An erasable optical disk (100K), for use with an erasable optical disk drive system, having a readout stimulation laser and a recording laser, is disclosed. The disk utilizes electron trapping optical memory material as the storage medium and comprises a disk substrate (10a), a layer of electron trapping optical memory material (14) coated on the disk substrate, a first light absorbing layer (120) coated on the layer of electron trapping optical memory material, a second light absorbing layer (122) coated on the first absorbing layer, and a reflective layer (20) coated on the second absorbing layer.
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Improved Optical Disk Structures For
Electron Trapping Optical Memory Media

Background of the Invention

Cross-Reference To Related Applications


Background Of The Invention

The present invention relates to disks for use with optical mass storage devices for data storage. More particularly, the present invention relates to a method of and apparatus for constructing an erasable optical disk for mass data or information storage which performs all of the erasing of data, in a purely photoelectric manner.

Optical storage devices for use in storing computer and other data are presently known in the art. Such devices are desirable because of their ability to store vastly more information per disk than known magnetic disk storage devices. While most of the known optical disk drive devices perform read-only functions, write-once-read-many times (WORM) and erasable optical
memory systems are also known. However, heretofore, erasable optical memory systems have encountered much greater developmental difficulty than the read-only or WORM systems, due in part to the increased technical complexity of the characteristics of the disk media itself.

In order to overcome the problems of prior art erasable optical disk drives, a related company to the assignee of the present invention has developed a new approach to the optical storage materials which provide the storage function of the erasable optical disk drive. This development utilizes the phenomenon known as electron trapping in a class of materials which comprise an alkaline earth chalcogenide crystal typically doped with rare earth elements. Thin crystalline forms of such materials may be formed on various substrate structures, such as glass or alumina, in order to provide the disk storage medium. Since the electron trapping phenomenon is a purely electronic process, read-write-erase operations can be performed in very short periods of time. In addition, the physical trapping phenomenon appears to offer a practically limitless media life.

The materials which may be used as the media for the optical disk storage system described herein are the subject of United States Patent No. 4,864,536, which is a continuation of Patent No. 4,830,875. Other materials useful as the storage media herein are disclosed in United States Patent No. 4,839,092, which issued June 13, 1989, United States Patent No. 4,806,772, which issued February 21, 1989 and United States Patent No. 4,842,960, which issued June 27, 1989.

Reference is made to each of the foregoing issued United States patents and patent applications, as well as to the applications discussed in the Cross Reference To Related Applications section for a discussion of the electron trapping and electron trapping media phenomena.

In constructing such disks suitable for use with electron trapping optical material coated on disks, it is desirable to utilize a disk structure which allows a submicron resolution of written data patterns. In prior disk structures, as disclosed in the 07/277,255 application and United States Patent No.
4,864,536, for example, the methodology of writing, reading and erasing of
the media consisted of performing all of those functions directly on a single
layer of media. The data patterns are written in a specific location on the
disk, using a focused short wavelength (for example, blue or green) light,
which results in electrons becoming trapped and stored at those locations. The
stored data patterns are then read by subsequent illumination with infrared
light, which causes the trapped electrons to be released and to emit an orange
light at the previously written storage locations. The orange emission is then
converted to electrical signals which represent the original data patterns.

In addition to writing, reading and erasing functions, the necessary
focusing and tracking functions are also performed using the same single layer
electron trapping optical memory media. In order to accomplish the focusing
and tracking functions, a portion of the infrared light produced by the read
laser is reflected back from the media surface and transmitted to focusing and
tracking error detection diodes. The derived focus error signal is proportional
to the plane of the predetermined best focus of the reading laser spot and the
active layer on the disk surface. The focus servo system utilizes that signal
in order to position the objective lens so that the focal point is located at its
optimum position.

The tracking operation is similar to that described with regard to the
focusing operation, except that the output of the tracking error diodes is used
to maintain both the radial position of the optical head on a given track and to
permit the seeking and capture of a particular desired track.

