

CHEMICALLY ORDERED PERPENDICULAR RECORDING MEDIA

Cross References

This invention claims priority to Provisional Patent Application Number 60/843,352 filed on September 8, 2006 which is hereby incorporated by reference as if set forth in the present application.

Technical Field

The present invention relates to a magnetic recording media. In particular, the present invention relates to chemically ordered perpendicular recording media and method for forming the media.

Background of the invention

The storage density of commercially available hard disk drives is increasing at an astonishing rate of 60%-100% per annum. As magnetic data storage systems based on conventional longitudinal recording technology rapidly approach their storage limit due to the superparamagnetic instabilities, those skilled in the art have given increasing attention to the perpendicular recording technology. Perpendicular recording technology provides high magnetic anisotropy material to realize higher density recording.

CoCr-based alloy recording media are extensively used in conventional longitudinal recording technology. Thus, Co-Cr based alloys can be used as the perpendicular recording media. Perpendicular recording media can be made by changing the orientation of the magnetic easy axis of the Co-Cr based alloys. CoCr-based perpendicular recording media are commercially used in hard disk industries. However, those skilled in the art have not yet determined whether the anisotropy of the CoCr-based medium can be increased to avoid superparamagnetic instabilities at ultra-high areal densities. Those skilled in the have reported that to make CoCr-alloy-based perpendicular recording medium

with a remnant squareness of 1 is difficult. Those skilled in the art strive to reduce the remnant squareness to 1 because a small remnant squareness can lead to substantial amounts of DC noise. Therefore, there is a need in the art to further increase the recording densities, magnetic recording media with higher anisotropy are required.

$L1_0$ ordered alloys such as FePt, CoPt, FePd, CoPd are promising candidates for future ultra-high densities perpendicular recording medium. Currently, the formation of an ordered alloy needs a phase transition either via post-annealing or deposited at heated substrates, normally at a relatively high process temperature.

In most of the research works done so far, process temperatures for formation of the high anisotropy ordered alloy films are over 450°C. Such a high process temperature may cause problems on both quality control of a magnetic recording media and the compatibility of the media with manufacturing processes used in hard disk drive (HDD) industry. One problem with the high process temperatures is deformation of the Al based alloy used in HDD industry that acts as the process chamber material, shell, and so on. Another problem is the high process temperatures inhibit the deposition of the diamond liked carbon (DLC) overcoats for HDD. The temperature required for DLC coating is about 200°C in currently used processes. Thus, if the recording media are formed at a high temperature, i.e. over 450°C, all the post annealing processes need to be modified to accommodate the high processing temperature for media formation.

From applications' viewpoint, a recording layer with well-isolated and magnetic decoupled grains is one of the critical requirements for the high density perpendicular recording media. $L1_0$ ordered alloy based composite films are proposed and extensive investigations have been done on these films with variant additives such as, Ag, B, SiO₂, MgO, Al₂O₃, etc. The high anisotropy composite films are obtained by either performing post annealing after the formation of the composite film, or depositing the composite film on in-situ heated substrate. The

post annealing method has the advantage of allowing control of the microstructure and magnetic properties of the composite films via changing the annealing profile and/or the amount of the dopants. However, the post annealing method does not allow for precise control of the crystal orientation of the ordered alloy films in most of cases. Furthermore, the annealing temperature is too high and the intermediate manufacturing step is too complicated.

Therefore, depositing the composite film on in-situ heated substrate is more favorable to the HDD industry. Most of the works related to the directly depositing FePt composite film on heated substrate require the substrate temperature to be at least 450°C.

US patent No. 6641934 B1 proposes a FePt based perpendicular recording media deposited on heated substrates with basic structure of MgO/Cr/FeSi/MgO/FePt, as shown in Fig. 1 (e) and Fig. 1 (f) of the patent. The recording layer, according to this patent, is either pure FePt or FePt with additives of MgO, SiO₂ and Al₂O₃. The growth of the films is controlled in such a way that a crystal plane having a crystal lattice face of a Miller index (100) is parallel to the substrate. In the case of a 450°C substrate temperature, only the FePt film with MgO dopant shows the perpendicular magnetic easy axis orientation with coercivity of about 3.4 kOe, whereas for the cases of SiO₂ and Al₂O₃ doping, the fabricated medium shows soft magnetic properties. Thus, the L1₀ ordered FePt phases is not well formed at a substrate temperature of 450°C. Further improvements of the magnetic properties of the composite films in prior arts thus need even higher substrate temperature.

