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MAGNETIC RECORDING MEDIUM, THE METHOD OF MANUFACTURING THE SAME, AND THE MAGNETIC STORAGE USING THE MAGNETIC RECORDING MEDIUM

Field of the Invention

The present invention relates to a magnetic recording medium and the method of manufacturing the magnetic recording medium. Specifically, the present invention relates to a magnetic recording medium used in an external storage of a computer and such a magnetic storage and the method of manufacturing such a magnetic recording medium. The present invention relates also to a magnetic storage using the magnetic recording medium described above.

Prior Art

Recently, the magnetic recording media mounted on various magnetic storage apparatuses such an external storage of a computer are expected to exhibit a high recording capacity. For meeting the demands for high recording capacity, it has been required for the magnetic recording medium to reliably exhibits a high recording density and it has been required for the magnetic head to facilitate reliable low-height floating. To meet these requirements, various compositions and structures have been proposed for the magnetic layer of the magnetic recording medium, various materials for the nonmagnetic undercoating layer and various materials for the nonmagnetic substrate. It is indispensable for the magnetic recording media for digital household appliances now under development to be inexpensive.

For realizing magnetic recording media exhibiting a high recording density and compatible with a low-floating-height magnetic head, various

compositions and structures have been proposed for the magnetic layer of the magnetic recording medium, various materials for the nonmagnetic undercoating layer and various materials for the nonmagnetic substrate. Although aluminum and glass are the main materials for the nonmagnetic substrate, a polymer resin substrate, the so-called plastic substrate, has been proposed recently for the nonmagnetic substrate.

Problems to be solved by the Invention

For facilitating lower-height floating of the magnetic head so that the realized higher recording density in the magnetic recording media may be fully utilized, it is required for the magnetic recording media to be used reliably for a long period of time in severer environments. It is also required for the magnetic recording media for digital household appliances now under development to be used reliably for a long period of time in severer environments. The conditions, under which the magnetic recording media are used, extend from very cold −40 ℃ to very hot and humid 80 ℃ and 80 % (in relative humidity). Some household appliance makers require that the magnetic recording media be working normally for five years under the conditions described above.

The tests conducted under the severe conditions described above have revealed that film swelling (a kind of film cleavages) is caused during the tests of the magnetic recording media including the plastic substrates presently available.

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In view of the foregoing, it is a first object of the invention to provide a magnetic recording medium, that is used reliably for a long period of time without causing any film selling under severe environmental conditions. It is a second object of the invention to provide a method of manufacturing such a reliable magnetic recording medium. It is a third object of the

invention to provide a magnetic storage using such a reliable magnetic recording medium.

Means for solving the Problems

Extensive and intensive investigations conducted by the present inventor have revealed that a magnetic recording medium, including a nonmagnetic substrate having a trench in the vicinity of the edge thereof, does not cause any film swelling under the severe environmental conditions.

According to a first aspect of the invention, there is provided a magnetic recording medium including: a nonmagnetic substrate made of a plastic resin, the nonmagnetic substrate including a trench in the vicinity of the edge thereof, the trench extending along the edge of the nonmagnetic substrate; a nonmagnetic undercoating layer on the nonmagnetic substrate; a magnetic layer above the nonmagnetic undercoating layer; a protection layer on the magnetic layer; and a liquid lubricant layer on the protection layer.

Advantageously, the trench is from 0.1 μm to 1.0 μm in width and 100 nm or deeper in depth.

Advantageously, the trench is in the area within 2 mm from the edge of the nonmagnetic substrate.

Advantageously, the trench is outside the data area of the nonmagnetic substrate.

According to a second aspect of the invention, there is provided a method of manufacturing a magnetic recording medium including a nonmagnetic substrate; a nonmagnetic undercoating layer on the

nonmagnetic substrate; a magnetic layer above the nonmagnetic undercoating layer; a protection layer on the magnetic layer; and a liquid lubricant layer on the protection layer, the method including the steps of: preparing a plastic substrate for the nonmagnetic substrate; and forming a trench extending along the edge of the plastic substrate in the vicinity of the edge of the plastic substrate.

Advantageously, the trench formed is from 0.1 μ m to 1.0 μ m in width and 100 nm or deeper in depth.

Advantageously, the trench is formed in the area within 2 mm from the edge of the nonmagnetic substrate.

