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METHOD FOR PREPARING A SUBSTRATE FOR A MAGNETIC DISK

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Background of the Invention

10 This invention relates to substrates for magnetic disks, and methods for coating and texturing (i.e. roughening) such substrates.

15 It is known in the art to use glass substrates for magnetic disks because glass is suitably impact resistant. In other words, a glass substrate will not be deformed if a read-write head strikes the disk. However, because glass is hard and brittle, it is difficult to mechanically texture glass substrates, and instead, they are typically textured with an HF

20 chemical etching process prior to being covered with an underlayer and a magnetic film. See, for example, U.S. Patent 5,087,481, issued to Chen, et al. and U.S. Patent 4,833,001, issued to Kijima, et al., each of which is incorporated herein by

25 reference. (The reason that magnetic disk substrates are textured is to reduce stiction between the magnetic disk and a read-write head during use.) Unfortunately, even chemical texturing of glass substrates is difficult and



expensive, and it is particularly difficult to obtain consistent results with chemical texturing.

5 It is also known in the art to use aluminum substrates covered with plated NiP to manufacture magnetic disks. Of importance, aluminum is a light weight material and NiP can be polished and mechanically textured. Further, the NiP is hard and prevents the aluminum substrate from becoming dented if the read-write head strikes the disk.

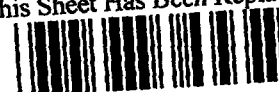
10 (In contrast, it is unnecessary to cover glass substrates with plated NiP because glass is more impact resistant than NiP, and to the best of the present inventor's knowledge, NiP is not plated onto glass substrates in the manufacture of
15 magnetic disks.) Also of importance, NiP lends itself to being mechanically textured.

NiP-coated aluminum substrates are typically prepared by subjecting an aluminum substrate to a zincating process, during which it is immersed in
20 an alkaline zinc immersion bath. Such a process is described at pages 593 to 595 of "Modern Electroplating", edited by Lowenheim, published by John Wiley & Sons, Inc. in 1974, incorporated herein by reference. The zincating process
25 results in formation of a thin Zn layer on the aluminum substrate. The substrate is then plated with NiP by electroless plating. See, for

example, F. Pearlstein, "Electroless Plating",
published at pages 710 to 725 of "Modern
Electroplating", also incorporated herein by
reference. During this process, the Zn layer is
5 consumed and replaced by a NiP layer. The NiP
layer is then polished and mechanically textured.

In recent years, industry has started
experimenting with laser texturing. During laser
texturing, a laser beam is used to form craters in
10 the NiP layer. See, for example, U.S. Patent
5,062,021 and 5,108,781, each issued to Ranjan et
al., incorporated herein by reference. Also see
Baumgart, et al., "Safe Landings: Laser Texturing
of High-Density Magnetic Disks", Data Storage,
15 March 1996, also incorporated herein by reference.
When using this process, the substrate must be
smooth prior to laser texturing.

One advantage of laser texturing is that it
can be used to texture a small portion of the disk
20 surface to form a "take-off and landing zone"
(also called a "contact-start-stop zone" or "CSS
zone") where the read-write head takes off and
lands when the disk drive is turned on and off.
The remainder of the disk (the "data zone") is
25 used to store data. In contrast, it is difficult
to limit texturing to a take-off and landing zone



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with the above-described HF chemical etching process.

It has previously been difficult to use a laser to texture a magnetic disk with a glass substrate because laser light having wavelengths normally used to texture disks is not readily absorbed by a glass substrate. One has to use a relatively powerful laser that produces a longer wavelength, e.g. a CO₂ laser, to texture glass.

See, for example, Teng, et al., "Laser Zone Texture on Alternative Substrate Disks", published at the 1996 Intermag Conference, incorporated herein by reference. It would be desirable to be able to laser texture a glass substrate instead of the above-mentioned chemical etching techniques.

Summary

A method in accordance with our invention comprises the step of depositing a smooth metallic layer on a glass substrate and texturing the metallic layer with a laser beam. The metallic layer is preferably impact resistant, hard and has a high melting temperature (e.g. greater than 1000°C), or for the case of an amorphous metallic layer, a high glass transition temperature (e.g., greater than 500°C).

In a first embodiment, a metallic initiation layer is deposited on the glass substrate followed



by electroless plating of NiP onto the initiation layer. The initiation layer is a material which facilitates electroless plating of NiP, such as Zn, Pd, Co, Fe, Rh, Be, NiP, Ni or alloys thereof.

5 The initiation layer is formed because it is not possible to electroless plate NiP directly onto glass. After electroless plating, the NiP layer is then polished and laser textured.