US Patent application publication no. 2003/0215675 A1 proposed to control the growth of the L1₀ ordered alloys using a series of underlayers such as, an underlayer having the bcc crystalline structure (Cr based alloy); an underlayer having the bct crystalline structure (Ni-Al or Ni-Al with other added element); an underlayer having the fcc crystalline structure (Pt, Pd, Rh, and noble metals); and an underlayer having the NaCl crystalline structure (MgO, LiF and NiO). Experimental results based on CoPt films with B additive show a perpendicular

magnetic "c-axis". However, the substrate temperature for film growth in accordance with this application is in the range of 400°C~550°C.

A high temperature is required for the formation of the ordered alloy with $L1_0$ crystalline structure. This high temperature causes problems as mentioned before and the requirements for recording media itself also need to be further improved.

SUMMARY OF INVENTION

The above and other problems are solved and an advance in the art is made by a media and method for making the media in accordance with this invention. Embodiments of the present invention develop a method to manufacture $L1_0$ ordered alloy based recording media with: (a) lower substrate temperature for formation of ordered $L1_0$ phases; (b) well-isolated magnetic grains; and (c) good crystalline orientation of the ordered $L1_0$ phases (perpendicular magnetic "c-axis").

Embodiments of the present invention also provide a method to reduce the substrate temperature for formation of the $L1_0$ ordered FePt phases, while the magnetic grains are well separated by added carbon element. The ordered FePt $L1_0$ phases also have a good perpendicular magnetic "c-axis". This method may be used to form promising candidates for future perpendicular recording media.

Ordered high anisotropy alloy thin films with or without doped additives are deposited on a substrate by using DC and/or RF-magnetron sputtering. High anisotropy $L1_0$ ordered alloy films have been obtained at a substrate temperature of 280°C. Formation of high anisotropy $L1_0$ ordered alloy films at such a lower substrate temperature presents a significant improvement to the hard-disk industry for application of ordered alloy films with $L1_0$ crystalline structure acting as the magnetic perpendicular recording media.

Embodiments of the present invention also provide layer structures of $L1_0$ ordered alloy films based double-layered perpendicular recording media. Embodiments of the present invention provide solutions of obtaining ordered alloy films with $L1_0$ crystalline structure at a low temperature together with the well-isolated column magnetic grains. Perpendicular magnetic recording media formed according to embodiments of the present invention may well serve as future magnetic recording media in high capacity data storage systems.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects and advantages of the present invention will be described in detail with reference to the accompanying drawings, in which:

Fig. 1(a) is a schematic cross sectional view showing a layer structure of a perpendicular recording medium according to one embodiment of the present invention;

Fig. 1(b) is a schematic cross sectional view showing a layer structure of a perpendicular recording medium according to another embodiment of the present invention;

Fig. 1(c) is a schematic cross sectional view showing a layer structure of a perpendicular recording medium according to another embodiment of the present invention;

Fig. 1(d) is a schematic cross sectional view showing a layer structure of a perpendicular recording medium according to another embodiment of the present invention;

Fig. 1(e) is a schematic cross sectional view showing a layer structure of a conventional perpendicular recording medium;

Fig. 1(f) is a schematic cross sectional view showing another layer

structure of a conventional perpendicular recording medium;

Fig. 2 is a chart showing an X-ray diffraction pattern of Glass/CrRu/MgO/FePt, where the FePt films are deposited at different substrate temperature;

Fig. 3 is a chart showing the magnetic characteristics of Glass/CrRu/MgO/FePt, where the FePt film is deposited at substrate temperature of 280°C and 400°C, respectively;

Fig. 4 and FIG. 5 show the X-ray diffraction pattern and the magnetic characteristics of the magnetic recording media in FIG. 1(b);

Fig. 6 is an X-ray diffraction pattern of the magnetic recording medium in FIG. 1(b), where the FePt films with the different vol% of C are deposited at substrate temperature of 300°C;

Fig. 7 is a chart showing the magnetic characteristics of the magnetic recording media in FIG. 1(b), where the FePt films with the different vol% of C are deposited at substrate temperature of 300°C;

Fig. 8 is an X-ray diffraction pattern of the magnetic recording media in FIG. 1(b), where the FePt films (with 20 vol% of C) of different thickness are deposited at substrate temperature of 280°C;

Fig. 9 is a chart showing the magnetic characteristics of the magnetic recording media in FIG. 1(b), where the FePt films (with 20 vol% of C) of different thickness are deposited at substrate temperature of 280°C; and

