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(54) **MAGNETIC RECORDING MEDIUM, PRODUCTION PROCESS THEREOF, MAGNETIC RECORDING AND REPRODUCING APPARATUS, AND SPUTTERING TARGET**

(76) Inventors: **Akira Sakawaki**, Chiba (JP); **Masato Kokubu**, Chiba (JP); **Ryuji Sakaguchi**, Chiba (JP); **Hiroshi Sakai**, Chiba (JP)

Correspondence Address:
SUGHRUE, MION, ZINN, MACPEAK & SEAS, PLLC
2100 Pennsylvania Avenue, N.W.
Washington, DC 20037-3213 (US)

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(57) **ABSTRACT**

An object of the present invention is to provide a process for easily producing a magnetic recording medium exhibiting excellent magnetic characteristics. In the present invention, an orientation-determining film is formed on a non-metallic substrate which has undergone texturing, the orientation-determining film is subjected to oxidation or nitridation, and a non-magnetic undercoat film and a magnetic film are formed on the film.

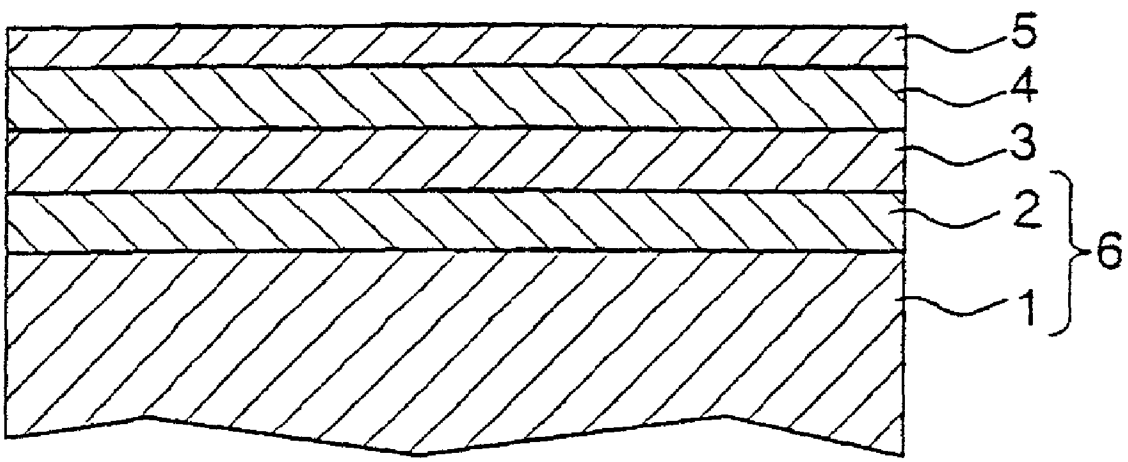


Fig. 1

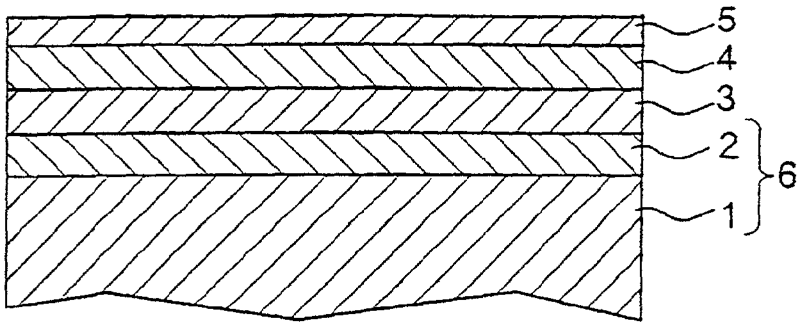


Fig. 2

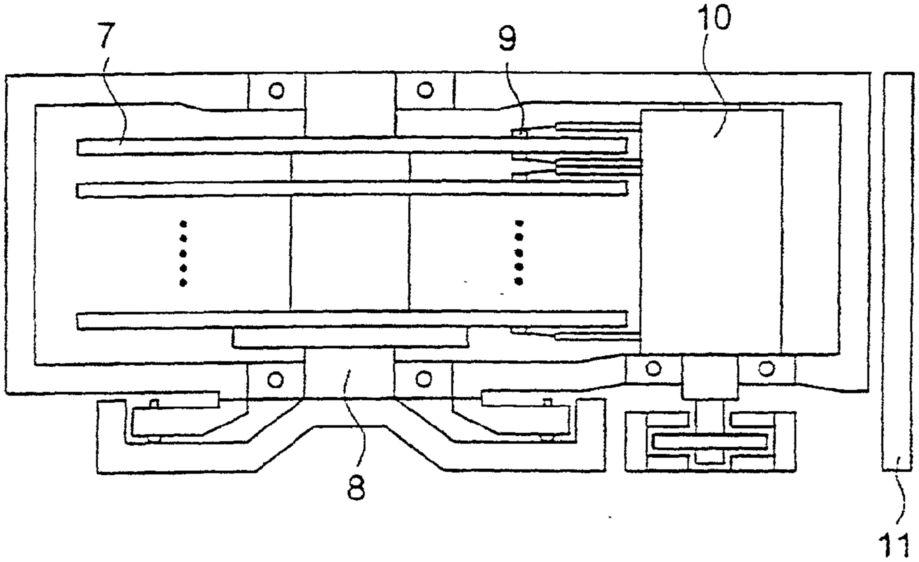
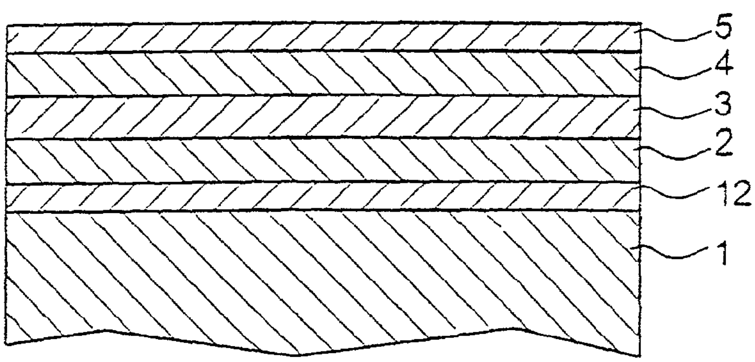


Fig. 3



MAGNETIC RECORDING MEDIUM, PRODUCTION PROCESS THEREOF, MAGNETIC RECORDING AND REPRODUCING APPARATUS, AND SPUTTERING TARGET

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is an application filed under 35 U.S.C. §111(a) claiming benefit pursuant to 35 U.S.C. §119(e)(1) of the filing date of Provisional application No. 60/230,810 filed Sep. 7, 2000 pursuant to 35 U.S.C. §111(b).

FIELD OF THE INVENTION

[0002] The present invention relates to a magnetic recording medium employed in an apparatus such as a magnetic disk apparatus; a process for producing the magnetic recording medium; a sputtering target employed for producing the magnetic recording medium; and a magnetic recording and reproducing apparatus comprising the magnetic recording medium.

BACKGROUND OF THE INVENTION

