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

5 Field of the Invention

The present invention relates to a magnetic recording medium mounted on an external storage of a computer and such a magnetic storage, the method of manufacturing the magnetic recording medium, and the magnetic storage using the magnetic recording medium.

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Prior Art

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 media, 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 at present, a polymer resin substrate, the so-called plastic substrate, has been proposed recently for the nonmagnetic substrate.

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Problems to be solved by the Invention

For facilitating lower-height floating of the magnetic head so that the higher recording density realized in the magnetic recording media may be fully utilized, it is required for the magnetic recording media to be used reliably for a long time in severer environments. It is also required for the magnetic recording media for digital household appliances, which will be developing in the near future, to be used reliably for a long time in severer environments. The conditions, under which the magnetic recording media are expected to be useable, extend from very cold -40°C to very hot and



humid 80 °C and 80 % (relative humidity). Some household appliance makers require that the magnetic recording media be working normally for five years under the conditions described above. It is necessary that the magnetic recording media for household appliances be manufactured with low costs. Although the polymer resin substrate is hopeful for the substrate of the magnetic recording media, film inflation (a kind of layer parting) is caused in the magnetic recording media including the polymer resin substrate.

10 In view of the foregoing, it is an object of the invention to provide a magnetic recording medium, which obviates the problems described above. It is another object of the invention to provide the method of manufacturing the magnetic recording medium and the magnetic storage mounting the magnetic recording medium thereon.

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Means for solving the Problems

Usually, an undercoating layer is formed on the plastic substrate or an intermediate layer is formed below the magnetic layer to improve the electromagnetic conversion characteristics of the magnetic recording medium. Film inflation is prevented from causing by controlling the structure of the undercoating layer or the intermediate layer. For controlling the layer structure, it is preferable to select an appropriate material for the undercoating layer or the intermediate layer or to control the deposition conditions, especially the pressure, under which the undercoating layer or the intermediate layer is formed. Materials, which facilitate providing a columnar structure in a relatively wide pressure range, include Mo, CrW and NiP. TiW and Ru, which facilitate obtaining excellent electromagnetic conversion characteristics, provide the undercoating layer or the intermediate layer with a columnar structure, when the undercoating layer or the intermediate layer is formed under a high pressure.

It has been revealed that film inflation, which poses problems on the magnetic recording media including a plastic substrate, is caused by aggregation of water (moisture). It is possible to prevent water (moisture) from aggregating and film inflation from causing by controlling the structure of the undercoating layer or the intermediate layer.

According to a first aspect of the invention, there is provided a magnetic recording medium including: a nonmagnetic substrate made of a polymer resin; a magnetic layer above the nonmagnetic substrate; a protection layer above the magnetic layer; and a liquid lubricant layer on the protection layer.

Advantageously, the magnetic recording medium further includes a nonmagnetic undercoating layer on the nonmagnetic substrate.

Advantageously, the nonmagnetic undercoating layer is a metal layer containing an element selected from the group consisting of (Ru, Re, Os, and Mo), an alloy layer comprising an element selected from the group consisting of (Ru, Re, Os, and Mo), an alloy layer containing W and one or more elements selected from the group consisting of (Ti, Zr, and Cr), or an alloy layer containing Ni and P.

According to a second aspect of the invention, there is provided the method of manufacturing the magnetic recording medium including the step of forming a TiW alloy undercoating layer under the pressure of 60 mTorr or higher, the step of forming a CrW alloy undercoating layer under the pressure of 5 mTorr or higher, the step of forming a metal undercoating layer containing Ru, Re or Os as the main component thereof under the pressure of 60 mTorr or higher, the step of forming an alloy undercoating layer containing Ru, Re or Os as the main component thereof under the

pressure of 60 mTorr or higher, the step of forming a metal undercoating layer containing Mo as the main component thereof under the pressure of 5 mTorr or higher, the step of forming an alloy undercoating layer containing Mo as the main component thereof under the pressure of 5 mTorr or higher, or the step of forming a NiP alloy undercoating layer under the pressure of 5 mTorr or higher.

Advantageously, the magnetic recording medium further includes an intermediate layer on the nonmagnetic undercoating layer.

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Advantageously, the intermediate layer is a metal layer containing an element selected from the group consisting of (Ru, Re, Os, and Mo), an alloy layer containing one or more elements selected from the group consisting of (Ru, Re, Os, and Mo), an alloy layer containing W and one or more elements selected from the group consisting of (Ti, Zr, and Cr), or an alloy layer containing Ni and P.

According to a third aspect of the invention, there is provided the method of manufacturing the magnetic recording medium including the step of forming a TiW alloy intermediate layer under the pressure of 60 mTorr or higher, the step of forming a CrW alloy intermediate layer under the pressure of 5 mTorr or higher, the step of forming a metal intermediate layer containing Ru, Re or Os as the main component thereof under the pressure of 60 mTorr or higher, the step of forming an alloy intermediate layer containing Ru, Re or Os as the main component thereof under the pressure of 60 mTorr or higher, the step of forming a metal intermediate layer containing Mo as the main component thereof under the pressure of 5 mTorr or higher, the step of forming an alloy intermediate layer containing Mo as the main component thereof under the pressure of 5 mTorr or higher, or the step of forming a NiP alloy intermediate layer under the pressure of 5

mTorr or higher.