Fig. 10 is an HRTEM cross-section image of the magnetic recording media in FIG. 1(b), where the FePt films (with 15 vol% of C) of different thickness are deposited at substrate temperature of 350°C.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

According to embodiments of the present invention, chemical ordering of the FePt films is controlled based on the lattice misfit between the underlayer and the magnetic recording layer during the epitaxial growth of the magnetic recording layer. In one embodiment, a lattice misfit of about 6% is found to be effective to improve the chemical ordering of the FePt films. Therefore, the strain energy resulting from the lattice misfit during the epitaxial growth can be used to improve the chemical ordering of the FePt film. As such, the ordering temperature of $L1_0$ ordered FePt phases is much reduced. In other embodiments, a lattice misfit in a range of about 3% to 10% is effective to improve the chemical ordering of the FePt films. By considering the diffusion of the Cr element to the recording layer and the effect of the additives to the epitaxial growth of the $L1_0$ ordered alloys, a CrRu/MgO bilayer structure is used as the underlayer/buffer layer in embodiments of the present invention.

Some embodiments use epitaxial growth and FePt phase transformation from fcc to fct, with the aid of strain energy arising from the lattice misfits and/or the doped elements.

Some embodiments of the present invention include in-situ deposition of $L1_0$ ordered FePt or $L1_0$ ordered FePtX films (where X is a compound selected from the group consisting of C, SiO_2 , Al_2O_3 and ZrO) by DC/RF magnetron sputtering at a temperature below 400°C, to form a perpendicular recording medium. These embodiments make use of epitaxial growth and FePt phase transformation from fcc to fct tetragonal $L1_0$ structure, with the aid of strain energy arising from the lattice misfits between the CrRu underlayer/MgO buffer layer and the FePt recording layer, during the growth of FePt or FePtX films. An exemplary layer structure and the detailed description of embodiments of the present invention will be given below.

FIG. 1(a) shows a structure of a perpendicular recording medium 110 according to one embodiment of the present invention. An underlayer 114 is formed on a substrate 112, and a buffer layer 116 is formed on underlayer 114. Thereafter, a magnetic recording layer 118, such as a FePt layer, is formed on buffer layer 116. Underlayer 114 may be a CrRu layer having a (002) texture. Buffer layer 116 may be an MgO layer, also having a (002) texture. Alternatively, underlayer 114 may be other Cr-alloys, such as CrMo, CrMn, CrW, CrTi, CrZr or CrV, and having a lattice constant the same as that of CrRu layer. Buffer layer 116 may also be a SrTiO₃ layer with (002) texture. The CrRu layer with proper Ru element percentage is used to control the growth of MgO (002) buffer layer in the present embodiment.

In the shown embodiment, perpendicular recording medium 110 is configured such that there exists a lattice misfit between underlayer 114 and recording layer 118 to induce strain energy without causing deterioration of the epitaxial growth of the FePt magnetic recording layer 118. According to embodiments of the present invention, the lattice misfit is in a range of about 3% to 10%, and preferably is approximately 6%. The MgO buffer layer 116 will follow the lattice of the CrRu underlayer 114, then affects the FePt magnetic recording layer 118 on top. The MgO buffer layer 116 is used to control the microstructure of the FePt based composite films. The lattice misfit induces a strain energy during depositing the magnetic recording layer 118, and the strain energy forms the magnetic recording layer 118 with chemically ordered structure at a substrate temperature of below about 400 °C.

A Fast Fourier Transform (FFT) of the HRTEM image of a selected area of MgO layer 116 in multilayer structure of CrRu/MgO/FePt indicates that the d spacing of the Mg (002) planes is 0.22617 nm compared to the standard value 0.2107 nm of MgO. The addition thickness means the lattice constant of MgO layer 116 will follow the lattice constant of CrRu underlayer 114. Thus, a favorable lattice misfit can be achieved via tuning the lattice constant of Cr layer 114 and consequently, the lattice constant of MgO layer 116 for the epitaxial growth of the

chemically ordered FePt films. This method has a great potential to reduce the ordering temperature for formation of the chemically ordered FePt films.

In the fabrication process, the substrate 112 is heated and held at the set-point temperature for 15 minutes before sputtering. The Cr based alloy underlayer 114 with thickness in the range of 5 nm~60 nm is deposited on the substrate 112 when substrate 112 has a temperature of about 200°C to about 400°C.