[0003] Conventionally, a metallic substrate formed of, for example, an aluminum alloy is widely employed as a substrate for producing a magnetic recording medium. Usually, such a metallic substrate undergoes texturing, and is employed for producing a magnetic recording medium.

[0004] Texturing is a process for forming an irregular surface on a substrate along a predetermined direction (usually in a circumferential direction) of the substrate. When the surface of a substrate undergoes texturing, the crystalline orientation of an undercoat film and a magnetic film, which are formed on the substrate, is enhanced, and the magnetic film exhibits magnetic anisotropy. Thus magnetic characteristics, such as thermal stability and resolution, of a magnetic recording medium can be enhanced.

[0005] In recent years, instead of a metallic substrate formed of aluminum or similar metal, a non-metallic substrate formed of material such as glass or ceramic has been widely employed as a substrate for producing a magnetic recording medium. Such a non-metallic substrate has an advantage that head slap does not easily occur in the substrate, because of the high hardness of the substrate.

[0006] However, in the case in which a non-metallic substrate such as a glass substrate is employed, the magnetic film may not be imparted with satisfactory magnetic anisotropy even when the substrate undergoes texturing. As a result, the resultant magnetic recording medium may exhibit unsatisfactory magnetic characteristics.

[0007] In order to solve such problems, formation of a hard film which can be easily textured on a non-metallic substrate formed of material such as glass or ceramic has been proposed.

[0008] For example, Japanese Patent Application Laid-Open (kokai) No. 5-197941 discloses a magnetic recording medium including a non-metallic substrate formed of material such as glass or ceramic, and the substrate is coated through sputtering with NiP film serving as a hard film which is easily textured.

