

Write-once optical record carrier for high-speed recording

The present invention relates to a write-once optical record carrier, such as a DVD+R, in particular to a single-layer DVD+R, which is adapted for high-speed recording of data thereon.

At present, the development of a high-speed DVD+R standard has a high priority. Current dye-based high-speed DVD+R media exhibit reasonable performance up to 4x or even 6x. The power margins, however, are getting more and more narrow at higher speeds. It is believed that at the high powers required for high-speed recording delamination occurs at the dye-metal interface, i.e. at the interface between the recording layer made of an organic dye material and a metal reflective layer provided for cooling of the recording layer. These problems raise concerns about the possibility to achieve higher recording speeds with write-once optical record carriers, in particular DVD+R media, comprising a recording layer made of an organic dye material. However, the use of dyes is considered favourable because of the backwards compatibility of recorded disc on existing players due to the dye's intrinsic high transparency which allows (together with a reflector layer) a high reflectivity disc.

The thickness of the metal reflective layer is usually around 100nm. An important effect of the presence of the metal reflective layer is its large cooling power, i.e. its high heat capacity. It is thus believed that a reduction of the thickness of the metal reflective layer will result in a less efficient cooling of the dye recording layer. Since the dye has only a very poor heat conduction, the efficient cooling by the metal reflective layer induces a large temperature gradient near the interface between the recording layer and the metal reflective layer. It is possible that mechanical stress that may result from this steep gradient leads to the above-mentioned delamination problem.

US 5,718,961 discloses a phase-change type optical disc in which a first dielectric film, a second dielectric film, a recording film and a reflective film are sequentially stacked on a substrate. The thickness of the reflective layer can be in a broad range of 10 to 120nm. By use of ZnO-BN as material for the first and second dielectric film a high

recording sensitivity and thermal stability can be achieved, and heat produced during recording can be rapidly dissipated to the reflective layer.

5 It is an object of the present invention to provide a write-once optical record carrier which allows higher recording speeds but has a reduced temperature gradient at the interface between the recording layer and the metal reflective layer to avoid mechanical problems such as delamination.

This object is achieved according to the present invention by a write-once
10 optical record carrier as claimed in claim 1 comprising:

a substrate layer,
a recording layer of an organic dye material on top of the substrate layer and
a metal reflective layer of a thickness below 75 nm on top of the recording
layer.

15 The invention is based on the finding that, contrary to common believe, a reduction of the thickness of the metal reflective layer can be advantageous. It has been found that by a reduction of the thickness, the cooling becomes less efficient, which, however, leads in consequence to a temperature gradient at the interface between the recording layer and the metal reflective layer which is more gradual. This will reduce mechanical stress and thereby
20 prevent delamination. It has thus been recognized that a deterioration of the cooling in the recording stack may actually improve the high-speed recording performance. This means that by this invention it is proposed to do the opposite from what experts in this field commonly believe both for record carriers having a recording layer made of an organic dye material or made of a phase-change material.

25 Preferred embodiments of the invention are defined in the dependent claims. While an improvement of the high-speed recording performance can be achieved by a metal reflective layer thickness below 75nm, a further improvement can be achieved by reducing the thickness even more below 50nm, in particular below 30nm.

According to another preferred embodiment an additional dielectric layer is
30 provided between the recording layer and the metal reflective layer. This dielectric layer acts as a thermal barrier and can mimic the reduced heat-sink capability of the reflective layer. The introduction of the additional dielectric layer, e.g. SiO₂, ZnS, ZnS-SiO₂ mixture (e.g. 8:2), TiO₂ or an other dielectric material, slightly enhances the reflection of the recording stack at the cost of reduced absorption. However, it can be foreseen further, to use a thinner

recording layer which usually has a thickness of 100nm, or a dye having a higher k value, k being the imaginary part of the complex refractive index, in order to compensate this.

Optionally, another dielectric layer can be provided between the recording layer and the substrate layer, in particular to improve stability of the whole recording stack.

5 At least the first dielectric layer between the recording layer and the metal reflective layer has a thickness below 50nm, in particular below 25nm.

A preferred material for the metal reflective layer substantially consists of silver (Ag). However, other materials such as Al, Au or other metals can be used as well.