During one process in accordance with the
10 first embodiment, the initiation layer is a thin Zn layer, and is formed by a zincating process. During this process, Al is deposited on the glass substrate, e.g. by sputtering, evaporation or other method. Thereafter, the substrate is
15 subjected to the zincating process to form the Zn layer on the Al layer (the Al layer is typically either partly or completely consumed during the zincating process). A NiP layer is then plated onto the thin Zn layer, e.g. by electroless
20 plating. The NiP layer is then polished and laser textured. Of importance, the thin Zn layer facilitates electroless plating of NiP, and the Al layer facilitates the formation of the Zn layer by the zincating process. (The zincating process
25 does not work on bare glass.) In lieu of Al, other materials which can be subjected to a zincating process, e.g. Mg, can be used.



5 In one variation of the first embodiment, an
adhesion layer is deposited, e.g. by sputtering,
on the glass substrate prior to depositing the Al
layer. The adhesion layer causes the Al layer to
strongly adhere to the substrate. The adhesion
layer is typically Cr, Ta, Mo, W, V, Nb or alloys
thereof.

10 In a second embodiment, instead of using a Zn
layer formed by the zincating process as the
initiation layer, the initiation layer is formed
on the substrate (or adhesion layer) by another
process, e.g. sputtering or evaporation. The NiP
layer is then formed on the substrate by
15 electroless plating. The NiP layer is then
polished and laser textured. The advantage of
forming the initiation layer in this manner is
that it obviates the need for the zincating and
other pretreatment steps. (In conventional
production of NiP plated aluminum substrates,
20 prior to NiP plating, the aluminum substrate is
etched, subjected to a first zincating step to
form a Zn layer, the Zn layer is stripped off, the
substrate is subjected to a second zincating step,
and the resulting Zn layer is stripped off. The
25 substrate is then subjected to a third zincating
step. The etching, first and second zincating

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steps, and stripping steps are referred to herein as "pretreatment".)

Plating NiP onto a glass substrate and then laser texturing the NiP has numerous advantages. First, it is difficult to laser texture a glass substrate because glass is not very absorptive of laser light having wavelengths normally used to texture magnetic disks. One needs a powerful laser which produces light having longer wavelengths, e.g. a CO₂ laser, to texture uncoated glass. In contrast, it is relatively easy to texture a NiP layer because NiP readily absorbs laser light produced by common lasers such as YLF or vanadate lasers.

Second, when laser texturing a substrate, it is necessary that the substrate be smooth and polished. It is difficult and expensive to polish a glass substrate because glass is hard and brittle. We have discovered that the process of the first and second embodiments do not require that the glass substrate be polished. Rather, one can simply plate NiP onto a glass substrate and then polish the NiP layer, which is easier and less expensive than polishing the glass substrate.

Third, it is very easy to zone texture a substrate by laser texturing, whereas it is

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difficult or impractical to zone texture a glass substrate by chemical etching.

5 Fourth, glass used to manufacture magnetic disks typically has corrosive constituents such as Na. The Na can diffuse out of the substrate and promote corrosion of the magnetic layer. During a process in accordance with our invention, the glass substrate is essentially encapsulated by NiP, and Na and other impurities cannot reach and
10 corrode the magnetic layer.

Fifth, plated glass substrates have better impact resistance than commonly used plated aluminum substrates.

15 Of importance, most disks are manufactured using an aluminum substrate that is subjected to the zincating process and then plated with NiP. A glass substrate with a thin Zn layer can be processed into a completed magnetic disk without deviating from manufacturing processes already
20 established for conventional aluminum substrate magnetic disks.

In accordance with a third embodiment of our invention, a layer of material is deposited on a glass substrate (e.g. by sputtering, evaporation
25 or other technique) and then the layer of material is laser textured. The layer of material subjected to laser texturing is capable of

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absorbing light having the wavelength of the laser used during laser texturing. In addition, the layer of material has good impact resistance and hardness. In one embodiment, the layer of material subjected to laser texturing is

5 amorphous, e.g. an alloy comprising at least one of Ni, Pd, Pt, Re and Fe and at least one of Nb, Ta, Zr, Ti, W and V. The layer of material can also be an alloy comprising at least one of Ni, 10 Co, Fe and Mo and at least one of P, B, Se and Sb.

In another embodiment, the layer of material is a crystalline material having a high melting point such as a Co or Ni based alloy, or a silicide of Ni, Nb and Pt.

15 In accordance with one variation of the third embodiment, an adhesion layer such as sputtered Cr is formed between the substrate and the laser textured material.

