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(58) Field of search
G8R
H3B

(54) Magnetooptic memory medium

(57) A new magnetic storage medium includes a layer 2 of amorphous material typically GdDyFe whose Curie recording point is lower than its crystallization point (e.g., 120°C for 350°C) to enable crystallization to cause variations in its optical properties such as transmittance or reflectivity for thermomagnetic writing. By varying the output level of the beam from laser 5 either reversible recordings are set upon the amorphous material layer by thermomagnetic writing technique for example the Curie point writing, or unchangeable or permanent recordings are set up on the amorphous material layer through crystallization of the amorphous material layer.

FIG.3

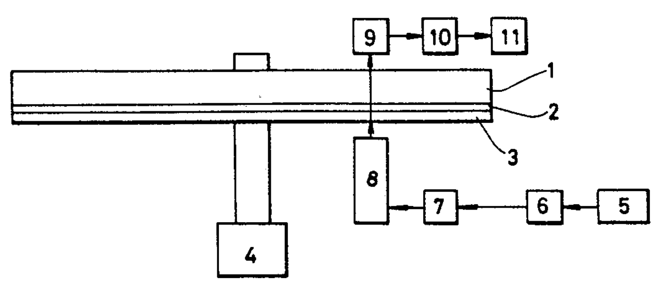

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FIG.1

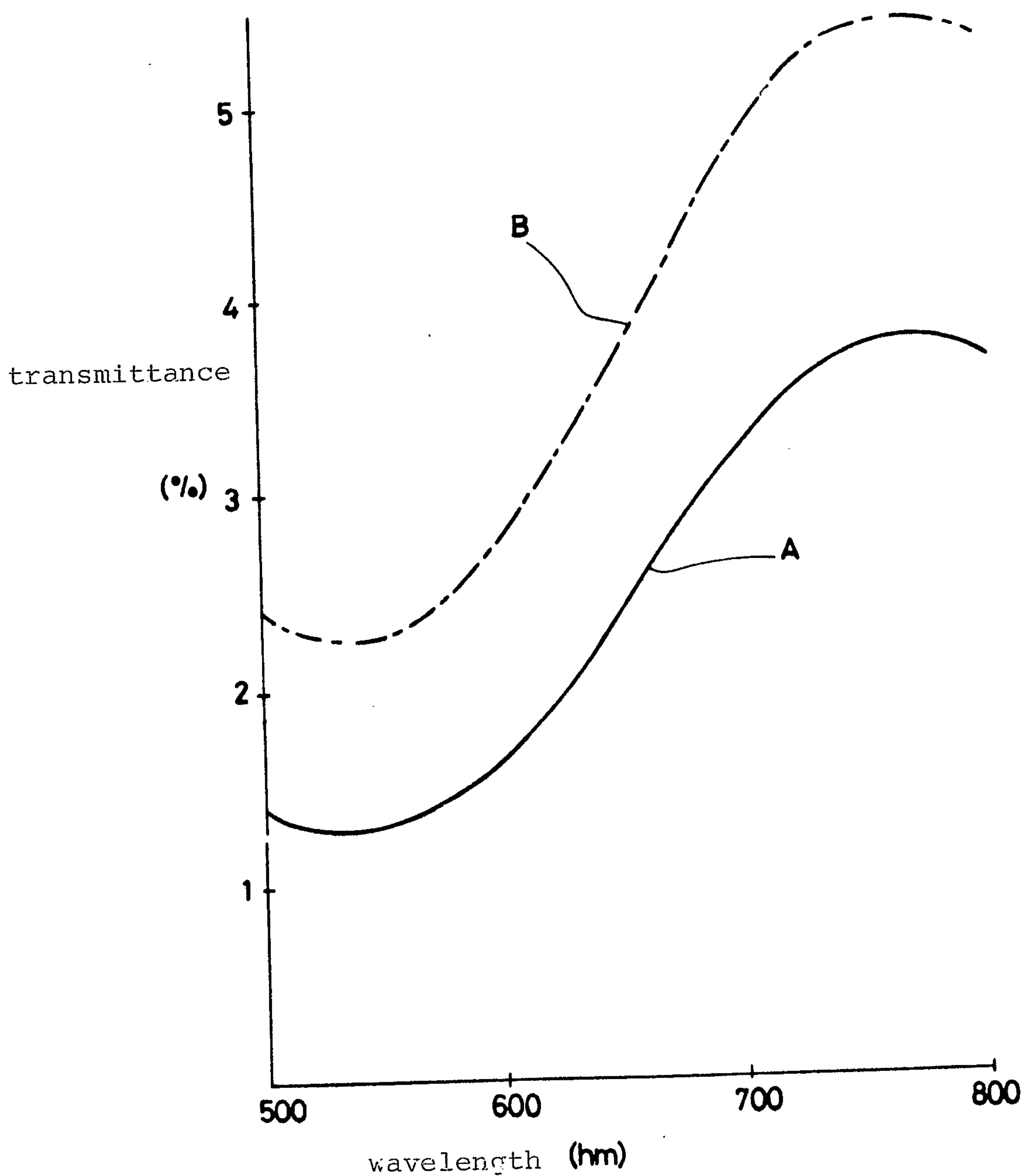


FIG.2

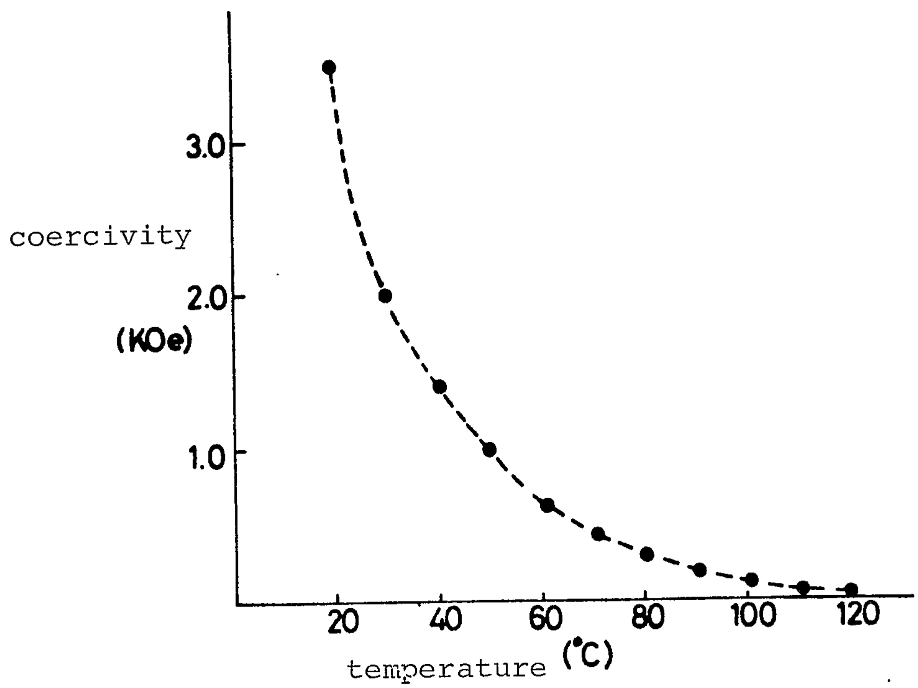

3.0
coercivity
2.0
(KOe)
1.0
20
40
60
80
100
120
temperature (°C)