Those prior disk structures for accomplishing reading, writing, erasing,
focusing and track functions created certain disadvantages. For example, the
assignee’s prior methods of reading and writing introduce standing waves in
the laser light intensity which reduce the efficiency of the laser light.

The invention disclosed herein overcomes the disadvantages of the
prior disk structures and methods of performing the various functions
associated with those structures by providing for several distinct layers each
of which performs an active function, in addition to the active media layer.
The invention disclosed herein overcomes the disadvantages of the prior structures and methods in which a reflective layer is used to approximately double the level of the signal read out from the disk. The reflective layer is utilized with a series of simple dyed layers which are placed between the electron trapping optical memory (ETOM) phosphor layer and the reflective layer in order to suppress undesirable reflection at certain wavelengths.

**Summary And Objects Of The Invention**

In view of the foregoing, it should be apparent that there still exists a need in the art for a method of constructing and structures for an erasable optical disk for mass data or information storage purposes in which a plurality of layers are utilized in a simple and precise manner to achieve a sub-micron resolution of the written data patterns on the disk.

It is the object of the present invention to provide a method of constructing and structures for an erasable optical disk in which the intensity of the read out signal from the disk is increased by use of a reflective layer and in which additional wavelength reflective layers of material are placed on the disk between the ETOM phosphor layer and the reflective layer in order to suppress certain undesired wavelengths.

Briefly described, the above and other objects of the invention are accomplished in accordance with its method of constructing and structure aspects by providing a layer of electron trapping optical memory material on a substrate, first and second thick polymer layers of material which are placed on the disk between the layer of electron trapping optical memory material, and a reflective layer that can be used to double the level of the read out signal. Such thick polymer layers are designed to respectively absorb the writing and stimulating or erasing wavelengths, which would otherwise cause undesirable standing waves after being reflected by the reflective layer.
With these and other objects, advantages and features of the invention that may become hereinafter apparent, the nature of the invention may be more clearly understood by reference to the following detailed description of the invention, the appended claims and to the several drawings attached herein.

**Brief Description Of The Drawing**

The single drawing Figure is a diagram illustrating a preferred embodiment of the present invention comprising an electron trapping optical memory layer in combination with two layers of wavelength selective absorbing material in addition to a single layer of reflective material.

**Detailed Description Of The Preferred Embodiment**

Referring now in detail to the drawing, there is illustrated in the Figure a preferred disk structure for use with an erasable optical disk drive system. The preferred embodiment of the present invention selectively suppresses the coherent reflection of the two coherent laser beams used for writing and erasing functions. In that manner, it is possible to obtain the benefits of the redirection of the read-out beam without introducing large standing waves in the writing and erasing beams. In the absence of standing waves in the internal fields of the writing and erasing beams, the maximum number of traps in the electron trapping layer can be filled and emptied, thus producing the maximum read-out signal. Redirection of the read-out light to the drive side of the optical disk doubles the signal available to the read detector if there were no losses in transit of the read-out light due to scattering and absorption.

The drawing Figure shows the construction in diagrammatic form of an erasable optical disk 100K. The various layers of material are deposited on a substrate structure 10a, which may be preferably a ceramic material, such
as aluminum oxide. Alternatively, high temperature glasses and other ceramic materials, such as SPINEL (magnesium aluminum silicate) can be used. The substrate may preferably be 1-2mm in thickness. It should be understood that the layers on the drawing are not drawn to scale with respect to the relative dimensions of the layers or size of the disk.

An electron trapping optical memory (ETOM) layer 14 is deposited on top of the transparent substrate 10a and provides the data storage capacity through the electron trapping phenomena. It may preferably be between 1-5 microns in thickness.

A first thick polymer layer 120 is deposited on top of the electron trapping layer 14. It may preferably be formed from a polymer loaded with an infrared absorbing dye. The dyed polymer layer 120 absorbs the erasing light but is transparent at the writing and read-out wavelengths. A second thick polymer layer 122 is deposited on top of the first thick polymer layer 120. The second thick polymer layer 122 may preferably be formed from a blue-green absorbing dye polymer. The second thick dyed polymer layer 122 absorbs the writing light but is transparent at the read-out wavelengths. Each of the thick polymer layers is preferably between 0.01 mm (10 microns) and 1 mm in thickness.