Advantageously, the trench is formed outside the data area of the nonmagnetic substrate.

According to a third aspect of the invention, there is provided a magnetic storage including a magnetic recording medium mounted thereon, the magnetic recording medium including a nonmagnetic substrate made of a plastic resin, the nonmagnetic substrate including a trench in the vicinity of the edge thereof, the trench extending along the edge of the nonmagnetic substrate; a nonmagnetic undercoating layer on the nonmagnetic substrate; a magnetic layer above the nonmagnetic undercoating layer; a protection layer on the magnetic layer; and a liquid lubricant layer on the protection layer.

Modes for carrying out the Invention

Now the invention will be described below in connection with the embodiments of circular magnetic recording media.

First, the mechanism that causes film swelling will be described.

When a magnetic recording medium is left in a high temperature and high humidity environment, moistures penetrate the constituent layers to the surface of the nonmagnetic substrate. If the nonmagnetic substrate is a plastic substrate (polymer resin substrate), the moistures aggregate due to the hydrophobic nature of the plastic substrate and the aggregating moistures cause film swelling. When contaminants are on the surface of the nonmagnetic substrate, the contaminants work as nuclei promoting aggregation of the moistures.

The magnetic recording medium according to the invention prevents the film swelling, that would be caused as described above, from causing and further prevents film cleavages from causing. The magnetic recording medium according to the invention includes a nonmagnetic substrate, a nonmagnetic undercoating layer on the nonmagnetic substrate, a magnetic layer above the nonmagnetic undercoating layer, a protection layer on the magnetic layer, and a liquid lubricant layer on the protection layer. The nonmagnetic substrate is a plastic substrate including a circular portion embossed almost concentrically with the outer circumference of the nonmagnetic substrate. The circular embossed portion is from 0.1 μm to 1.0 μm in width and 100 nm or deeper in depth.

Caused film swelling localizes to the embossed portion of the plastic substrate, since the water coming out from the substrate and the water coming from the outside localize to the trench formed by embossing. Therefore, the trench is formed in the vicinity of and in parallel to the edge of the magnetic recording medium. More in detail, the trench is formed by embossing in the area within 2 mm from the outer circumference or the inner circumference of the magnetic recording medium. Preferably, the trench is formed outside the data area, i.e. in the non-data area. When the

trench is formed near the outer circumference, the non-data area includes a sky-jump area or the area surrounding the L/UL area. When the trench is formed near the inner circumference, the non-data area includes the clump area.

Swelling of the data area is prevented from causing by forming an almost one turn of a trench, 0.5 μm in width and 100 nm or deeper in depth, near the edge of a usual plastic substrate. The area, in which swelling is caused, is narrowed by irradiating plasma to the substrate or by coating carboxylic acid. For the treatment by plasma irradiation, it is preferable to use Ar gas, O_2 gas or a mixture of Ar gas and O_2 gas. Carboxylic acid is coated by dip coating, vapor coating or spin coating.

Commercial products such as APL6015T supplied from Mitsui Chemicals, Inc., ZEONEX 280R supplied Nippon Zeon Co., Ltd., and ARTON supplied from JSR Corp. are used for the nonmagnetic substrate, although other materials may be used with no problem.

A turn of embossing is conducted concentrically with the circumference of a nonmagnetic substrate made of any of the materials described above. For example, the nonmagnetic substrate is formed by injection molding or by compression molding using a die, the surface thereof is machined such that the die is suitable for forming a substrate having a trench. Alternatively, the nonmagnetic substrate is formed by using a die having a mirror-polished inner surface and, then, a trench is formed by a stamper.

A laminate including at least a nonmagnetic undercoating layer, a magnetic layer on the nonmagnetic undercoating layer, a protection layer on the magnetic layer and a liquid lubricant layer on the protection layer is formed on the nonmagnetic substrate, the surface thereof has been treated

as described above, resulting in a magnetic recording medium.

The resulting magnetic recording medium is mountable on a magnetic storage of a data processing apparatus.