The third embodiment enjoys many of the same 20 advantages of the first and second embodiments, except that it is preferable that the glass substrate be polished and initially smooth before depositing layers thereon.

The third embodiment has the advantage in 25 that sputtering is a low cost, clean, fast process. In the third embodiment, plating is avoided.

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The third embodiment also permits a wider range of laser bump shapes to be provided than can be provided in a layer of plated NiP. For example, one can make "sombbrero" bumps over a wider range of laser texturing conditions than the plated NiP, depending on the material used.

In another variation of the third embodiment, the layer of material subjected to laser texturing comprises sputtered NiNb. The NiNb can be 50% by mole Ni and 50% Nb, but other compositions, including compositions with additives, may also be used. Of importance, NiNb has the following advantages:

- a) It is hard; so it is unlikely to deform if the disk impacts a read-write head.
- b) NiNb resists corrosion.
- c) NiNb is amorphous, and forms laser bumps having regular shapes.
- d) NiNb does not "splatter" when textured with a laser pulse.
- e) NiNb does not easily crack or burn through when textured with a laser pulse;
- f) One can form laser texture features having good shapes even when the NiNb is relatively thin.

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g) The height of the NiNb texture feature .
does not change too much if the laser
power varies. (This makes it easier to
control the texture features during
manufacturing.)

h) NiNb strongly adheres to glass without
the need for a separate adhesion layer.

It is desirable to deposit the layer of
material to be laser textured such that it has a
smooth surface. However, in one embodiment, this
layer has a small amount of roughness to lower
stiction and friction in case the read write head
inadvertently touches down in the data zone.

A substrate used with a process in accordance
with our invention is typically a chemically
strengthened glass substrate, such as a
borosilicate glass. The glass substrates
discussed in the above-incorporated Kijima and
Chen patents can be used. Alternatively, other
substrate materials such as glass ceramic, SiC,
sintered carbon or Si can be used.

Brief Description of the Drawings

Figs. 1a and 1b illustrate in cross section a
magnetic disk having a glass substrate during a
manufacturing process in accordance with a first
embodiment of our invention.

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Fig. 1c illustrates in cross section the magnetic disk of Figs. 1a and 1b at the conclusion of manufacturing.

5 Figs. 2a and 2b illustrate laser bumps formed in a plated NiP layer in accordance with our invention.

10 Fig. 3 illustrates in cross section a magnetic disk having a glass substrate during a manufacturing process in accordance with a second embodiment of our invention.

Fig. 4 illustrates in cross section a magnetic disk having a glass substrate constructed in accordance with a third embodiment of our invention.

15 Fig. 5 illustrates laser bumps formed in a NiNb layer formed on a glass substrate in accordance with our invention.

20 Fig. 6 illustrates a "sombbrero" shaped bump formed by a laser in a sputtered NiP layer (15.5 wt. % P).

Fig. 7 illustrates a "ridge" shaped bump formed by a laser in a sputtered NiP layer (15.5 wt. % P).

25 Fig. 8 illustrates the relationship between the thickness of a NiNb layer and the energy required to burn through the NiNb layer.

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Fig. 9 illustrates the relationship between bump height and laser pulse energy for various texture layer materials.

5 Fig. 10 compares the impact resistance of disks comprising Al substrates covered with plated NiP and disks comprising glass substrates.

Fig. 11 schematically illustrates a magnetic disk drive incorporating a disk in accordance with our invention.

10

Detailed Description

First Embodiment Using a Plating Process

15 Referring to Fig. 1a, a disk 110 includes a glass substrate 112, a Cr adhesion layer 114 and an Al layer 116. Substrate 112 is typically chemically strengthened borosilicate or aluminosilicate glass. Cr adhesion layer 114 is typically 5 to 50 nm thick (in one embodiment it is 20 nm thick) and is formed by sputtering at a
20 rate of 4 nm/second at a power of 1 kw and a pressure of 6.5 mtorr in argon. In one embodiment, an Intevac 250A sputtering system (manufactured by Intevac of Santa Clara, CA) is
25 used to D.C. magnetron sputter layers 114 and 116. Al layer 116 is typically 50 to 500 nm thick (in one embodiment 200 nm thick) and is also formed by

5 sputtering, at a rate of 6.3 nm/second at a power of 1 kw and a pressure of 10 mtorr in argon. Cr layer 114 is optional, and is provided to ensure that subsequently deposited layers strongly adhere to glass substrate 112. Al layer 116 facilitates a subsequent zincating process.

10 Referring to Fig. 1b, disk 110 is subjected to a zincating process, e.g. as described in the above-incorporated Lowenheim reference, to form a Zn initiation layer 117. Zn initiation layer 117 is typically about 5 to 10 nm thick. During this process, Al layer 116 is partially or completely consumed, depending on its thickness.