According to a fourth aspect of the invention, there is provided the magnetic storage including the above described magnetic recording medium
5 mounted thereon.

Brief Description of the Drawing Figure

Fig. 1 is a cross sectional view of a magnetic recording medium according to the first embodiment or the second embodiment of the invention.

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Fig. 2 is a cross sectional view of a magnetic recording medium according to the third embodiment of the invention.

Modes for carrying out the Invention

15 Now the invention will be described in detail hereinafter with reference to the accompanied drawing figures which illustrate the preferred embodiments of the invention.

First embodiment

20 Fig. 1 is a cross sectional view of a magnetic recording medium according to a first embodiment or a second embodiment of the invention.

Referring now to Fig. 1, the magnetic recording medium according to the first embodiment includes a laminate formed of a plastic substrate 1, an undercoating layer 2, a CoCrPt-SiO₂ layer 3, a Ti layer 4, a CN layer 5 and a
25 lubricant layer 6. The undercoating layer 2 is formed by depositing a TiW layer, a CrW layer, a Mo layer or a NiP layer under a pressure between 5 mTorr and 30 mTorr. The thickness of the undercoating layer 2 is fixed at 10 nm. Then, environmental tests are conducted in a constant temperature oven to investigate whether film inflation is caused or not in the magnetic
30 recording media according to the first embodiment. The magnetic recording

media are stored at first at the room temperature, then at 80°C and 80 % (relative humidity) for 4 hr., then at -40°C for 4 hr., and again at the room temperature. Then, the magnetic recording media are observed under an optical microscope to find whether film inflation is caused or not. Table 1 lists the results.

Table 1

Deposition conditions	Undercoating layers			
	TiW	CrW	Mo	NiP
5 mTorr	×	○	○	○
15 mTorr	×	○	○	○
30 mTorr	×	○	○	○

○: Film inflation is not caused. ×: Film inflation is caused.

Observations in a transmission electron microscope have revealed that the CrW layer, the Mo layer and the NiP layer have a columnar structure or a structure near to the columnar structure. The TiW layer does not have any columnar structure but has a uniform structure. In other words, the TiW layer does not have any distinctive structure. Film inflation is not caused when a CrW layer, a Mo layer or a NiP layer is used for the undercoating layer. Film inflation is caused when a TiW layer is used for the undercoating layer.

Second embodiment

Referring again to Fig. 1, the magnetic recording medium according to the second embodiment includes a laminate formed of a plastic substrate 1, an undercoating layer 2, a CoCrPt-SiO₂ layer 3, a Ti layer 4, a CN layer 5 and a lubricant layer 6. The undercoating layer 2 is formed by depositing a TiW layer, or a Ru layer under a pressure between 30 mTorr and 80 mTorr according to the second embodiment. The thickness of the undercoating

layer 2 is fixed at 10 nm. Then, environmental tests are conducted in a constant temperature oven to investigate whether film inflation is caused or not in the magnetic recording media according to the second embodiment. The magnetic recording media are stored at first at the room temperature, then at 80°C and 80 % (relative humidity) for 4 hr., then at -40°C for 4 hr., and again at the room temperature. Then, the magnetic recording media are observed under an optical microscope to find whether film inflation is caused or not. Table 2 lists the results.

Table 2

Deposition conditions	Undercoating layers	
	TiW	Ru
30 m Torr	×	×
45 m Torr	×	×
60 m Torr	○	○
80 m Torr	○	○

○: Film inflation is not caused. ×: Film inflation is caused.

Observations in a transmission electron microscope have revealed that the TiW layer and the Ru layer do not have any columnar structure when they are formed under a low pressure but have a columnar structure or a structure near to the columnar structure when they are formed under a high pressure. Film inflation is not caused in the TiW layer and the Ru layer formed under a pressure of 60 mTorr or higher.

Third embodiment

Fig. 2 is a cross sectional view of a magnetic recording medium according to a third embodiment of the invention.

Referring now to Fig. 2, the magnetic recording medium according to the third embodiment includes a laminate formed of a plastic substrate 7, an undercoating layer 8, an intermediate layer 9, a CoCrPt-SiO₂ layer 10, a

Ti layer 11, a CN layer 12 and a lubricant layer 13. The undercoating layer 8 is formed by depositing a TiW layer, or a CrW layer under a pressure of 30 mTorr. The thickness of the undercoating layer 8 is fixed at 10 nm. The intermediate layer 9 is formed by depositing a Ru layer at a pressure
 5 between 30 mTorr and 80 mTorr according to the third embodiment. The thickness of the intermediate layer 9 is fixed at 20 nm. Then, environmental tests are conducted in a constant temperature oven to investigate whether film inflation is caused or not in the magnetic recording media according to the third embodiment. The magnetic recording media are stored at first at
 10 the room temperature, then at 80°C and 80 % (relative humidity) for 4 hr., then at -40°C for 4 hr., and again at the room temperature. Then, the magnetic recording media are observed under an optical microscope to find whether film inflation is caused or not. Table 3 lists the results.

