Title of the Invention

Magnetic recording medium, method for manufacturing a magnetic recording medium and magnetic recording device

Technical field of the invention

The present invention relates to a magnetic recording medium mounted on magnetic recording devices, such as an external memory device of a computer. The invention also relates to a method for manufacturing such a medium and to a device employing such a medium.

Background of the invention

To a magnetic recording medium with high recording density and low noise, various compositions and structures of a magnetic layer and materials for a non-magnetic under-layer have been proposed. In particular, a magnetic layer called a granular magnetic layer has been proposed having a structure in which a ferromagnetic grain is surrounded by non-magnetic non-metallic substance, such as oxide or nitride.

Japanese Unexamined Patent Application Publication No. H8-255342, for example, discloses attaining low noise by forming a granular recording layer in which ferromagnetic grains are dispersed in a non-magnetic film, by a method comprising steps of sequentially depositing a non-magnetic film, a ferromagnetic film and a non-magnetic film on a non-magnetic substrate, and heat-treating the laminate. For the non-magnetic film here, oxide or nitride of silicon is used. US Patent No. 5,679,473 discloses that a granular recording film in which each magnetic grain is surrounded by a non-magnetic oxide and separated with each other can be formed by means of RF sputtering using a CoNiPt target added with an oxide, such as SiO_2, and high coercive force and low noise is achieved by such a recording film. Since the granular magnetic layer facilitates separation of magnetic grains even by lamination without heating, an inexpensive substrate such as injection-molded plastic may be

employed as a non-magnetic substrate. Consequently, the granular magnetic layer is effective also for cost reduction of a magnetic recording medium.

An alloy with hexagonal closest packed (hcp) lattice structure composed mainly of cobalt is commonly used for a magnetic layer of a magnetic recording medium. C-axis of the hcp structure is necessary to orient in the film surface in order to obtain excellent characteristics. This orientation is accomplished in a conventional magnetic recording medium by controlling crystal orientation of an under-layer and making the magnetic layer to epitaxially grow on such an under-layer. While, in a magnetic recording medium having a granular magnetic layer, the control of crystal orientation of the magnetic layer has been considered to be difficult because the epitaxial growth is liable to be hindered by the existence of oxide or nitride.

Problem to be solved by the invention

Recently, it has been demonstrated that the control of crystal orientation of the magnetic layer is still possible in a magnetic recording medium having a granular magnetic layer by controlling the structure of the under-layer. For example, a document from the abstracts of the 22nd Conference of the Magnetics Society of Japan, P. 469 (1998), entitled "Effect of Cr-Mo under-layer in a CoPt-SiO_2 medium" discloses that low noise was attained by provision of an under-layer of CrMo alloy for the granular magnetic layer and controlling the lattice constants of the under-layer with varied amount of molybdenum. Another document from the abstracts of the 24th Conference of the Magnetics Society of Japan, p.21 (2000), entitled "A high coercive force medium that need not heating in lamination process" discloses that low noise was also attained by forming a ruthenium layer beneath the granular layer.

However, the information processing field showing rapid development in recent years demands much more extensive improvement over the achieved level in noise reduction of a magnetic recording medium by employing the above-mentioned technologies.

In view of the above, an object of the present invention is to provide a magnetic recording medium achieving more reduction of noise by more precise control of structure of magnetic grain, which is implemented by forming a plurality of intermediate layers on an under-layer before laminating the magnetic layer. Other objects are to provide a method for manufacturing such a medium and to provide a magnetic recording device comprising such a medium.

Means to solve the problem

To solve the above problems, the inventors of the present invention have made rigorous studies and experiments and obtained the following knowledge.

It has been revealed that high coercive force and low media noise of a magnetic recording medium are achieved by a first structure of the invention that provides on the under-layer a first non-magnetic metallic intermediate layer that is composed of at least an element selected from the group consisting of Ru, Re and Os and contains oxygen, and on the first intermediate layer and beneath the magnetic layer a second non-magnetic metallic intermediate layer that is composed of a CoCr alloy containing at least an element selected from the group consisting of Nb, Mo, Ru, Rh, Pd, Ta, W, Re, Os, Ir and Pt.