Embodiments

First embodiment

Nonmagnetic plastic substrates, each having a circular embossed portion 0.5 μ m in width and 45 mm in radius, a circular embossed portion 0.5 μ m in width and 45.5 mm in radius, a circular embossed portion 0.5 μ m in width and 46 mm in radius, a circular embossed portion 0.5 μ m in width and 14 mm in radius, a circular embossed portion 0.5 μ m in width and 14.5 mm in radius, and a circular embossed portion 0.5 μ m in width and 15 mm in radius, are fabricated. Swellings caused in the magnetic recording media, the respective embossing depths thereof are 20 nm, 25 nm, 50 nm, 75 nm, 100 nm, 125 nm, and 150 nm, are observed under an optical microscope.

Swellings caused in the magnetic recording media according to the first embodiment are observed in the following way.

The magnetic recording media obtained are left for one hour at 25 ℃ in the humidity of 25 %. Then, the magnetic recording media are left for one hour at 80 ℃. Then, the magnetic recording media are left for four hours at 80 ℃ in the humidity of 80 %. Then, the humidity is changed from 80 % to 5 % for one hour, and the magnetic recording media are left for one hour at 80 ℃ in the humidity of 5 %. Then, the magnetic recording media are left for four hours at −40 ℃. Then, the temperature is changed to 25 ℃ and the humidity to 5% for one hour. Then, the magnetic recording media are left for one hour at 25 ℃ in the humidity of 5 %. Then, the test conditions

are returned to the temperature of 25 ℃ and the humidity of 25 %.

Then, the swellings caused in the magnetic recording media are observed under the optical microscope.

When the embossing depth is 100 nm or deeper, swellings localize to the trenches formed by embossing. Except for the area between 45 mm and 46 mm in radius and the area between 14 mm and 15 mm in radius, any swelling is not caused when the embossing depth is 100 nm or deeper.

Although swellings localize to the vicinities of the trenches formed by embossing, the depth thereof is 75 nm or shallower, some swellings are caused also in the area, the radius thereof is 45 mm or shorter. When the embossing depth is 20 nm, swellings are caused in almost all the areas.

Second embodiment

Nonmagnetic plastic substrates, each having a circular embossed portion 0.5 μ m in width and 45.5 mm in radius, a circular embossed portion 0.5 μ m in width and 46 mm in radius, a circular embossed portion 0.5 μ m in width and 14 mm in radius, and a circular embossed portion 0.5 μ m in width and 14.5 mm in radius, are fabricated. Swellings caused in the magnetic recording media, the respective embossing depths thereof are 20 nm, 25 nm, 50 nm, 75 nm, 100 nm, 125 nm, and 150 nm, are observed under an optical microscope.

Swellings caused in the magnetic recording media according to the second embodiment are observed in the following way.

The magnetic recording media obtained are left for one hour at 25 ℃ in the humidity of 25 %. Then, the magnetic recording media are left for one hour at 80 ℃. Then, the magnetic recording media are left for four hours at 80 ℃ in the humidity of 80 %. Then, the humidity is changed from 80 % to

5 % for one hour, and the magnetic recording media are left for one hour at 80 ℃ in the humidity of 5 %. Then, the magnetic recording media are left for four hours at −40 ℃. Then, the temperature is changed to 25 ℃ and the humidity to 5% for one hour. Then, the magnetic recording media are left for one hour at 25 ℃ in the humidity of 5 %. Then, the test conditions are returned to the temperature of 25 ℃ and the humidity of 25 %. Then, the swellings caused in the magnetic recording media are observed under the optical microscope.

Although swellings localize to the trenches formed by embossing when the embossing depth is 50 nm or deeper, some swellings are caused also in the area, the radius thereof is 45.5 mm or shorted. When the embossing depth is 20 nm, swellings are caused in almost all the areas.

Third embodiment

Nonmagnetic plastic substrates, each having a circular embossed portion 0.5 μ m in width and 45.5 mm in radius, a circular embossed portion 0.5 μ m in width and 46 mm in radius, a circular embossed portion 0.5 μ m in width and 14 mm in radius, and a circular embossed portion 0.5 μ m in width and 14.5 mm in radius, are fabricated. The embossing depths in the respective nonmagnetic substrates are 20 nm, 25 nm, 50 nm, 75 nm, 100 nm, 125 nm, and 150 nm. The respective nonmagnetic substrate are treated by radio frequency (RF) glow discharge, and, then, the swellings caused in the magnetic recording media including the respective nonmagnetic substrates are observed.

Swellings caused in the magnetic recording media according to the third embodiment are observed in the following way.