A reflecting layer 20 is deposited on top of the second thick polymer layer 122. Like the other layers, reflecting layer 20 may be deposited either by vapor or electron beam deposition, sputtering or any other of many similar known processes. This reflecting layer 20 serves to reflect the visible photon emission created by impingement of a read laser beam on the disk 100 and therefore provides for a greater intensity read back signal. It may be formed from a metal, such as aluminum, and have a thickness of a few hundred Angstroms.

The first and second thick polymer layers 120 and 122 and the reflecting layer 20 form a structure which strongly reflects the read-out light without reflecting the writing and erasing light.
A transparent overcoat 22 is coated on top of the reflective layer 20 and serves to protect the optical layers on the substrate from dust and moisture. The overcoat layer 22 may be formed of transparent polymer and be about .01 to 1 millimeter in thickness.

In operation, the writing wavelength passes through the electron trapping layer 14 and is absorbed in the second thick polymer layer 122. The writing light field within the electron trapping layer 14 is uniform.

The erasing wavelength passes through the electron trapping layer 14 and is absorbed in the first thick polymer layer 120. The erasing light field within the electron trapping layer 14 is uniform.

The read-out signal passes through the transparent substrate 10a and the electron trapping layer 14 in the usual manner. However, the read-out signal emanating in the rear hemisphere passes undisturbed through the first and second thick polymer layers 120, 122 and is reflected by the reflecting layer 20. The read-out signal is then redirected into the front hemisphere of the disk. That increases the signal seen by the read optics of the drive. The transit delay experienced by the reflected read-out light due to its longer path to the drive read detector is negligible since light requires only 0.03 nS in order to travel one centimeter.

The use of optically thick wavelength selective layers with the electron trapping layer in an erasable optical disk is advantageous since such layers are much less expensive to fabricate and can be made of materials which would not work in thin layers. The disk structure of Figure 12 can be implemented equally as well by utilizing a highly scattering layer rather than the reflecting layer 20. The use of such a highly scattering layer would be useful in those instances where the larger fraction of redirected light is misdirected because the index of refraction of the electron trapping layer is high.

Alternatively, instead of using a structure designed to absorb the two undesired wavelengths, a coherent optical filter stack could be used to transmit those undesired wavelengths out of the disk structure while reflecting the one desired wavelength. The object is to produce a tuned dielectric reflector
whose reflection at the desired wavelength strongly peaked at the read-out wavelength.

Although a preferred embodiment is specifically illustrated and described herein, it should be appreciated that many modifications and variations of the present invention are possible in light of the above teachings and within the purview of the appended claims without departing from the spirit and intended scope of the invention.
What Is Claimed Is:

1. An erasable optical disk for use with an erasable optical disk drive system, having a readout stimulation laser and a recording laser, which utilizes electron trapping optical memory material as the storage medium comprising:
   a. a disk substrate;
   b. a layer of electron trapping optical memory material coated on said disk substrate;
   c. a first light absorbing layer coated on said layer of electron trapping optical memory material;
   d. a second light absorbing layer coated on said first absorbing layer; and
   e. a reflective layer coated on said second absorbing layer.

2. The erasable optical disk of claim 1, wherein each of said first and second absorbing layers attenuates a different wavelength of light.

3. The erasable optical disk of claim 1, wherein said first light absorbing layer attenuates light either at the wavelength of the recording laser or the readout stimulation laser.

4. The erasable optical disk of claim 1, wherein said second light absorbing layer attenuates light at a wavelength of the laser not attenuated by the first light absorbing layer.
5. A method of making an erasable optical disk for use with an erasable optical disk drive system, having a readout stimulation laser and a recording laser, which utilizes electron trapping optical memory material as the storage medium comprising the steps of:

a. forming a layer of electron trapping material on a disk substrate;

b. forming a first light absorbing layer on said layer on said layer of electron trapping optical memory material;

c. forming a second light absorbing layer on said first light absorbing layer; and

d. forming a reflective layer on said second light absorbing layer.