FIG.3

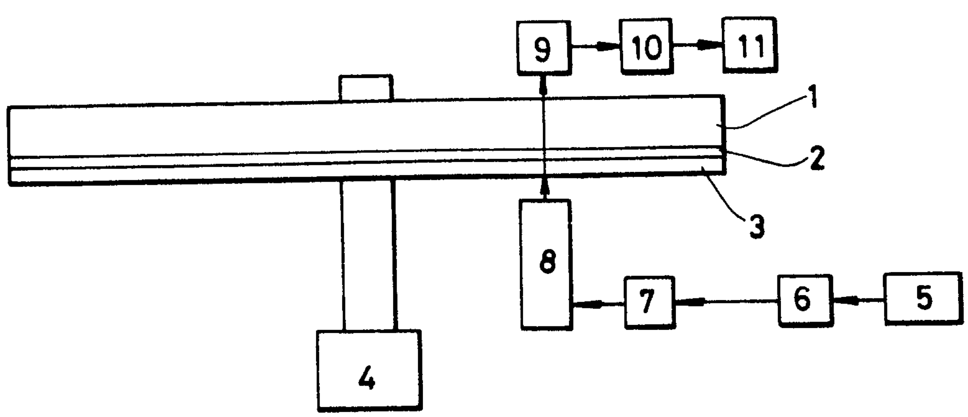

9
10
11
1
2
3
8
7
6
5
4

FIG. 4

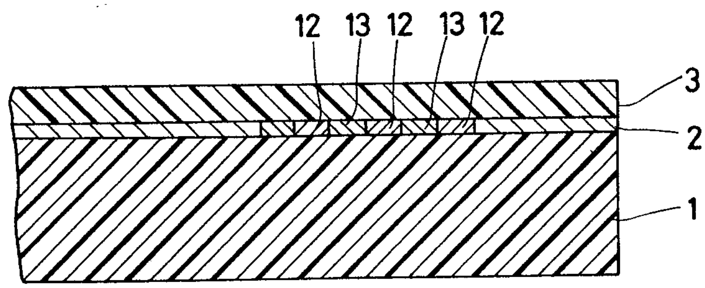
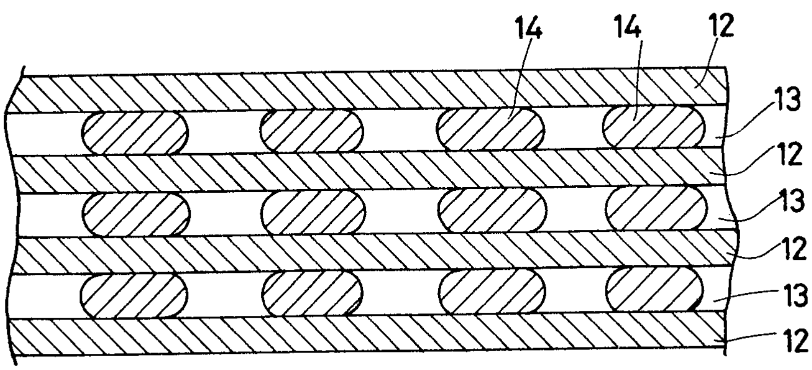


FIG. 5



SPECIFICATION

Magnetooptic Memory Medium

Background of the Invention

This invention relates to a magnetooptic data storage medium, of amorphous magnetic material and more particularly to a magnetooptic data storage medium including changeable and readable memory locations and unchangeable memory locations.

In recent years, the use of thin films of amorphous magnetic materials for thermomagnetic writing, erasing and magnetooptical reading has received particularly intensive study. This sort of optical memory system can be classified into the following categories, depending on data storage properties:

(1) it is readable only;

(2) it can hold additional recordings and readable immediately after writing; and

(3) it is writable, readable and erasable.

Of these three different categories the last is most suitable for computer applications and typically comprises amorphous magnetic films as a storage medium.

Furthermore, the methods of writing for the magnetooptic storage medium developed to data are as follows: (a) Curie point writing technique by which the temperature of a memory bit location is elevated above the Curie point where magnetizations are destroyed. (b) Compensation temperature technique which takes advantage of the coercivity falling when the memory bit location about at the compensation temperature is further heated. (c) Temperature dependent coercivity technique relying upon the phenomenon where the coercivity varies greatly with a temperature rise. Recording is achieved by applying a laser beam onto the memory bit location in the order of 1 um ϕ and thus varying magnetizations in light-activated domains due to temperature increases. Erasing recordings demands energy for restoring the original magnetizations, using the same optical system as for writing. This sort of amorphous magnetic material is well known as a changeable optical memory medium. Reversibility of the medium, however, results in erasing recordings upon malfunction or erroneous operation of a recording system and making data unstable due to fluctuations in the ambient temperature.

Objects and Summary of the Invention

Accordingly, it is an object of the present invention to provide a magnetooptic recording medium which has a writable and erasable memory location for thermomagnetic writing, erasing and recording and magnetooptical reading and unchangeable memory location for only magnetooptical recording.

Brief Description of the Drawings

For a more complete understanding of the present invention and for further objects and advantages thereof, reference is now made to the following description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a graph plotting transmittance of a GdDyFe film in the amorphous state and crystallized state overcovered with a SiO_2 layer as a function of wavelength;

Fig. 2 is a graph showing the relation between coercivity and Curie point;

Fig. 3 is a schematic diagram of an optical data storage device using Faraday effect.

Fig. 4 is a storage medium with guide tracks according to the present invention; and

Fig. 5 is an enlarged view of the guide tracks in Fig. 4.