It has also been revealed that high coercive force and low media noise of a magnetic recording medium are achieved by a second structure of the invention that provides on the under-layer a first non-magnetic metallic intermediate layer that is composed of a CoCr alloy containing at least an element selected from the group consisting of Nb, Mo, Ru, Rh, Pd, Ta, W, Re, Os, Ir and Pt, and on the first intermediate layer and beneath the magnetic layer a second non-magnetic metallic intermediate layer that is composed of at least an element selected from the group consisting of Ru, Re and Os and contains oxygen.

Crystal orientation of the magnetic layer is more favorably controlled when the crystal structure of the second intermediate layer and the crystal structure of the ferromagnetic grains of the magnetic layer in the above-described first structure are both hexagonal closest packed structure and the misfit between lattice constants of unit cells of the two layers within ± 3 %. Here, the misfit of lattice constants is defined by

misfit in a-axis = 100 x (a2 - a3) / a2 (%)

misfit in c-axis = 100 x (c2 - c3) / c2 (%)

where a3 and c3 are lattice constants of the ferromagnetic grain of the magnetic layer; a2 and c2 are lattice constants of the second intermediate layer. The best effect is gained if the both misfits are within ± 3 %.

In the above-described second structure, crystal orientation of the magnetic layer is more favorably controlled when the crystal structure of the first intermediate layer and the crystal structure of the second intermediate layer are both hexagonal closest packed structure and the misfit between the lattice constants of unit cells of the two layers is within ± 3 %. Here, the misfit of lattice constants is defined by

misfit in a-axis = 100 x (a1 - a2) / a1 (%)

misfit in c-axis = 100 x (c1 - c2) / c1 (%)

where a2 and c2 are lattice constants of the second intermediate layer; a1 and c1 are lattice constants of the first intermediate layer. The best effect is gained if the both misfits are within ± 3 %.

Brief description of the drawings

Fig. 1 is a schematic cross-sectional view of a first structure of a magnetic recording medium according to the present invention.

Fig. 2 is a schematic cross-sectional view of a second structure of a magnetic recording medium according to the present invention.

Aspects of embodiments of the invention

The present invention will hereinafter be described in further detail in some aspects of embodiments with reference to the drawings.

First aspect of embodiments

First aspect of preferred embodiments will be described in the following. Fig. 1 is a schematic cross-sectional view of a first structure of a magnetic recording medium of the present invention. The magnetic recording medium has a structure in which an under-layer 2, first non-magnetic metallic intermediate layer 3a, second non-magnetic metallic intermediate layer 4a, a granular magnetic layer 5 and a protective film 6 are sequentially formed on a non-magnetic substrate 1, and a liquid lubricant layer 7 is further formed on the laminate. In order to produce a magnetic recording medium with low cost, it is effective to utilize a substrate that is manufactured by injection-molding polycarbonate, polyolefin or other resins. For the protective film 6, a thin film having thickness of from 3 nm to 10 nm composed mainly of carbon may be used. For the liquid lubricant layer 7, perfluoropolyether lubricant may be used.

The magnetic layer 5 is a so-called granular magnetic layer that comprises ferromagnetic grains and non-magnetic grain boundaries surrounding the grains, and the non-magnetic grain boundary is composed of oxide or nitride of a metal or silicon. Such structure may be fabricated by lamination process employing a sputtering method using a target of ferromagnetic metal containing oxide that consists the non-magnetic grain boundary, or by lamination process employing a reactive sputtering method in

an oxygen-containing argon gas atmosphere using a target of ferromagnetic metal.

For material composing the ferromagnetic crystal, CoPt alloy may be favorably used. For material composing the non-magnetic grain boundaries, it is particularly favorable for forming stable granular structure to use oxide of at least an element selected from the group consisting of Cr, Co, Si, Al, Ti, Ta, Hf and Zr. Film thickness of the magnetic layer is necessary to be the thickness for obtaining sufficient head regeneration output when regenerating a record.

