

completed this invention.

[0015]

A method of manufacturing a perpendicular magnetic recording medium according to an embodiment of this invention is characterized by forming, over a substrate, a
5 nonmagnetic underlayer having a granular structure in which crystal grains are grown in a columnar shape, and a magnetic recording layer having a granular structure in which magnetic grains are grown in a columnar shape, wherein the underlayer is one of CoCr or CoCrX (X is a nonmagnetic substance), CoCr-oxide, and CoCrX-oxide, and a film forming gas pressure for the
10 underlayer is 4Pa or less. The film forming gas pressure for the underlayer is more preferably 0.5Pa to 2Pa.

[0016]

According to the above-mentioned structure, it is possible to form the underlayer that exhibits a high coercive force even if formed at a low gas
15 pressure and thus it is possible to manufacture a magnetic recording medium that can simultaneously realize an increase in recording density, high impact resistance, and prevention of corrosion.

[0017]

The content of Cr is preferably more than 35at% and not more than
20 55at%. If Cr is 35at% or less, the content of Cr between Co becomes small so that the crystal spacing between Co grains containing Cr is narrowed. Therefore, the magnetic crystal grain spacing of the magnetic recording layer epitaxially formed on such an underlayer is also narrowed. Thus, the interaction between the magnetic crystal grains of the magnetic recording layer
25 increases to degrade the magnetic properties. On the other hand, if more than 55at%, the crystal orientation of CoCr becomes tetragonal to degrade the crystal orientation of the magnetic recording layer so that the orientation of the magnetic recording layer cannot be improved.

[0018]

When the underlayer is CoCrX, X may contain at least one of B, Ru, Ti, V, Cr, Zr, Nb, Mo, Hf, Ta, and W. If such a material is contained in the underlayer, B can facilitate miniaturization and separation, Ru can improve the crystal orientation, and the other materials can facilitate separation of the magnetic grains with respect to the magnetic recording layer.

[0019]

An orientation control layer may be formed on the side closer to the substrate than the underlayer and a second orientation control layer with an amorphous structure containing at least one of C, Mo, Nb, Zr, B, and Ta may be formed between the orientation control layer and the underlayer. This second orientation control layer with the amorphous structure functions as a lattice spacing adjusting layer for slightly blocking lattice spacing chains between the orientation control layer and the underlayer and can improve the crystal orientation of the underlayer.

[0020]

The orientation control layer is preferably NiW, NiCr, CuW, or Ti. These materials each have a hardness higher than Pd often used in conventional orientation control layers and thus improve the impact resistance and, since the texture is dense and the corrosion resistance is high, the corrosion can be easily prevented and, further, since the magnetic properties are not degraded even if heated, a heat treatment can be performed in a manufacturing process.

[0021]

An alternative method of manufacturing a perpendicular magnetic recording medium according to an embodiment of this invention is characterized by comprising forming, over a substrate, an orientation control layer made of Ti and having a hcp structure, a second orientation control layer having an amorphous structure,

a nonmagnetic underlayer made of one of CoCr or CoCrX (X is a nonmagnetic substance), CoCr-oxide, and CoCrX-oxide and having a granular structure in which crystal grains are grown in a columnar shape, the nonmagnetic underlayer formed at a film forming gas pressure of 4Pa or less, and a magnetic recording layer having a granular structure in which magnetic grains are grown in a columnar shape.

[0022]

If the Ti layer and the CoCr underlayer are in direct contact with each other, there is a possibility that the hcp structure of Co crystals is disturbed by the hcp structure of Ti so that the crystal orientation is degraded to reduce the coercive force. However, according to the above-mentioned method, by slightly interposing the second orientation control layer with the amorphous structure therebetween, the second orientation control layer slightly blocks lattice spacing chains between the orientation control layer and the underlayer and thus functions as a lattice spacing adjusting layer so that it is possible to prevent degradation in crystal orientation. Therefore, it is possible to form the underlayer that exhibits a high coercive force even if formed at a low gas pressure and thus it is possible to simultaneously realize an increase in recording density, high impact resistance, and prevention of corrosion.

[0023]

An alternative method of manufacturing a perpendicular magnetic recording medium according to an embodiment of this invention is characterized by forming, over a substrate, an orientation control layer made of NiW and having a fcc structure, a nonmagnetic underlayer made of one of CoCr or CoCrX (X is a nonmagnetic substance), CoCr-oxide, and CoCrX-oxide and having a granular structure in which crystal grains are grown in a columnar shape, the nonmagnetic underlayer formed at a film forming gas pressure of 4Pa or less, and a magnetic recording layer having a granular structure in which magnetic grains are grown

in a columnar shape.

[0024]

Although the lattice spacing chains between the orientation control layer and the underlayer can be blocked by providing a layer with an amorphous structure between the orientation control layer and the underlayer, there is a possibility that the crystal orientation decreases as the thickness of the layer with the amorphous structure increases and, following this, the coercive force decreases. However, if NiW is used as the orientation control layer, NiW has the fcc structure and thus does not disturb the hcp structure of Co crystals. Therefore, according to the above-mentioned method, it is possible to form, without forming the second orientation control layer with the amorphous structure, the underlayer that exhibits a high coercive force even if formed at a low gas pressure and thus it is possible to simultaneously realize an increase in recording density, high impact resistance, and prevention of corrosion.