Detailed Description of the Invention

A film of amorphous magnetic material including rare earth metals and transition metals manifests an increase in transmittance and a decrease in reflectivity by crystallization, as is clear from Fig. 1 where the curve A shows the amorphous state of the film and the curve B shows the crystallized state. Of particular interest is DgDyFe which exhibits a remarkable trend to vary its transmittance or reflectivity depending whether it is in the amorphous state or the crystallized state. This leads to the possibility that crystallizing desired ones of bit locations can provide brightness-varying signals in reading out the locations via a light detector and an optical reproduction system (using Faraday effect or the like) can be utilized as it is. It is obvious from Fig. 2 that the Curie point of the amorphous magnetic material GdDyFe is approximately 120° and the transmisssion point from the amorphous to the crystallized state is 350°. There is therefore a difference of temperature sufficient to enable both the Curie point writing (as a changeable memory) and Crystallization writing (as an unchangeable or permanent memory) on a same medium through the step of varying the intensity of a light source for recording.

In other words, as seen from Fig. 3, a thin film of amorphous GdDyFe (e.g., Gd:Tb:Fe ratio=0.24:0.18:1) and thickness=500—800 Å) whose Curie point recording is possible at a temperature significantly lower than that of the crystallization or transition temperature is deposited on a substrate 1 of glass or transparent plastic. An example of the substrate 1 used is glass, acryl or polycarbonate. The GdDyFe thin film 1 is overcovered with a protective film 3 of SiO_2 (e.g., thickness=5400 Å), thus completing a magnetooptic recording medium. Then, the memory medium is shaped into a disk which is driven at an appropriate rate by a rotating driving system 4 such as a motor.

To record and fetch data on and from the above-mentioned storage medium, there is provided an optical memory system which relies upon the Curie point writing using the magnetooptical Faraday effect of the thin film. In this drawing, a laser 5 typically of He—Ne is provided which releases a laser beam via a light modulator 6 and a polarizer 7 toward an optical system 8 including a mirror for changing the direction of its optical path and a recording lens. The optical system 8 is located vis-a-vis with memory bit locations of the storage medium to apply the laser beam thereto so that data may be written as the changeable recording or the unchangeable recording, based on the output level of the laser beam. Furthermore, the data fetched from the storage medium 1 is led to a detector 10 via an optical system 9 including a mirror for changing the optical path and a condensor lens and then to a light detector 11. This results in reading the data from the changeable memory locations and the unchangeable memory locations.

Although the foregoing has set forth the use of the GdDyFe film as a typical example of the amorphous magnetic material, other materials whose recording temperatures are lower than its crystallization points to enable crystallization to cause a difference in transmittance or reflectivity are available for the purpose of the present invention, for example, GdTbFe, DyFe, TbFe, etc. The other methods of writing and reading other than the above mentioned Curie point writing and Faraday effect reading are also useful as long as the present invention is concerned.

As noted earlier, the present invention utilizes the temperature dependency of the magnetization properties and crystallization properties of the amorphous magnetic material, thus making it possible to set up both the reversible recordings and unchangeable recordings on the same storage medium with different conditions of erasing information. More particularly, the permanent recordings are made with no possible destruction of information. In addition, writing and reading require no particular expenditure.

Generally speaking, a high packing density storage medium has recording tracks each of a width in the order of 1 um. For writing and reading by the laser beam to be practical, it is essential that the laser beam be spotted on only a track sought to be written or read and not the other tracks. To this end a precision optical system or a servo system with the help of guide tracks are necessary.

In another preferred aspect of the present invention, the unchangeable recordings are effectively utilized as guide tracks for the laser-addressing technique. Figs. 4 and 5 illustrate a magnetooptic data storage medium with crystallized guide tracks. The guide tracks 12 are formed to be flush with recording (reversible) tracks 13 upon laser beam application. In order to form the guide tracks 12 as minute as possible, the laser beam of a short wavelength is employed, for example, Ar laser beam of about 4880 Å. Especially, both sides of a respective one of the recording tracks 13 are heated to above the crystallization temperature (typically, 350°C) for the setup of the guide tracks 12.

In the case where the guide tracks 12 are set up along the recording tracks in this manner, the recording tracks 13 are never crystallized to ensure that the recordings are stable even during exposure of the laser beam for the setup of record bits 14 at a temperature near the Curie point (about 100°C). Furthermore, the other recording tracks 13 are not affected by exposure of the laser beam because of the recording tracks being sandwiched between the guide tracks 12.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications are intended to be included within the scope of the following claims.