15 In one embodiment, the substrate is subjected to a first zincating process, the resulting Zn layer is stripped off by dilute nitric and sulfuric acids, the substrate is subjected to a second zincating process, the resulting Zn layer is stripped off, and then the substrate is
20 subjected to a third zincating process. These process steps result in formation of an improved NiP film (formed in a subsequent plating process, described below) with a finer NiP nodule structure, and a smoother NiP surface, but it is
25 not presently clear why this is. In other embodiments, the zincating process is only

performed twice. In yet other embodiments, the zincating process is only performed once.

5 Referring to Fig. 1c, NiP layer 118 is deposited to a thickness between 5 and 10 microns, and typically about 8 microns, by electroless plating. NiP plating is discussed by Pearlstein, "Electroless Plating", which is chapter 31 of the third edition of "Modern Electroplating", edited by Lowenheim, published by Wiley in 1974,
10 incorporated herein by reference. During NiP plating, Zn layer 117 is consumed. (Of importance, electroless plating of NiP is an autocatalytic process. Zn layer 117 initiates that process.)

15 NiP layer 118 is then polished using conventional techniques and laser textured to form bumps B. Laser texturing can be accomplished using an yttrium vanadate laser, available from Spectra Physics Corporation. Such a laser
20 typically produces pulses at a frequency of 5 KHz having a duration of about 10 to 70 nanoseconds ("ns"), a spot size of 6 to 11 microns, delivering 0.06 to 3 microjoules per pulse and a wavelength of 1.064 microns. Alternatively, an yttrium
25 lutetium fluoride ("YLF") laser, manufactured by Schwartz Electro Optics Co., with a wave length of 1.047 microns, 0.3 to 15 microjoules per pulse, a



spot size of 6 to 11 microns, a pulse rate of 70 .
KHz, and a pulse duration of 200 to 300 ns can be
used. However, other types of lasers can be used
to texture a disk in accordance with our
invention.

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While the laser is pointed at the NiP film,
the substrate is rotated, so that each pulse forms
a bump at a different position on the disk. The
amount of energy delivered during each pulse, the
pulse duration and spot size are selected to
provide bumps having a desired size and profile.
Fig. 2a illustrates a series of laser bumps formed
on a plated NiP layer on a glass substrate. The
substrate included a 20 nm thick Cr layer and a
200 nm thick Al layer. A sacrificial Zn layer was
formed by a zincating process, and the NiP was
plated thereon. The laser bumps were formed in a
series, each group of bumps in the series labeled
from 1 to 19 in Fig. 2a. Laser pulses at 2.86
microjoules of energy were used to form group 1.
The spot size was 11 microns, and the laser pulse
duration was 25 ns.

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The power used to form the bumps in group 2
was 5% greater than the power used to form the
bumps in group 1, the power used to form the bumps
in group 3 was 5% greater than the power used to
form the bumps in group 2, and so forth. As can

be seen, one can alter the size and profile of the laser bumps by adjusting the power of the laser beam used to form the bumps. In one embodiment, the energy used to form laser bumps is between 2 and 6 microjoules, the pulse duration is between 14 and 40 ns, and the spot size is between 6 and 11 microns. However, our invention is not limited to the specific parameters used to form bumps, and those skilled in the art will be able to select laser parameters to tailor bump sizes and profiles to suit their requirements.

The bump shapes in Fig. 2a are generally "sombrero" shaped. Laser pulses typically form either a sombrero shape (e.g. as shown in Fig. 6) or a ridge shape (Fig. 7). In a plated NiP layer, one can form sombrero shaped bumps, as shown in Fig. 2a and 6, or ridge shaped bumps, as shown in Fig. 2b and 7. (The bumps of Figs. 6 and 7 were formed in layers of sputtered NiP. Laser texturing of sputtered NiP layers is discussed below.) Sombreros can be formed in plated NiP using short pulses (e.g. less than about 30 ns) combined with wide spot sizes (e.g. greater than about 10 microns). Ridge shapes predominate under other conditions. Fig. 2b shows a set of ridge shaped bumps formed in plated NiP. The NiP was formed on a glass substrate covered with 20 nm

thick Cr and 200 nm thick Al. The Al was
subjected to a zincating step and electroless
plating of NiP. The bumps in Fig. 2b are arranged
in rows labeled 21 to 39. The bumps were formed
5 using 40 ns laser pulses and a spot size of 8
microns. The spots in row 21 were formed with
pulses of 0.77 microjoules. The pulses in row 22
had 10% more energy than those of row 21, the
pulses of row 23 had 10% more energy than those of
10 row 22, and so forth. As can be seen, the Fig. 2b
bumps are ridge shaped.