First non-magnetic metallic intermediate layer 3a is necessary to be material that is composed of at least an element selected from the group consisting of Ru, Re and Os and contains oxygen. These elements have stable hexagonal closest packed structure and their crystal orientation is favorably controlled by containment of oxygen. Addition of the oxygen may be performed by sputtering using a target that contains oxygen or by sputtering in an oxygen-containing gas atmosphere. The film thickness of the first intermediate layer 3a is preferably in the range from 10 nm to 50 nm.

For second non-magnetic metallic intermediate layer 4a, it is necessary for achieving desired effects of high Hc and low noise of the magnetic recording medium to employ a CoCr alloy that contains at least an element selected from the group consisting of Nb, Mo, Ru, Rh, Pd, Ta, W, Re, Os, Ir and Pt. Every metal of this group has an effect to increase the lattice constant when added to the CoCr alloy.

Further effect can be obtained by adjusting quantity of additives to the CoCr alloy and controlling the misfit between the lattice constant of the second intermediate layer 4a and the lattice constant of the ferromagnetic grain of the magnetic layer 5 to be within ± 3 %. This effect arises because the ferromagnetic grains in the magnetic layer 5 are made easy to epitaxially

grow on the intermediate layer 4a due to decrease of the misfit of lattice constants of the two layers. The film thickness of the second intermediate layer 4a is preferably in the range from 2 nm to 10 nm.

Material for the under-layer 2 may be selected from chromium and chromium alloys including CrMo, CrTi, CrW and CrV. When the crystal orientation plane parallel to the surface of this under-layer is formed to preferentially orient to (200) plane or (211) plane, c-axis of the hexagonal closest packed structure of the first intermediate layer 3a that is deposited on the under-layer tends to strongly align in the direction of the film surface of the intermediate layer. As a result, high Hc and low noise become possible to readily achieved.

Above-described magnetic recording medium as shown in Figure 1 exhibits excellent characteristics even if inexpensive plastic resin is used for the substrate. When such a magnetic recording medium is mounted on a magnetic recording device, a less expensive and high performance device is provided.

Second aspect of preferred embodiments

Second aspect of preferred embodiments of the present invention will be described in the following. Figure 2 is a schematic cross-sectional view of a second structure of a magnetic recording medium of the present invention. The elements in Figure 2 that are similar to the elements of the magnetic recording medium of Figure 1 are given the same reference numerals.

The magnetic recording medium of this construction has a structure in which an under-layer 2, first non-magnetic metallic intermediate layer 3b, second non-magnetic metallic intermediate layer 4b, a granular magnetic layer 5 and a protective film 6 are sequentially formed on a non-magnetic substrate 1, and a liquid lubricant layer 7 is further formed on the laminate.

In order to produce a magnetic recording medium with low cost, it is effective to utilize a substrate that is manufactured by injection-molding polycarbonate, polyolefin or other resins. For the protective film 6, a thin film having thickness of from 3 nm to 10 nm composed mainly of carbon may be used. For the liquid lubricant layer 7, perfluoropolyether lubricant may be used.

The magnetic layer 5 is a so-called granular magnetic layer that comprises ferromagnetic grains and non-magnetic grain boundaries surrounding the grains, and the non-magnetic grain boundary is composed of oxide or nitride of a metal or silicon. Such structure may be fabricated by lamination process employing a sputtering method using a target of ferromagnetic metal containing oxide that consists the non-magnetic grain boundary, or by lamination process employing a reactive sputtering method in an oxygen-containing argon gas atmosphere using a target of ferromagnetic metal.

For material composing the ferromagnetic crystal, CoPt alloy may be favorably used. For material composing the non-magnetic grain boundaries, it is particularly favorable for forming stable granular structure to use oxide of at least an element selected from the group consisting of Cr, Co, Si, Al, Ti, Ta, Hf and Zr. Film thickness of the magnetic layer is necessary to be the thickness for obtaining sufficient head regeneration output when regenerating a record.

For first intermediate layer 3b, it is necessary for achieving desired effects of high coercive force and low noise of the magnetic recording medium to employ a CoCr alloy that contains at least an element selected from the group consisting of Nb, Mo, Ru, Rh, Pd, Ta, W, Re, Os, Ir and Pt. Every metal of this group has an effect to increase the lattice constant when added to the CoCr alloy.