15 Table 3

Deposition conditions for the intermediate layers	Undercoating layers	
	CrW	TiW
30 m Torr	×	×
60 m Torr	○	×
80 m Torr	○	×

○: Film inflation is not caused. ×: Film inflation is caused.

Observations in a transmission electron microscope have revealed that
 20 the CrW undercoating layer has a columnar structure. The TiW undercoating layer does not have any columnar structure but has a uniform structure. In other words, the TiW undercoating layer does not have any distinctive structure. The Ru intermediate layer formed under a pressure of 60 mTorr or higher has a columnar structure. When the undercoating layer
 25 and the intermediate layer have the respective columnar structures, any film inflation is not caused. When the undercoating layer or the

intermediate layer does not have a columnar structure, film inflation is caused.

Advantageous Effects of the Invention

- 5 According to the invention, a magnetic recording medium, which does not cause any film inflation in the environmental condition range between—40°C and 80°C and 80 % (relative humidity), is obtained by providing the undercoating layer on the plastic substrate with a columnar structure.

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Claims

What is claimed is:

1. A magnetic recording medium comprising:
a nonmagnetic substrate made of a polymer resin;
5 a magnetic layer above the nonmagnetic substrate;
a protection layer above the magnetic layer; and
a liquid lubricant layer on the protection layer.
2. The magnetic recording medium according to Claim 1, further
comprising a nonmagnetic undercoating layer on the nonmagnetic
10 substrate.
3. The magnetic recording medium according to Claim 2, wherein the
nonmagnetic undercoating layer comprises an element selected from the
group consisting of (Ru, Re, Os, and Mo).
4. The magnetic recording medium according to Claim 3, wherein the
15 nonmagnetic undercoating layer comprises an alloy comprising an element
selected from the group consisting of (Ru, Re, Os, and Mo).
5. The magnetic recording medium according to Claim 2, wherein the
nonmagnetic undercoating layer comprises an alloy comprising W and an
element selected from the group consisting of (Ti, Zr, and Cr).
- 20 6. The magnetic recording medium according to Claim 2, wherein the
nonmagnetic undercoating layer comprises an alloy comprising Ni and P.
7. The method of manufacturing the magnetic recording medium
described in Claim 2, the method comprising the step of forming the
undercoating layer under the pressure of 5 mTorr or higher.

8. The method of manufacturing the magnetic recording medium described in Claim 2, the method comprising the step of forming the undercoating layer under the pressure of 60 mTorr or higher.
9. The method according to Claim 7, wherein the undercoating layer
5 comprises a CrW alloy.
10. The method according to Claim 7, wherein the undercoating layer comprises Mo as the main component thereof.
11. The method according to Claim 7, wherein the undercoating layer comprises a NiP alloy.
- 10 12. The method according to Claim 8, wherein the undercoating layer comprises a TiW alloy.
13. The method according to Claim 8, wherein the undercoating layer comprises an element selected from the group consisting of (Ru, Re and Os) as the main component thereof.
- 15 14. The magnetic recording medium according to Claim 2, further comprising an intermediate layer on the nonmagnetic undercoating layer.
15. The magnetic recording medium according to Claim 14, wherein the intermediate layer comprises an element selected from the group consisting of (Ru, Re, Os, and Mo) as the main component thereof.
- 20 16. The magnetic recording medium according to Claim 15, wherein the intermediate layer comprises an alloy comprising an element selected from the group consisting of (Ru, Re, Os, and Mo).
17. The magnetic recording medium according to Claim 14, wherein the intermediate layer comprises an alloy comprising W and an element selected
25 from the group consisting of (Ti, Zr, and Cr).

18. The magnetic recording medium according to Claim 14, wherein the intermediate layer comprises an alloy comprising Ni and P.
19. The method of manufacturing the magnetic recording medium described in Claim 14, the method comprising the step of forming the
5 intermediate layer under the pressure of 5 mTorr or higher.
20. The method of manufacturing the magnetic recording medium described in Claim 14, the method comprising the step of forming the intermediate layer under the pressure of 60 mTorr or higher.
21. The method according to Claim 19, wherein the intermediate layer
10 comprises a CrW alloy.
22. The method according to Claim 19, wherein the intermediate layer comprises Mo as the main component thereof.
23. The method according to Claim 19, wherein the intermediate layer comprises a NiP alloy.
- 15 24. The method according to Claim 20, wherein the intermediate undercoating layer comprises a TiW alloy.
25. The method according to Claim 20, wherein the intermediate layer comprises an element selected from the group consisting of (Ru, Re and Os) as the main component thereof.
- 20 26. The magnetic storage comprising:
a magnetic recording medium mounted thereon, the magnetic recording medium being described in any of Claims 1 through 6 and 14 through 18.