[0009] Japanese Patent Application Laid-Open (kokai) Nos. 4-29561 and 9-167337 disclose a magnetic recording medium including a non-metallic substrate which is plated with film such as electroless plating film, and the film serves as a hard film.

[0010] A magnetic recording medium including a hard film formed on a non-metallic substrate is produced through the following process: the hard film is formed on the substrate in a film formation apparatus such as a sputtering apparatus; the substrate is temporarily removed from the apparatus and is subjected to texturing by use of a texturing apparatus; the resultant substrate is again placed in the apparatus; and then an undercoat film and a magnetic film are formed on the substrate.

[0011] However, the aforementioned conventional production process for a magnetic recording medium includes complicated production steps, resulting in high production costs. Therefore, there has been keen demand for a production process for a magnetic recording medium, which encompasses a simplified production procedure.

SUMMARY OF THE INVENTION

[0012] In view of the foregoing, an object of the present invention is to provide a process for easily producing a magnetic recording medium exhibiting excellent magnetic characteristics.

[0013] The present invention provides a process for producing a magnetic recording medium characterized by forming an orientation-determining film, which determines the crystalline orientation of a film provided directly on the orientation-determining film, on a non-metallic substrate which has undergone texturing; subjecting the orientation-determining film to oxidation or nitridation; and forming a non-magnetic undercoat film and a magnetic film on the orientation-determining film.

[0014] The oxidation or nitridation is carried out by bringing the orientation-determining film into contact with an oxygen-containing gas or a nitrogen-containing gas.

[0015] The present invention also provides a process for producing a magnetic recording medium, which comprises forming an orientation-determining film, which determines the crystal orientation of a film provided directly on the orientation-determining film, on a non-metallic substrate which has undergone texturing; and forming a non-magnetic undercoat film and a magnetic film on the orientation-determining film, wherein the orientation-determining film is formed through sputtering by use of a sputtering gas containing nitrogen or a sputtering gas containing oxygen.

[0016] Preferably, the orientation-determining film comprises NiP (the content of P is 10-40 at %) as a primary component.

[0017] Preferably, the orientation-determining film comprises NiPX (wherein X is one or more species of Cr, Mo, Si, Mn, W, Nb, Ti, and Zr, and the content of X is 0-25 at %) as a primary component.

[0018] The present invention also provides a sputtering target for forming the orientation-determining film, which comprises NiPX (wherein X is one or more species of Cr, Mo, Si, Mn, W, Nb, Ti, and Zr, and the content of X is 0-25 at %) as a primary component.

[0019] The present invention also provides a magnetic recording medium comprising a non-metallic substrate which has undergone texturing; an orientation-determining film formed on the non-metallic substrate; and a non-magnetic undercoat film and a magnetic film, which are formed on the orientation-determining film, characterized in that the ratio of a coercive force in a circumferential direction of the medium (Hcc) to a coercive force in a radial direction of the medium (Hcr); i.e., Hcc/Hcr, is 1.1 or more.

[0020] The orientation-determining film has an average surface roughness (Ra) of less than 0.5 nm.

[0021] The magnetic recording medium of the present invention comprises a structure wherein a non-magnetic adhesive film, which prevents exfoliation of the orientation-determining film from the substrate, is formed between the non-metallic substrate and the orientation-determining film, and the non-magnetic adhesive film comprises one or more species of Cr, Mo, Nb, V, Re, Zr, W, and Ti.

[0022] The present invention also provides a magnetic recording and reproducing apparatus comprising the magnetic recording medium and a magnetic head for recording data onto the medium and reproducing the data therefrom.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] **FIG. 1** is a partially cross-sectional view of one embodiment of the magnetic recording medium of the present invention.

[0024] **FIG. 2** is a partially cross-sectional view of one embodiment of the magnetic recording and reproducing apparatus of the present invention.

[0025] **FIG. 3** is a partially cross-sectional view of another embodiment of the magnetic recording medium of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0026] **FIG. 1** is a schematic representation showing an example embodiment of the magnetic recording medium of the present invention. The magnetic recording medium comprises a non-metallic substrate **1** which has undergone texturing, an orientation-determining film **2** formed on the substrate, a non-magnetic undercoat film **3**, a magnetic film **4**, and a protective film **5**, the films **3** to **5** being successively formed on the film **2**. Hereinafter, the structure of the non-metallic substrate **1** and the orientation-determining film **2** will be called a medium substrate **6**.