Further effect can be obtained by adjusting quantity of additives to the CoCr alloy and controlling the misfit between the lattice constant of the first intermediate layer 3b and the lattice constant of the second intermediate layer 4b to be within ± 3 %. This effect arises because the ferromagnetic grains in the magnetic layer 5 are made easy to epitaxially grow on the second intermediate layer 4b due to decrease of the misfit of lattice constants of the two layers. The film thickness of the first intermediate layer 3b is preferably in the range from 2 nm to 10 nm.

Second intermediate layer 4b is necessary to be material that is composed of at least an element selected from the group consisting of Ru, Re and Os and contains oxygen. These elements have stable hexagonal closest packed structure and their crystal orientation is favorably controlled by containment of oxygen. Addition of the oxygen may be performed by sputtering using a target that contains oxygen or by sputtering in an oxygen-containing gas atmosphere. The film thickness of the second intermediate layer 4b is preferably in the range from 10 nm to 50 nm.

Material for the under-layer 2 may be selected from chromium and chromium alloys including CrMo, CrTi, CrW and CrV. When the crystal orientation plane parallel to the surface of this under-layer is formed to preferentially orient to (200) plane or (211) plane, c-axis of the hexagonal closest packed structure of the first intermediate layer 3b that is deposited on the under-layer tends to strongly align in the direction of the film surface of the intermediate layer. As a result, high coercive force and low noise become possible to readily achieved.

Above-described magnetic recording medium as shown in Figure 2 also exhibits excellent characteristics even if inexpensive plastic resin is used for the substrate. When such a magnetic recording medium is mounted on a magnetic recording device, a less expensive and high performance device is

provided.

Examples

The following shows some specific examples of embodiments of the present invention.

Examples 1 through 5 and Comparative Examples 1 and 2

A polycarbonate substrate that was injection-molded to a shape of 3.5 inch disk was used for a non-magnetic substrate. After cleaning, the substrate was introduced into a sputtering apparatus. An under-layer having thickness of 15 nm was formed of Cr-20 at% Mo under an argon gas pressure of 5 mTorr. Then, a first intermediate layer having thickness of 20 nm was formed using a ruthenium target under a mixed gas at 10 mTorr that is a mixture of argon and 3 % of oxygen. Subsequently, a second intermediate layer having thickness of 5 nm with one of varied compositions, which are given in Table 1, was formed under an argon gas pressure of 5 mTorr. Then, a granular magnetic layer having thickness of 20 nm was formed by an RF sputtering method using a target of $Co_{78}Cr_{10}Pt_{12}$ containing 10 mol% of SiO_2 under an argon gas pressure of 3 mTorr. After laminating a carbon protective layer with 5 nm thickness, the laminate was taken out from the vacuum of the sputtering apparatus. After that, liquid lubricant was applied to a thickness of 1.5 nm. Thus, a magnetic recording medium having a structure as shown in Figure 1 was formed. In the above-described laminating process, preliminary heating of the substrate was not performed. For comparison, a medium was produced as Comparative Example 1 in the same manner as in Example 1 except that no additive was contained in the CoCr alloy of the second intermediate layer. Another medium was produced as Comparative Example 2 in the same manner as in Example 1 except that second intermediate layer was not formed.

Table 1 shows the measured data for various compositions of the intermediate layer. The data are: the misfit between lattice constants of

magnetic layer crystals and the intermediate layer that was determined by X-ray diffraction, the coercive force Hc that was measured by a vibrating sample magnetometer VSM, and the signal-to-noise ratio SNR that was measured at a track recording density of 270 kFCI.

Table 1

	composition of second intermediate layer			misfit	Hc	SNR
	Co (at%)	Cr (at%)	additive /(at%)	(%)	(%)	(dB)
Example 1	50	25	Ru / 25	0.8	3,120	20.7
Example 2	50	35	Ru / 15	3.2	2,850	19.7
Example 3	50	40	W / 10	1.9	3,030	20.2
Example 4	50	44	Pt / 6	3.8	2,790	18.3
Example 5	50	38	Pt / 12	0.5	3,090	21.9
Comp Example 1	60	40	none	9.2	2,400	16.4
Comp Example 2	none			N.A.	2,030	15.3

Note: misfit values in the table are the larger of the misfits in a-axis and c-axis.