6. The method of claim 5, further including the step of forming a barrier layer on said reflective layer.

7. The method of claim 5, wherein each of said first and second light absorbing layers attenuates a different wavelength of light.

8. The method of claim 5, wherein said first light absorbing layer attenuates light either at the wavelength of the recording laser or the readout stimulation laser.

9. The method of claim 5, wherein said second light absorbing layer attenuates light at a wavelength of the laser not attenuated by the first light absorbing layer.
10. An erasable optical memory system, having a readout stimulation laser and a recording laser, which utilizes electron trapping optical memory material as a storage medium, comprising:
   a. a disk substrate;
   b. a layer of electron trapping optical memory material coated on said disk substrate;
   c. a first light absorbing layer coated on said layer of electron trapping optical memory material;
   d. a second light absorbing layer coated on said first absorbing layer; and
   e. a reflective layer coated on said second absorbing layer.

11. The erasable optical memory system of claim 10, further including a barrier layer coated on said reflective layer.

12. The erasable optical memory system of claim 10, wherein each of said first and second absorbing layers attenuates a different wavelength of light.

13. The erasable optical memory system of claim 10, wherein said first light absorbing layer attenuates light either at the wavelength of the recording laser or the readout stimulation laser.

14. The erasable optical memory system of claim 10, wherein said second light absorbing layer attenuates light at a wavelength of the laser not attenuated by the first light absorbing layer.

15. The erasable optical disk of claim 1, further including a barrier layer coated on said reflective layer.
FIGURE 1

PROTECTIVE_LAYER (22)

REFLECTING_LAYER (20)

SECOND_THICK_POLYMER_LAYER (122)

FIRST_THICK_POLYMER_LAYER (120)

E.T.O.M. LAYER (14)

TRANSPARENT_SUBSTRATE (10a)

AIR

100K -> LIGHT_IMPinging_SIDE
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**
IPC(5) :G11B 3/70; G11C 13/04; G03C 1/00
US CL :369/275.2,284; 365/110; 430/495; 430/945
According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**
Minimum documentation searched (classification system followed by classification symbols)
U.S. : 369/275.2,284; 365/110; 430/495; 430/945 365/106,111,112; 369/288,286; 428/690

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Please See Extra Sheet.

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tbody>
<tr>
<td>A</td>
<td>US,A, 4,064,066 (Toshinai et al.) 20 December 1977 See the entire document.</td>
<td>1,5 and 10</td>
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<tr>
<td>A</td>
<td>US,A, 4,864,536 (Lindmayer) 05 September 1989 See the entire document.</td>
<td>1,5 and 10</td>
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<td>A</td>
<td>US,A, 5,038,321 (Van Zeghbroeck) 06 August 1991 See the entire document.</td>
<td>1,5 and 10</td>
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<td>A</td>
<td>WO 85/04892 (Kabay) 07 November 1985 See the entire document.</td>
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[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

Date of the actual completion of the international search: 14 JUNE 1993

Date of mailing of the international search report: AUG 03 1993

Name and mailing address of the ISA/US Commissioner of Patents and Trademarks
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<td><strong>Sensors</strong>, March 1986, Lindmayer &quot;Infrared Phosphors as Sensors.&quot; See the entire document.</td>
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<tr>
<td>A</td>
<td><strong>Solid State Technology</strong>, August 1988 Lindmayer &quot;A New Erasable Optical Memory&quot;. See the entire document.</td>
<td>1,5 and 10</td>
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</table>
B. FIELDS SEARCHED
Electronic data bases consulted (Name of data base and where practicable terms used):

APS- Visible (P)(Ultra-Violet)(P)(Infrared);
     Memory (5a) optical?;
     Reflect? (5A) layer;
     Diso or Disk