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The invention will now be explained in more detail with reference to the drawings, in which:

Fig. 1 shows power margins for a DVD+R disc with a 100nm Ag layer;

Fig. 2 shows power margins for a DVD+R disc with a 10nm Ag layer;

15 Fig. 3a shows the temperature distribution after applying a DC-power level to a conventional write-once record carrier;

Fig. 3b shows the temperature distribution after applying a DC-power level to a write-once optical record carrier according to the present invention;

20 Fig. 4 shows the thermal distribution for another embodiment of a record carrier according to the invention;

Fig. 5 shows the thermal distribution for still another embodiment of a record carrier according to the invention;

Fig. 6 shows a schematic layout of a first embodiment of a record carrier according to the invention; and

25 Fig. 7 shows a schematic layout of a second embodiment of a record carrier according to the invention.

30 Fig. 1 shows a typical power margin in case of a thick reflective layer, in particular a 100nm Ag layer, in a DVD+R disc. Shown is the jitter in percentage over write power in mW for leading and trailing edges of bits to be recorded on the disc. This power margin needs to be compared to the power margin for a thin reflective layer shown in Fig. 2 where the reflective layer made of Ag in a DVD+R has a thickness of 10nm. As can be seen

the jitter is much lower in a broader range of write powers, in particular for higher write powers compared to the jitter achieved with the thick reflective layer shown in Fig. 1.

The temperature distribution after applying a dc-power level to a conventional DVD+R recording stack having a thick reflective layer 1 made of Ag (100nm), a dye recording layer 2 (100nm) and a polycarbonate substrate layer 3 (100nm) is shown in Fig. 3a. Not shown in Fig. 3a is the dummy substrate that is glued by means of a UV-curable lacquer on top of the thick reflective layer. Since the dye material has very poor heat conduction, the efficient cooling by the reflective layer 1 induces a large temperature gradient near the interface between the reflective layer 1 and the recording layer 2. From this steep gradient mechanical stress may result which may lead to delamination at the interface between the reflective layer 1 and the recording layer 2.

By reducing the thickness of the reflective layer 1, the cooling becomes less efficient, but advantageously as a consequence the temperature gradient becomes more gradual as can be seen from Fig. 3b where the temperature distribution after applying a DC-power level to a first embodiment of a record carrier according to the present invention is shown. Here the reflective layer has a thickness of approximately 10nm and is made of Ag.

The thermal distribution for a second embodiment of a record carrier according to the present invention is shown in Fig. 4. Therein, compared to the record carrier shown in Fig. 3a, an additional dielectric layer 5 made of SiO₂ having a thickness of 20nm is provided between the reflective layer 1 having a thickness of 40nm here and the recording layer 2. Not shown in Fig. 4 is the dummy substrate that is glued by means of a UV-curable lacquer on top of the 40 nm thick reflective layer. Further, the recording layer 2 has a reduced thickness of 80nm which leads to a more efficient absorption as is apparent from the somewhat higher maximum temperature that is reached. The introduction of the additional dielectric layer 5 further reduces the temperature gradient between the reflective layer 1 and the recording layer 2, and thus reduces mechanical stress and prevents delamination.

The thermal distribution for a third embodiment of a record carrier according to the present invention is shown in Fig. 5. Therein the reflective layer made of Ag has a thickness of 30nm which still yields rather high reflection, but the thermal capacity is reduced by a factor of 3.3. Nevertheless, also in this embodiment the thermal gradient becomes less steep. Not shown in Fig. 5 is the dummy substrate that is glued by means of a UV-curable lacquer on top of the thick reflective layer.

Figs. 6 and 7 schematically show two embodiments of record carriers according to the invention. Fig. 6 shows an embodiment for which the temperature profile is

shown in Fig. 5. In addition to the three layers shown in Fig. 5, a second polycarbonate substrate layer 4 (about 0.6 mm) is shown, which is glued by means of a UV-curable lacquer on top of the reflective layer 1. Fig. 7 shows an embodiment for which the temperature profile is shown in Fig. 4. In addition to the 4 layers shown in Fig. 4, again a second
5 polycarbonate substrate layer 4 (about 0.6 mm) is shown.

The embodiments shown in the figures are to be understood as examples. A number of further embodiments and further variations of the thicknesses of the different layers as well as the sequence and the provision of further layers is possible. The invention provides the advantage to get broader power margins for write-once optical record carriers, in
10 particular for DVD+R media. Further, the possibility to go to higher recording speeds is available. In addition, thinner reflective layers cost less time to sputter, i.e. a faster fabrication is possible and a reduction of fabrication costs can be obtained.

CLAIMS:

1. Write-once optical record carrier comprising:
a substrate layer (3);
a recording layer (2) of an organic dye material on top of the substrate layer
(3); and
5 a metal reflective layer (1) of a thickness below 75 nm on top of the recording
layer (2).
2. Record carrier according to claim 1, further comprising a dielectric layer (5)
between said recording layer (2) and said metal reflective layer (1).
- 10 3. Record carrier according to claim 2, wherein said dielectric layer (5) is of a
thickness below 50 nm, in particular below 25 nm.
4. Record carrier according to claim 1, further comprising a dielectric layer
15 between said recording layer (2) and said substrate layer (3).
5. Record carrier according to claim 1, wherein said metal reflective layer (1) is
substantially made of a material of the group consisting Ag, Al, Au, in particular made of Ag.
- 20 6. Record carrier according to claim 1, wherein said metal reflective layer (1) is
of a thickness below 50 nm, in particular below 30 nm.