Thereafter, a thin MgO or Pt layer with film thickness ranging from 2~8 nm is deposited at room temperature or a substrate temperature of 30~300°C. The MgO or Pt (001) is induced by (002) oriented Cr based alloy films as an underlayer 114. The FePt thin films with (001) orientation can grow atop MgO or Pt (001) by epitaxial growth. The FePt or FePtX film is fabricated on top of MgO or Pt buffer layer utilizing DC and/or RF-magnetron sputtering on a heated substrate (temperature ranging from 260~400°C).

For all the film deposition, a suitable base pressure in the sputtering chamber prior to the film deposition has been demonstrated to be 2×10^{-8} Torr. A FePt alloy target is used in the present embodiment. Alternatively, FePt films can be obtained by placing Fe-chips onto a Pt target. The FePtX films are prepared by co-sputtering of FePt target and the additives target. High purity Argon is used in the sputter deposition, the working gas pressure is in the range of 2 ~10 mTorr.

Further embodiments of the present invention are shown in Fig. 1 (c) and Fig. 1(d). In Fig. 1(c), a perpendicular recording medium 130 includes an underlayer 134 which is formed on a substrate 132. A buffer layer 136 is formed on underlayer 134. Thereafter, a recording layer, such as a FePt layer 138, is formed on buffer layer 136. Underlayer 134 may be a CrRu layer having a (002) texture. Buffer layer 136 may be an MgO layer, also having a (002) texture. The perpendicular recording medium 130 further includes a soft magnetic underlayer 133a and a SiO₂ or other amorphous layer 133b formed between substrate 132 and underlayer 134.

In Fig. 1(d), a perpendicular recording medium 140 includes an underlayer 144 which is formed on a substrate 142. A buffer layer 146 is formed on underlayer 144. Thereafter, a recording layer, such as a FePt layer 148, is formed on buffer layer 146. Underlayer 144 may be a CrRu layer having a (002) texture. Buffer layer 146 may be an MgO layer, also having a (002) texture. The perpendicular recording medium 140 further includes an amorphous soft magnetic underlayer 143 formed between substrate 142 and underlayer 144.

EXAMPLE 1

A first exemplary embodiment of the perpendicular recording medium 110 with structure shown in FIG. 1(a) is produced by C/RF magnetron sputtering. In this exemplary embodiment, the thickness of the CrRu underlayer 114 is 30 nm, the thickness of MgO buffer layer 116 is 2 nm and the thickness of FePt recording layer 118 is 15 nm. FePt recording layer 118 is deposited at respective substrate temperatures of 280°C, 300°C, 350°C, and 400°C.

FIG. 2 shows an XRD spectra of Glass/CrRu/MgO/FePt layers deposited at different substrate temperatures ranging from 280°C to 400°C. The diffraction peaks of FePt (001) and (002) are observed once the substrate is heated over 280°C. The intensity of diffraction peaks increases as the substrate temperature increases. Thus, the FePt films undergoes a transition from the disordered (fcc) phase to a chemically ordered (fct) phase when substrate temperature is over 280°C. Prior to manufacture of recording media 110 in the above manner, those skilled in the art have never reported that the fct phase FePt films could be obtained at such a low substrate temperature.

FIG. 3 shows the magnetic characteristics of the perpendicular recording media 110 shown in FIG. 1(a), where the FePt film is deposited at substrate temperatures of 280°C and 400°C, respectively. The corresponding coercivity (H_c) of the FePt films is 3.8 kOe for 280°C and 9 kOe for 400°C. Both FePt films show the perpendicular magnetic "c-axis" orientation, negative nucleation field,

and large squareness. These characteristics indicate that a $L1_0$ ordered FePt with good perpendicular magnetic properties has been achieved.

EXAMPLE 2

A second exemplary embodiment having the structure of perpendicular recording medium 120 shown in FIG. 1(b) is deposited on a substrate 122 by DC/RF magnetron sputtering. In this second exemplary embodiment, the thickness of the CrRu underlayer 124 is 30 nm, the thickness of MgO buffer layer 126 is 2 nm, and the thickness of C doped FePt recording layer 128 is 15 nm. The C doped FePt recording layer 128 is deposited at substrate temperature of 280°C. The volume percentage of C is varied in the range of from approximately 0% to about 30%.