As is apparent from Table 1, coercive force Hc and signal-to-noise ratio SNR significantly increase when the second intermediate layer is provided, and excellent Hc and SNR are attained if the misfit between lattice constants of the magnetic crystals and of the second intermediate layer is small. Though the misfit values of lattice constants in the Examples ranges within 3.8 %, the misfit of lattice constants within ± 3 % is necessary to attain Hc of more than 3000 Oe and SNR of more than 20 dB, both of which are required in very high density recording.

Examples 6 through 10 and Comparative Examples 3 and 4

A polycarbonate substrate that was injection-molded to a shape of 3.5 inch disk was used for a non-magnetic substrate. After cleaning, the substrate was introduced into a sputtering apparatus. An under-layer having thickness of 15 nm was formed of Cr-20 at% Mo under an argon gas pressure

of 5 mTorr. Then a first intermediate layer having thickness of 5 nm with one of varied compositions, which are given in Table 2, was formed under an argon gas pressure of 5 mTorr. Subsequently, a second intermediate layer having thickness of 20 nm was formed using a ruthenium target under a mixed gas at 10 mTorr that is a mixture of argon and 3 % of oxygen. Then, a granular magnetic layer having thickness of 20 nm was formed by an RF sputtering method using a target of $Co_{78}Cr_{10}Pt_{12}$ containing 10 mol% of SiO_2 under an argon gas pressure of 3 mTorr. After laminating a carbon protective layer with 5 nm thickness, the laminate was taken out from the vacuum of the sputtering apparatus. After that, liquid lubricant was applied to a thickness of 1.5 nm. Thus, a magnetic recording medium having a structure as shown in Figure 2 was formed. In the above-described laminating process, preliminary heating of the substrate was not performed. For comparison, a medium was produced as Comparative Example 3 in the same manner as in Example 6 except that no additive was contained in the CoCr alloy of the second intermediate layer. Another medium was produced as Comparative Example 4 in the same manner as in Example 6 except that second intermediate layer was not formed.

Table 2 shows the measured data for various compositions of the first intermediate layer. The data are: the misfit between lattice constants of the first non-magnetic metallic intermediate layer and the second non-magnetic metallic intermediate layer that was determined by X-ray diffraction, the coercive force Hc that was measured by a vibrating sample magnetometer VSM, and the signal-to-noise ratio SNR that was measured at a track recording density of 270 kFCI.

Table 2

	composition of first intermediate layer			misfit	Hc	SNR
	Co (at%)	Cr (at%)	additive /(at%)	(%)	(%)	(dB)
Example 6	50	25	Ru / 25	1.1	3,070	20.3
Example 7	50	35	Ru / 15	3.6	2,780	19.0
Example 8	50	40	W / 10	2.3	3,000	19.9
Example 9	50	44	Pt / 6	4.3	2,700	17.2
Example 10	50	38	Pt / 12	0.4	3,190	22.4
Comp Example 3	60	40	none	13.1	2,200	16.0
Comp Example 4	none			N.A.	2,030	15.3

Note: misfit values in the table are the larger of the misfits in a-axis and c-axis.

As is apparent from Table 2, Hc and SNR significantly increase when the first intermediate layer is provided, and excellent Hc and SNR are attained if the misfit between lattice constants of the first intermediate layer and of the second intermediate layer is small. Though the misfit values of lattice constants in the Examples ranges within 4.3 %, the misfit of lattice constants within ± 3 % is necessary to attain Hc of more than 3000 Oe and SNR of more than 20 dB, both of which are required in very high density recording.

