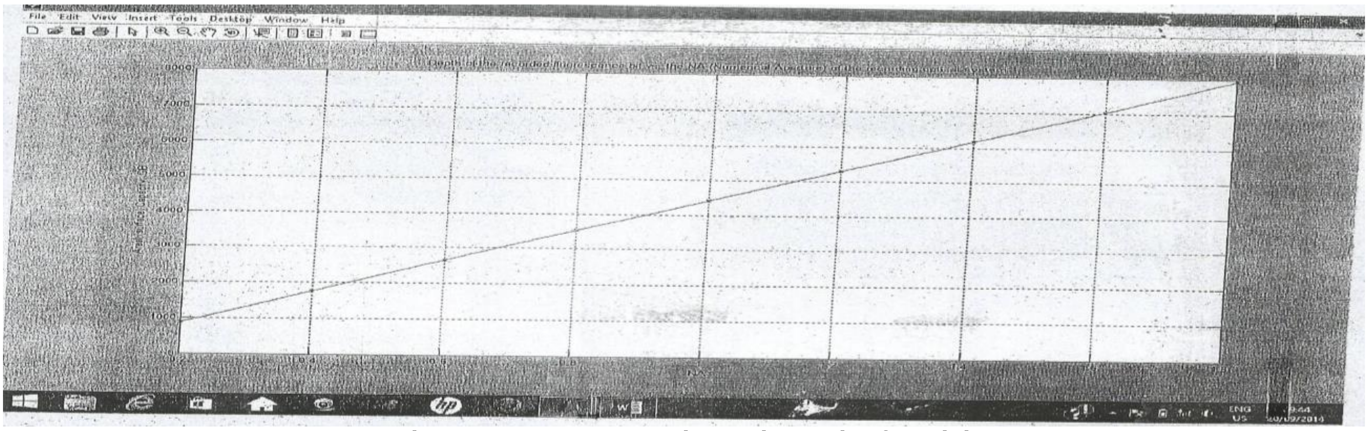

Fig 3.1: Storage Capacity and NA Plot for Disk

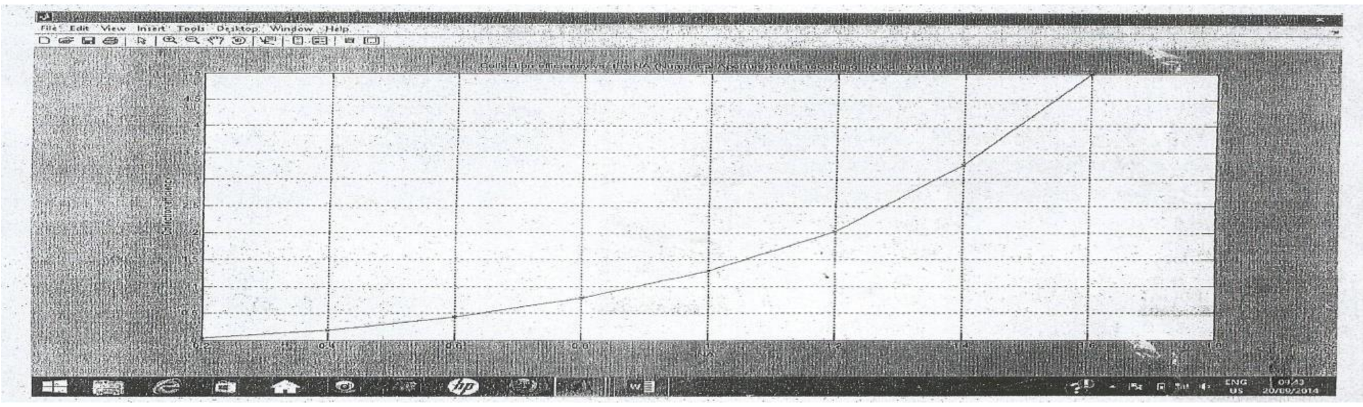

Fig. 3.2 Collection Efficiency

4. DATA ANALYSIS

There is a remarkable increase in the storage capacity of RMSDS from the era of magnetic floppy disk to the present period of optical and horographic technology. A high NA objective lens (NA>1) with a long working distance (>100mm) used together with a multilayer volumetric optical media provides an important direction towards the realization of ultra high density multi-layer recording by two photon absorption. A high NA objective lens decreases bit size, increases the volumetric density, and reduces the recording laser power requirements for a given recording speed. Static recording experiments have verified the recording potential performance of a high NA lens. Recording results at 1.8NA indicate reduction in peak recording power or recording data rate increase. In addition, the simulation and static read out experiments show that a high NA objective lens collects more fluorescence fro m a smaller volume and compensates the loss of the readout fluorescence caused by the smaller recorded bit size.

5. CONCLUSION

Improved performance in two-photon addressed volumetric optical disk storage systems is presented. Influence of the numerical aperture on a 3-D multi-layer optical data storage system is analyzed based on simulation and experiments. A high NA objective lens decreases bit size, layer separation, and increases the volumetric capacity. Increasing NA also decreases the required recording laser power for two-photon absorption recording. The concept of 3-D parallel readout, simultaneous readout of multiple-tracks across multiple layers, has been presented.

Two-photon absorption provides a means to record multiple data layers in one disk. Media properties such as non-reflective fluorescent written spots, unnoticeable index change and separated recording and readout absorption spectra make it possible to envision high data capacity disk systems with this approach. Based on experimental evidence, the projection for data capacity of a 12 0mm diameter 1.2mm thick disk exceeds 200 terabyte.

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