The magnetic recording media obtained are left for one hour at 25 ℃

in the humidity of 25 %. Then, the magnetic recording media are left for one hour at 80 ℃. Then, the magnetic recording media are left for four hours at 80 ℃ in the humidity of 80 %. Then, the humidity is changed from 80 % to 5 % for one hour, and the magnetic recording media are left for one hour at 80 ℃ in the humidity of 5 %. Then, the magnetic recording media are left for four hours at −40 ℃. Then, the temperature is changed to 25 ℃ and the humidity to 5% for one hour. Then, the magnetic recording media are left for one hour at 25 ℃ in the humidity of 5 %. Then, the test conditions are returned to the temperature of 25 ℃ and the humidity of 25 %. The foregoing RF glow discharge treatment is conducted at the RF power of 100 W in Ar gas of 100 % for 10 sec.

Swellings are observed in the vicinity of the trenches formed by embossing, and any swelling is not observed outside the trench areas.

Although the invention has been described in connection with the preferred embodiments thereof, changes and modifications are obvious to those skilled in the art without departing the true spirits of the invention. In detail, the invention has been described in connection with the nonmagnetic substrate for the circular magnetic media including a circular trench, the center thereof coincides with the center of the outer circumference or the inner circumference of the circular nonmagnetic substrate. However, the invention is applicable also to a magnetic tape and such other magnetic recording media. For example, the areas in the vicinity of the side edges of a magnetic tape are embossed. Preferably, the areas within 2 mm from the respective side edges or the areas outside the data area and extending along the traveling direction of the magnetic tape are embossed.

Advantageous Effects of the Invention

As described above, a magnetic recording medium, that does not cause any swelling under severe environmental conditions, is obtained by forming a trench in the vicinity of the edge of a plastic substrate. In detail, a magnetic recording medium, that does not cause any swelling in the data area under severe environmental conditions, such as in a very cold environment of −40℃ and a very hot and humid environment of 80 ℃ and 80 %, is obtained by forming a trench, from 0.1 μm to 1.0 μm in width and 100 nm or deeper in depth, by embossing.

What is claimed is:

1. A magnetic recording medium comprising:

a nonmagnetic substrate made of a plastic resin, the nonmagnetic substrate comprising a trench in the vicinity of the edge thereof, the trench extending along the edge of the nonmagnetic substrate;

a nonmagnetic undercoating layer on the nonmagnetic substrate;

a magnetic layer above the nonmagnetic undercoating layer;

a protection layer on the magnetic layer; and

a liquid lubricant layer on the protection layer.

2. The magnetic recording medium according to Claim 1, wherein the trench is from 0.1 μ m to 1.0 μ m in width and 100 nm or deeper in depth.

3. The magnetic recording medium according to Claim 1, wherein the trench is in the area within 2 mm from the edge of the nonmagnetic substrate.

4. The magnetic recording medium according to Claim 1, wherein the trench is outside the data area of the nonmagnetic substrate.

5. The method of manufacturing a magnetic recording medium including a nonmagnetic substrate; a nonmagnetic undercoating layer on the nonmagnetic substrate; a magnetic layer above the nonmagnetic undercoating layer; a protection layer on the magnetic layer; and a liquid lubricant layer on the protection layer, the method comprising the steps of:

preparing a plastic substrate for the nonmagnetic substrate; and

forming a trench extending along the edge of the plastic substrate in the vicinity of the edge of the plastic substrate.

6. The method according to Claim 5, wherein the step of forming

comprises forming the trench from 0.1 μ m to 1.0 μ m in width and 100 nm or deeper in depth.

7. The method according to Claim 5, wherein the step of forming comprises forming the trench in the area within 2 mm from the edge of the nonmagnetic substrate.

8. The method according to Claim 5, wherein the step of forming comprises forming the trench outside the data area of the nonmagnetic substrate.

9. A magnetic storage comprising:

a magnetic recording medium mounted thereon, the magnetic recording medium including

a nonmagnetic substrate made of a plastic resin, the nonmagnetic substrate comprising a trench in the vicinity of the edge thereof, the trench extending along the edge of the nonmagnetic substrate;

a nonmagnetic undercoating layer on the nonmagnetic substrate;

a magnetic layer above the nonmagnetic undercoating layer;

a protection layer on the magnetic layer; and

a liquid lubricant layer on the protection layer.