Advantageous Effect of the invention

As described so far, high coercive force and low media noise of a magnetic recording medium are achieved because crystal orientation of the magnetic layer is favorably controlled in the first structure according to the present invention by forming on the under-layer a first intermediate layer that is composed of at least an element selected from the group consisting of Ru, Re

and Os and contains oxygen, and on the first intermediate layer and beneath the magnetic layer a second intermediate layer that is composed of a CoCr alloy containing at least an element selected from the group consisting of Nb, Mo, Ru, Rh, Pd, Ta, W, Re, Os, Ir and Pt.

When the crystal structure of the second intermediate layer and the crystal structure of the ferromagnetic grains of the magnetic layer in the above-described first structure are both hexagonal closest packed structure and the misfit between lattice constants of unit cells of the two layers is within ± 3%, ferromagnetic grains epitaxially grow readily on the intermediate layer. As a result, the crystal orientation of the magnetic layer is more favorably controlled.

Since high coercive force is readily achieved in a magnetic recording medium by employing such an intermediate layer according to the invention, heating of the substrate is not required in the lamination process in producing a medium. Accordingly, excellent characteristics are exhibited by a medium employing an inexpensive plastic resin substrate as well as a conventional substrate of aluminum or glass. When such a medium is mounted on a magnetic recording device, a less expensive and high performance device is provided.

In the second structure according to the present invention, high Hc and low media noise of a magnetic recording medium are achieved because crystal orientation of the magnetic layer is favorably controlled by forming on the under-layer a first intermediate layer that is composed of a CoCr alloy containing at least an element selected from the group consisting of Nb, Mo, Ru, Rh, Pd, Ta, W, Re, Os, Ir and Pt, and on the first intermediate layer and beneath the magnetic layer a second intermediate layer that is composed of at least an element selected from the group consisting of Ru, Re and Os and contains oxygen.

When the crystal structure of the first intermediate layer and the second intermediate layer in the above-described second structure are both hexagonal closest packed structure and the misfit between lattice constants of unit cells of the two layers is within ± 3 %, ferromagnetic grains epitaxially grow readily on the intermediate layer through orientation control of the second non-magnetic intermediate layer. As a result, the crystal orientation of the magnetic layer is more favorably controlled.

Since high coercive force is readily achieved in a magnetic recording medium by employing such a non-magnetic intermediate layer according to the invention, heating of the substrate is not required in the lamination process in producing a medium. Accordingly, excellent characteristics are exhibited by a medium employing an inexpensive plastic resin substrate as well as a conventional substrate of aluminum or glass. When such a medium is mounted on a magnetic recording device, a less expensive and high performance device is provided.

Claims

1 A magnetic recording medium comprising:

a non-magnetic substrate composed of plastics;

at least a non-magnetic under-layer, first non-magnetic metallic intermediate layer, second non-magnetic metallic intermediate layer, a magnetic layer, a protective film, and a liquid lubricant layer sequentially laminated on said substrate, said magnetic layer comprising ferromagnetic grains containing at least cobalt and platinum and non-magnetic grain boundaries composed mainly of oxide surrounding the grains; wherein

said first intermediate layer is composed of at least an element selected from the group consisting of Ru, Re and Os and contains oxygen, and

said second intermediate layer is composed of a CoCr alloy containing at least an element selected from the group consisting of Nb, Mo, Ru, Rh, Pd, Ta, W, Re, Os, Ir and Pt.

2 A magnetic recording medium according to claim 1, wherein said plastics composing said non-magnetic substrate is polycarbonate or polyolefin.

3 A magnetic recording medium according to claim 1, wherein crystal structure of said second intermediate layer and crystal structure of said ferromagnetic grains in said magnetic layer are both hexagonal closest packed structure and misfit between lattice constants of unit cells of said intermediate layer and said ferromagnetic grains is within ± 3 %.

4 A magnetic recording medium according to claim 1, wherein said under-layer is composed of chromium or chromium alloy, and (200) lattice plane or (211) lattice plane is preferentially oriented in parallel with a film surface of said under-layer.