[0025]

A specific perpendicular magnetic recording medium according to an embodiment of this invention is characterized by comprising, over a substrate, an orientation control layer with a hcp structure, a second orientation control layer with an amorphous structure, an underlayer having a granular structure in which nonmagnetic crystal grains are grown in a columnar shape, and a magnetic recording layer having a granular structure in which magnetic grains are grown in a columnar shape, wherein the orientation control layer is Ti, and the underlayer is one of CoCr or CoCrX (X is a nonmagnetic substance), CoCr-oxide, and CoCrX-oxide. The second orientation control layer preferably has the amorphous structure containing at least one of C, Mo, Nb, Zr, B, and Ta.

[0026]

According to the above-mentioned structure, since the underlayer can be formed at a low gas pressure, it is possible to form the underlayer having a

high film density and adapted to exhibit a high coercive force. Particularly, the second orientation control layer having the amorphous structure slightly blocks lattice spacing chains between the orientation control layer and the underlayer and thus functions as a lattice spacing adjusting layer so that it is possible to improve the crystal orientation of the underlayer. By this, it is possible to simultaneously realize an increase in recording density, high impact resistance, and prevention of corrosion.

[0027]

Another specific perpendicular magnetic recording medium according to an embodiment of this invention is characterized by comprising, over a substrate, an orientation control layer with a fcc structure, an underlayer having a granular structure in which nonmagnetic crystal grains are grown in a columnar shape, and a magnetic recording layer having a granular structure in which magnetic grains are grown in a columnar shape, wherein the orientation control layer is one of NiW, NiCr, and CuW, and the underlayer is CoCr, CoCrX (X is a nonmagnetic substance), CoCr-oxide, or CoCrX-oxide.

[0028]

According to the above-mentioned structure, since the underlayer can be formed at a low gas pressure, it is possible to form the underlayer having a high film density and adapted to exhibit a high coercive force. By this, it is possible to simultaneously realize an increase in recording density, high impact resistance, and prevention of corrosion.

[0029]

When the underlayer is CoCr-oxide or CoCrX-oxide, the oxide preferably contains at least one of SiO_2 , TiO_2 , and Cr_2O_3 . By this, the lattice spacing of the underlayer can be properly adjusted and thus it is possible to improve the crystal orientation of the magnetic recording layer.

[0030]

When the underlayer is CoCr-oxide or CoCrX-oxide, the content of the oxide is preferably 6mol% or less. In other words, since the content of an oxide in the magnetic recording layer can be set to 8 to 15mol%, it is preferable that the oxide content of the underlayer be smaller than that of the magnetic recording layer. Since the underlayer contains more Cr than the magnetic recording layer so as to be nonmagnetic, the lattice spacing therebetween can be decreased by reducing the oxide content.

[0031]

The thickness of the underlayer is preferably 15nm or more. This is because if the thickness of the underlayer is less than 15nm, the coercive force H_c as a whole is extremely reduced. It is to be noted that if the thickness of the underlayer is set to 20nm or more, although the coercive force H_c is not reduced, a further improvement is not observed so much. Therefore, the thickness of the underlayer is more preferably 15 to 20nm.

[0032]

The thickness of the second orientation control layer is preferably 0.5nm or more and 1nm or less. This is because if the thickness is less than 0.5nm, it is extremely difficult to form the film. On the other hand, this is because if the second orientation control layer having the amorphous structure is thicker than 1nm, the second orientation control layer blocks the crystal orientation of the orientation control layer with the fcc structure and thus the crystal orientation of the underlayer decreases to reduce the coercive force H_c .

[0032a]

According to an aspect of this invention, there is provided a perpendicular magnetic recording medium comprising: a substrate, over a main surface of the substrate, a soft magnetic layer or layers; over the soft magnetic layer, a first orientation control layer with a hcp structure and, over the first orientation control layer, a second orientation control layer with an amorphous structure, over the second orientation control layer, an underlayer having a granular structure in which nonmagnetic crystal grains are grown in a columnar shape, and over the underlayer, a magnetic recording layer having a granular structure in which magnetic grains are grown in a columnar shape, wherein said first orientation control layer comprises Ti, said second orientation layer is formed between the first orientation control layer and the under layer and functions as a lattice spacing adjusting layer for blocking lattice spacing chains between the first orientation control layer and the underlayer, and said underlayer comprises one of CoCr or CoCrX (X is a nonmagnetic substance), CoCr-oxide, and CoCrX-oxide.

Effect of the Invention

[0033]

According to this invention, it is possible to form an underlayer that exhibits a high coercive force even if formed at a low gas pressure, and thus can manufacture a magnetic recording medium that can simultaneously realize