FIG. 4 and FIG. 5 show the X-ray diffraction pattern and the magnetic characteristics of the magnetic recording medium 120 in FIG. 1(b), where the FePtX films with different volume percentages of C are deposited at a substrate temperature of 280°C. From the XRD spectra, the $L1_0$ ordered FePt films with different volume percentage (up to 30 vol%) of C doping are obtained. The magnetic properties of the films demonstrate that the $L1_0$ ordered FePt films have perpendicular magnetic "c-axis" orientation. H_c of the $L1_0$ ordered FePt films varied in the range of 3.8 kOe to about 12 kOe as the carbon volume percentage of C is changed. The results suggest that the magnetic properties of the perpendicular recording medium 120 could be controlled by adjusting the volume percentage of the C additive / dopant. The results demonstrate that the $L1_0$ ordered FePt films with magnetic "c-axis" perpendicular to the film plane has been achieved at a low substrate temperature of 280°C. Furthermore, the coercivity of recording layer 128 can be adjusted by varying the volume percentage of the doped additives.

EXAMPLE 3

In a third exemplary embodiment, a perpendicular recording media 120 with structure shown in FIG. 1(b) is deposited by DC/RF magnetron sputtering, where the thickness of the CrRu underlayer 124 is 30 nm, the thickness of MgO buffer layer 126 is 2nm and the thickness of C doped FePt recording layer 128 is 15 nm. The C doped FePt recording layer 120 is deposited at substrate temperature of 300°C. In this third exemplary embodiment, the volume percentage of C is varied with the volume percentages being 0, 10%, and 15%, respectively.

FIG. 6 and FIG. 7 show the X-ray diffraction pattern and the magnetic characteristics of the magnetic recording media 124 in this third exemplary embodiment. The H_c of the $L1_0$ ordered FePt film without carbon doping is 4.4 kOe. The H_c increases to 8.4 kOe when the volume percentage of C is 10% and to 11.2 kOe the volume percentage of C increases to 15%. The XRD spectra indicate that the $L1_0$ ordered FePt films were obtained for all the cases. Furthermore, calculate the ordering parameters for each case can be calculated from analysis of the diffraction peaks. The calculated ordering parameters are listed in Table 1. Table 1 shows that the chemical ordering of the FePt films is improved by the doped carbon elements. This could be another reason why $L1_0$ ordered FePt films are obtained at such a low substrate temperature.

Table 1.1 The calculated ordering parameters ($(I_{001}/I_{002})^2$) of FePt with different percentage carbon doping based on XRD spectra shown in FIG. 6.

Different carbon at 300°C	001-position	001 FWHM	001-area	002-position	002 FWHM	002-area	$(I_{001}/I_{002})^2$
0%	23.89	0.99	843	48.534	1.591	1053	0.64
10%	23.99	0.876	939	48.946	1.33	824	1.29
15%	23.95	0.95	700	48.88	1.45	589	1.41

EXAMPLE 4

In a fourth exemplary embodiment, the thickness of recording layer is varied. In this embodiment, the perpendicular recording media has the structure of perpendicular recording media 120 shown in FIG. 1(b) and is deposited by DC/RF magnetron sputtering. The thickness of the CrRu underlayer 124 is 30 nm and the thickness of MgO buffer layer 126 is 2 nm. The thickness of the C doped FePt recording layer 128 is varied and is 5 nm, 7.5 nm, 10 nm and 15 nm, respectively. The volume percentage of the doped C is fixed at 20 % by volume. The C doped FePt recording layer 128 is deposited at a substrate temperature of 280°C.

FIG. 8 and FIG. 9 present the X-ray diffraction pattern and the magnetic characteristics of the magnetic recording medium 124 mentioned above with differing thicknesses of recording volume. The XRD results indicate that the $L1_0$ ordered FePt has been achieved. The magnetic properties of the films demonstrate that the $L1_0$ ordered FePt films have perpendicular magnetic "c-axis" orientation. H_c of the $L1_0$ ordered FePt films varied in the range of 10 kOe to about 13 kOe as the thickness of the recording layer is changed. The results give an opportunity to select the thickness of the recording layer over a relatively wide range when considering the thermal stability of the recording bits and the write field efficiency at the same time.

Fig. 10 shows the HRTEM cross-section image of the magnetic recording media 120 in FIG. 1(b), where the FePt films having 15% by volume of C and different thicknesses are deposited at substrate temperature of 350°C. In accordance with the observed curve, the FePt grains are column growth and are well-isolated by the added C additives. The average grain size in horizontal direction is about 7 nm, and the C boundary is about 1nm. Thus, the recording media could have a high pack density and a better thermal stability. Although the lattice misfit must be controlled to lower the ordering temperature of $L1_0$ ordered FePt films, the column growth itself is not dependent on such misfit control.