CLAIMS

1. A magnetooptical storage medium comprising a layer of GdDyFe as amorphous magnetic material for thermomagnetic writing.

2. A magnetic storage medium comprising a layer of amorphous material whose recording temperature is lower than its crystallization point to enable crystallization to cause variations in its optical property for thermomagnetic writing.

3. A magnetic storage medium comprising:

a layer of amorphous material whose recording temperature is lower than its crystallization point to enable crystallization to cause variations in its optical property for thermomagnetic writing;

reversible recordings set up on said amorphous material layer; and

unchangeable recordings set up on said amorphous material layer through crystallization of said amorphous material layer.

4. A magnetooptical storage medium as set forth in claim 3 wherein said reversible recordings are set up by the Curie point writing technique.

5. A magnetic storage medium comprising:

a layer of amorphous material whose recording temperature is lower than its crystallization point to enable crystallization to cause variations in its optical property for thermomagnetic writing;

reversible recording tracks set up on said amorphous material layer; and

unerasable guide tracks set up on said amorphous material layer through crystallization of said amorphous material layer.

6. A magnetooptical storage medium as set forth in claim 5 wherein said recording tracks are flanked with said guide tracks.

7. A magnetooptical storage medium as set forth in claim 5 wherein said guide tracks are set up by heating said amorphous material layer to above the crystallization point.

8. A magnetooptical storage medium as set forth in claim 1 wherein said crystallization point is about 350°C where said GdDyFe layer changes from the amorphous state to the crystallized state.

9. A magnetooptical storage medium as set forth in claim 8 wherein said GdDyFe has a Curie point of about 120°C.

10. A magnetic storage medium comprising a layer of GdTbFe whose recording temperature is lower than its crystallization point to enable

crystallization to cause variations in its optical property for thermomagnetic writing.

11. A magnetic storage medium comprising a layer of DyFe whose recording temperature is lower than its crystallization point to enable crystallization to cause variations in its optical property for thermomagnetic writing.

12. A magnetic storage medium comprising a layer of TbFe whose recording temperature is lower than its crystallization point to enable crystallization to cause variations in its optical property for thermomagnetic writing.

13. A magnetooptical storage medium whose optical properties can be selectively varied to store information in an alterable form and, by selective crystallization of the medium, in a permanent form.

14. A storage medium substantially as herein described with reference to the accompanying drawings.

New Claims or Amendments to claims filed on 27/7/84.
Superseded Claims All

New or Amended Claims:

1. A magnetooptic storage medium capable of storing alterable data recorded by thermomagnetic writing of the medium, the medium storing in bit locations permanent data which has been recorded by heating selected locations of the medium to a temperature greater than that reached during thermomagnetic writing so as to change the physical characteristics of the medium at those locations.

2. A magnetooptic storage medium as claimed in claim 1, wherein the permanent data has been recorded by crystallization of the material.

3. A magnetooptic storage medium as claimed in claim 1 or claim 2, the material storing alterable data.

4. A magnetooptic storage medium as claimed in claim 3, wherein said alterable data has been recorded by the Curie point writing technique.

5. A magnetooptic storage medium as claimed in claim 3, wherin said alterable data has been recorded by the compensation temperature technique.

6. A magnetooptic storage medium as claimed in claim 3, wherein said alterable data has been recorded by the temperature dependent coercivity technique.

7. A magnetooptic storage medium as claimed in any preceding claim, wherein the crystallization point of the medium is about 350°C.

8. A magnetooptic storage medium as claimed in any preceding claim, wherein the medium has a Curie point of about 120°C.

9. A magnetooptic storage medium as claimed in any preceding claim, the medium comprising material selected from the following:

(a) GdDyFe
(b) GdTbFe
(c) DyFe
(d) TbFe.

10. A method of storing information on a magnetooptic storage medium, the method comprising recording alterable data by thermomagnetic writing of the medium and recording permanent data by heating selected bit locations of the medium to a temperature greater than that reached during thermomagnetic writing so as to change the physical characteristics of the medium at those locations.

11. A method as claimed in claim 10, wherein the permanent data is recorded by heating said locations so as to crystallize the medium at those locations.

12. A method of storing permanent and alterable data on a magnetooptic storage medium, the method being substantially as herein described with reference to the accompanying drawings.

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