5 A method for manufacturing a magnetic recording medium comprising steps of sequentially laminating a non-magnetic under-layer, first non-

magnetic metallic intermediate layer, second non-magnetic metallic intermediate layer, a magnetic layer that comprises ferromagnetic grains containing cobalt and platinum and non-magnetic grain boundaries composed mainly of oxide surrounding the grains, a protective film and a liquid lubricant layer on a non-magnetic substrate of plastics; wherein

said first intermediate layer is composed of at least an element selected from the group consisting of Ru, Re, and Os and contains oxygen, and

said second intermediate layer is composed of a CoCr alloy containing at least an element selected from the group consisting of Nb, Mo, Ru, Rh, Pd, Ta, W, Re, Os, Ir and Pt.

6 A method for manufacturing a magnetic recording medium according to claim 5, wherein said plastics composing said substrate is polycarbonate or polyolefin.

7 A method for manufacturing a magnetic recording medium according to claim 5, wherein crystal structure of said second intermediate layer and crystal structure of said ferromagnetic grains in said magnetic layer are both hexagonal closest packed structure and misfit between lattice constants of unit cells of said intermediate layer and said ferromagnetic grains is within ± 3 %.

8 A method for manufacturing a magnetic recording medium according to claim 5, wherein said under-layer is composed of chromium or chromium alloy, and (200) lattice plane or (211) lattice plane is preferentially oriented in parallel with a film surface of said under-layer.

9 A magnetic recording device comprising a magnetic recording medium that is defined by claim 1.

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10 A magnetic recording medium comprising:

a non-magnetic substrate composed of plastics;

at least a non-magnetic under-layer, first non-magnetic metallic intermediate layer, second non-magnetic metallic intermediate layer, a magnetic layer, a protective film, and a liquid lubricant layer sequentially laminated on said substrate, said magnetic layer comprising ferromagnetic grains containing at least cobalt and platinum and non-magnetic grain boundaries composed mainly of oxide surrounding the grains; wherein

said first intermediate layer is composed of a CoCr alloy containing at least an element selected from the group consisting of Nb, Mo, Ru, Rh, Pd, Ta, W, Re, Os, Ir and Pt, and

said second intermediate layer is composed of at least an element selected from the group consisting of Ru, Re and Os and contains oxygen.

11 A magnetic recording medium according to claim 10, wherein said plastics composing said non-magnetic substrate is polycarbonate or polyolefin.

12 A magnetic recording medium according to claim 10, wherein crystal structure of said first intermediate layer and crystal structure of said second intermediate layer are both hexagonal closest packed structure and misfit between lattice constants of unit cells of said first intermediate layer and said second intermediate layer is within ± 3 %.

13 A magnetic recording medium according to claim 10, wherein said under-layer is composed of chromium or chromium alloy, and (200) lattice plane or (211) lattice plane is preferentially oriented in parallel with a film surface of said under-layer.

14 A method for manufacturing a magnetic recording medium comprising steps of sequentially laminating a non-magnetic under-layer, first non-magnetic metallic intermediate layer, second non-magnetic metallic

intermediate layer, a magnetic layer that comprises ferromagnetic grains containing at least cobalt and platinum and non-magnetic grain boundaries composed mainly of oxide surrounding the grains, a protective film and a liquid lubricant layer on a non-magnetic substrate of plastics; wherein

said first intermediate layer is composed of a CoCr alloy containing at least an element selected from the group consisting of Nb, Mo, Ru, Rh, Pd, Ta, W, Re, Os, Ir and Pt, and

said second intermediate layer is composed of at least an element selected from the group consisting of Ru, Re, and Os and contains oxygen.

15 A method for manufacturing a magnetic recording medium according to claim 14, wherein said plastics composing said substrate is polycarbonate or polyolefin.

16 A method for manufacturing a magnetic recording medium according to claim 14, wherein crystal structure of said first intermediate layer and crystal structure of said second intermediate layer are both hexagonal closest packed structure and misfit between lattice constants of unit cells of said first intermediate layer and said second intermediate layer is within ± 3 %.

17 A method for manufacturing a magnetic recording medium according to claim 14, wherein said under-layer is composed of chromium or chromium alloy, and (200) lattice plane or (211) lattice plane is preferentially oriented in parallel with a film surface of said under-layer.

18 A magnetic recording device comprising a magnetic recording medium that is defined by claim 10.