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Although embodiments of the present invention have been illustrated in conjunction with the accompanying drawings and described in the foregoing detailed description, it should be appreciated that the invention is not limited to the embodiments disclosed, and is capable of numerous rearrangements, modifications, alternatives and substitutions without departing from the spirit of the invention as set forth and recited by the following claims.

CLAIMS

1. A method for forming a chemically ordered perpendicular recording medium, comprising:
 - depositing an underlayer on a substrate, wherein the underlayer has a (002) orientation;
 - depositing a buffer layer on the underlayer, wherein the buffer layer has a (002) orientation; and
 - depositing a magnetic recording layer on the buffer layer while the substrate has a temperature that is less than 400 degrees Celsius, wherein the underlayer and the magnetic recording layer have a lattice misfit to induce a strain energy during depositing the magnetic recording layer on the buffer layer, and wherein the strain energy causes the magnetic recording layer to form with chemically ordered structure.
2. The method of claim 1, wherein the underlayer is a Cr-based alloy.
3. The method of claim 2, wherein the Cr-based alloy is CrRu.
4. The method of claim 2, wherein the Cr-based alloy is one selected from the group consisting of CrMo, CrMn, CrW, CrTi, CrZr and CrV.
5. The method of claim 1, wherein the buffer layer is MgO.
6. The method of claim 1, wherein the buffer layer is SrTiO₃.
7. The method of claim 1, wherein the underlayer and the magnetic recording layer have a lattice misfit of between about 3% to about 10%.
8. The method of claim 7, wherein the under layer and the magnetic recording layer have a lattice misfit of about 6%.

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9. The method of claim 1 further comprising:
depositing a soft magnetic underlayer and an amorphous layer on the substrate prior to depositing the underlayer on the substrate.
10. The method of claim 1 further comprising:
depositing an amorphous soft magnetic underlayer on the substrate prior to depositing the underlayer on the substrate.
11. The method of claim 1, further comprising:
introducing an additive into the magnetic recording layer wherein the magnetic recording layer is formed of magnetic grains isolated by a boundary phase formed by the additive.
12. The method of claim 11, wherein the additive is selected from the group consisting of C, SiO₂, Al₂O₃, ZrO, or a combination thereof.
13. A method for forming a chemically ordered perpendicular recording medium, comprising:
depositing an underlayer on a substrate, wherein the under layer has a (002) orientation;
depositing a buffer layer on the underlayer, wherein the buffer layer has a (002) orientation; and
depositing a magnetic recording layer on the buffer layer while introducing a additive into the magnetic recording layer and wherein the magnetic recording layer is formed of magnetic grains isolated by a boundary phase formed by the additive.
14. A chemically ordered perpendicular magnetic recording medium comprising :
a substrate;

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an underlayer on the substrate, wherein the under layer has a (002) orientation;
a buffer layer on the underlayer, wherein the buffer layer has a (002) orientation; and
a magnetic recording layer on the buffer layer, wherein the magnetic recording layer is formed of ordered alloy having an $L1_0$ crystalline structure.

15. The medium of claim 14, wherein the underlayer is a Cr-based alloy.
16. The medium of claim 15, wherein the Cr-based alloy is CrRu.
17. The medium of claim 15, wherein the Cr-based alloy is one selected from the group consisting of CrMo, CrMn, CrW, CrTi, CrZr and CrV.
18. The medium of claim 14, wherein the buffer layer is MgO.
19. The medium of claim 14, wherein the buffer layer is SrTiO₃.
20. The medium of claim 14, wherein the underlayer and the magnetic recording layer have a lattice misfit of between about 3% to about 10%.
21. The medium of claim 14, wherein the under layer and the magnetic recording layer have a lattice misfit of about 6%.
22. The medium of claim 14 further comprising:
a soft magnetic underlayer deposited between the substrate and the underlayer; and
an amorphous layer between the substrate and the underlayer.
23. The medium of claim 14 further comprising:
an amorphous soft magnetic underlayer between the substrate and the underlayer.

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24. The medium of claim 14, further comprising:
an additive in the magnetic recording layer wherein the magnetic recording layer is formed of magnetic grains isolated by a boundary phase formed by the additive in the magnetic recording layer.
25. The medium of claim 24, wherein the additive is selected from the group consisting of C, SiO₂, Al₂O₃, ZrO, or a combination thereof.