[0027] The non-metallic substrate **1** is formed from a non-metallic material such as glass, ceramic, silicon, silicon carbide, or carbon. Particularly, from the viewpoint of durability and cost, a glass substrate is preferably employed.

[0028] The glass substrate is formed from amorphous glass or crystallized glass. The amorphous glass may be widely-used soda-lime glass, aluminocate glass, or aluminosilicate glass. The crystallized glass may be lithium-based crystallized glass.

[0029] Particularly, amorphous glass exhibiting uniform physical properties such as hardness is preferably employed as a material of the substrate, since the substrate can be subjected to uniform texturing.

[0030] Meanwhile, a ceramic substrate may be a widely-used sintered compact predominantly containing aluminum oxide, aluminum nitride, and silicon nitride; or fiber-reinforced material thereof.

[0031] The non-metallic substrate **1** is subjected to mechanical texturing or similar processing by use of a lapping tape containing fixed abrasive grains or by use of free abrasive grains, to have a textured surface.

[0032] Texture lines formed on the non-metallic substrate **1** through texturing are preferably along the circumferential direction of the substrate.

[0033] The average surface roughness (Ra) of the non-metallic substrate **1** is 0.1-1 nm (1-10 Å), preferably 0.3-0.8 nm (3-8 Å).

[0034] When the average surface roughness (Ra) is below the above range, the non-metallic substrate **1** is excessively smooth, and thus the substrate encounters difficulty in enhancing the magnetic anisotropy of the magnetic film **4**. In contrast, when the average surface roughness (Ra) is in excess of the above range, the evenness of the medium is lowered, resulting in poor glide height characteristics. As a result, reducing the flying height of a magnetic head during reproduction of data becomes difficult.

[0035] As compared with a metallic material, the non-metallic substrate **1** has a high hardness and is difficult to texture. Therefore, when the substrate is subjected to texturing, abnormal protrusions such as fins are difficult to form, with the result that the maximum protrusion height (Rp) is lowered.

[0036] The orientation-determining film **2** is provided for determining the crystalline orientation of the non-magnetic undercoat film **3** formed on the film **2** and for determining the crystalline orientation of the magnetic film **4** formed on the film **3**, to thereby enhance the magnetic anisotropy of the magnetic film **4**. The orientation-determining film **2** determines the crystalline orientation of the non-magnetic undercoat film **3** and the magnetic film **4**, and also functions as a film for forming fine crystal grains; i.e., the film **2** forms fine magnetic grains in the films **3** and **4**.

[0037] The orientation-determining film **2** is preferably formed from a material containing NiP as a primary component. The content of P is 10-40 at %, preferably 15-35 at %.

[0038] The reasons for this are that, when the content of P is less than 10 at %, NiP is susceptible to magnetization. In contrast, when the content of P is in excess of 40 at %, the crystal orientation of the non-magnetic undercoat film **3** and the magnetic film **4** is easily impaired.

[0039] Alternatively, the orientation-determining film **2** is preferably formed from a material containing NiPX (wherein X is one or more species of Cr, Mo, Si, Mn, W, Nb, Ti, and Zr) as a primary component. The content of X is 0-25 at %, preferably 5-25 at %, more preferably 10-25 at %. When the content of X is in excess of 25 at %, the crystalline orientation of the non-magnetic undercoat film **3** and the magnetic film **4** is impaired, and the magnetic anisotropy of the magnetic film **4** is lowered.

[0040] As used herein, the term "primary component" refers to the case in which the content of the component is in excess of 50 at %.

[0041] The thickness of the orientation-determining film **2** is preferably 2-100 nm (20-1,000 Å). When the thickness is below the above range, the magnetic anisotropy of the magnetic film **4** is lowered, whereas when the thickness is in excess of the above range, the orientation-determining film **2** is easily exfoliated and production costs increase, which is unsatisfactory.

[0042] The orientation-determining film **2** may be or may not be subjected to texturing.

[0043] When orientation-determining film **2** is subjected to texturing, texture lines are preferably along the circumferential direction of the substrate.

[0044] The orientation-determining film **2** preferably has an average surface roughness (Ra) of 1 nm or less, from the viewpoint of glide height characteristics.

[0045] The average surface roughness (Ra) of the orientation-determining film **2** is more preferably less than 0.5 nm (5 Å), much more preferably less than 0.3 nm.

[0046] The orientation-determining film **2** is formed from a metallic material which has a relatively low hardness and is easily processed, such as NiPX. Therefore, when the film **2** is subjected to texturing, large protrusions such as fins and burrs are easily produced on the surface of the film, and thus the maximum protrusion height (Rp) tends to increase.

[0047] When the average surface roughness (Ra) of the orientation-determining film **2** is less than 0.5 nm (5 Å), the amount of abraded substance is reduced during texturing, and an increase in the maximum protrusion height (Rp) of the film **2** is prevented. Consequently, the maximum protrusion height (Rp) of the medium can be reduced, and deterioration of the glide height characteristics can be prevented.

[0048] The non-magnetic undercoat film **3** may be formed from conventionally known materials for undercoat film. For example, the film may be formed from an alloy of one or more species of Cr, Ti, Ni, Si, Ta, W, Mo, V, and Nb. Alternatively, the film **3** may be formed from an alloy of one or more of the above elements and other elements, so long as such "other elements" do not impede the crystallinity of the film.

[0049] Particularly, the film **3** is preferably formed from Cr or a Cr alloy (e.g., CrTi, CrW, CrMo, CrV, or CrSi).

[0050] The non-magnetic undercoat film **3** may be of a single-layer structure, or of a multi-layer structure formed of a plurality of films which are of the same composition or of different compositions. The thickness of the non-magnetic undercoat film **3** is 1-100 nm (10-1,000 Å), preferably 2-50 nm (20-500 Å).

[0051] The crystalline orientation of the non-magnetic undercoat film **3** is preferably (002).

[0052] The magnetic film **4** is preferably formed from a material containing Co as a primary component. The material may be, for example, an alloy of Co and one or more species of Cr, Pt, Ta, B, Ti, Ag, Cu, Al, Au, W, Nb, Zr, V, Ni, Fe, and Mo.

[0053] Preferable specific examples of the above material include materials predominantly containing a CoCrTa-, CoCrPt-, CoCrPtB- or CoCrPtTa-based alloy. Of these alloys, in particular, a CoCrPtTa-based alloy is preferably employed.

[0054] The thickness of the magnetic film **4** may be 5-30 nm (50-300 Å).

[0055] The crystalline orientation of the magnetic film **4** is preferably (110).

[0056] The magnetic film **4** may be of a single-layer structure, or of a multi-layer structure formed of a plurality of films which are of the same composition or of different compositions.

[0057] Preferably, a non-magnetic intermediate layer is provided between the non-magnetic undercoat film and the magnetic film, in order to further improve the crystal orientation of the magnetic film and to further enhance the effects of the present invention.

[0058] The non-magnetic intermediate layer may be formed from a CoCr alloy (content of Cr: 20-40 at %).

[0059] The protective film **5** may be formed from conventionally known materials. For example, the film may be formed from a material containing a single component such as carbon, silicon oxide, silicon nitride, or zirconium oxide; or a material predominantly containing such components.

[0060] The thickness of the protective film **5** is preferably 2-10 nm (20-100 Å).

[0061] If necessary, a lubrication film formed from a lubricant such as a fluorine-based liquid lubricant (e.g., perfluoropolyether) may be provided on the protective film **5**.

[0062] In the magnetic recording medium of the present invention, the ratio of a coercive force in a circumferential direction of the medium (Hcc) to a coercive force in a radial direction of the medium (Hcr); i.e., Hcc/Hcr, is 1.1 or more, preferably 1.2 or more.

[0063] When the ratio Hcc/Hcr is below the above range, the magnetic anisotropy a of the magnetic recording medium is insufficient, and magnetic characteristics of the medium, such as thermal stability, are unsatisfactory.

[0064] A first embodiment of the production process for a magnetic recording medium of the present invention will next be described by taking, as an example, production of the aforementioned magnetic recording medium.

[0065] Firstly, the non-metallic substrate **1** is subjected to texturing. Preferably, the substrate **1** is subjected to mechanical texturing by use of lapping tape containing fixed abrasive grains, or by use of free abrasive grains. During texturing, texture lines are preferably formed in the circumferential direction of the substrate.

[0066] The substrate may be subjected to chemical etching after mechanical texturing, in order to remove fine fins, burrs, and the like which are produced on the surface during mechanical texturing, and to obtain excellent surface evenness.

[0067] Subsequently, the orientation-determining film **2** is formed on the non-metallic substrate **1**, to thereby form the medium substrate **6**.

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