Our invention encompasses both ridge and
sombbrero bumps. In the case of either type of
bump, the bump height increases with increased
15 laser power. For either type of bump, the laser
power must be sufficient to melt the NiP. The
laser power should not be so great as to burn
through the NiP.

After texturing, disk 110 is then completed
20 by a conventional process, e.g. sputtering a non-
ferromagnetic underlayer such as a NiP or Cr
underlayer 120, a magnetic layer 122 and a
protective overcoat 124. See, for example, U.S.
Patent 5,180,640, issued to Yamashita,
25 incorporated herein by reference.

In one embodiment, underlayer 120 is Cr and
magnetic layer 122 is an alloy such as CoCrTa



deposited at a relatively high sputtering rate
(e.g. about 10 nm/second). The substrate is
heated to about 200°C during sputtering. Cr
underlayer 120 is used to control the
5 magnetization direction of magnetic layer 122.

The present invention can also be used in a
sputtering process in which the substrate is not
heated. In one example of such a process,
underlayer 120 includes a mixture of NiP and about
10 2% Al₂O₃, and magnetic layer 122 comprises
CoNiPtTiTa and a small amount of SiO₂, sputtered
at a relatively slow rate (e.g. less than 0.5
nm/second). (See, for example, U.S. Patent
Application Serial No. 08/286,653, filed by Chen,
15 et al., assigned to Komag, Inc., incorporated
herein by reference.) However, our invention is
not limited to the specific materials used in the
underlayer or magnetic layer, nor is our invention
limited to the specific deposition methods or
20 conditions.

For example, in lieu of sputtered NiP, other
sputtered underlayer materials can be used, e.g.
as described in U.S. Patent 4,786,564,
incorporated herein by reference.

25 In lieu of Cr as adhesion layer 114, other
materials can be used, e.g. Ta, Mo, W, V or Nb, or

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alloys thereof. Alternatively, adhesion layer 114 can be omitted.

5 In lieu of Al layer 116, other materials that can be subjected to a zincating process can be used, e.g. Mg or alloys of Al or Mg.

In lieu of plated NiP, other materials can be plated onto the substrate for laser texturing, e.g. CoP or FeP.

10 In lieu of borosilicate or aluminosilicate glass, other glass compositions or materials such as silicon, SiC, ceramic, glass ceramic, or sintered carbon can be used as substrate 112.

15 As mentioned above, a substrate in accordance with this embodiment need not be extremely smooth. Instead, one can use an unpolished glass substrate, plate NiP thereon, and polish the NiP. In one embodiment, the glass substrate has a roughness Ra greater than 50Å as measured by an atomic force microscope. In another embodiment,
20 the glass substrate has a roughness Ra greater than 100Å, and in one embodiment, greater than 200Å. The glass substrate Ra is typically less than about 10% of the thickness of the NiP formed on the disk.

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Second Embodiment Using a Plating Process

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Fig. 3 illustrates a magnetic disk 150 during a manufacturing process in accordance with a second embodiment of our invention, including glass substrate 112 and optional Cr adhesion layer 114 as discussed above. However, in the embodiment of Fig. 3, a Zn initiation layer 115 is formed by a vacuum deposition process such as sputtering. When formed by sputtering, Zn layer 115 can be sputtered at a rate of 24 nm/second at a power of 1 kw and a pressure of 10 mtorr in argon. Zn layer 115 is typically 60 nm thick.

Thereafter, NiP layer 118 is electroless plated onto Zn initiation layer 115, and is then polished and laser textured. (Zn layer 115 is either partially or completely consumed during NiP plating.) Manufacture of the disk is then completed by deposition of underlayer 120, magnetic layer 122 and protective overcoat 124 as discussed above in relation to Fig 1c.

In lieu of Zn, other materials capable of initiating electroless plating can be used, e.g. Pd, Co, Fe, Rh, Be, NiP, Ni and alloys thereof. Such materials can be vacuum-deposited (e.g., by sputtering) either onto adhesion layer 114, or directly onto substrate 112:



Third Embodiment Using a Vacuum Deposited Texture Layer

Referring to Fig. 4, in another embodiment of our invention, instead of using electroless plated NiP, a NiNb layer 119 (e.g. 50% Ni, 50% Nb by mole) is vacuum-deposited onto adhesion layer 114, e.g. to a thickness of 50 to 500 nm. In one embodiment, NiNb is deposited by sputtering. NiNb is amorphous and does not tend to crystallize. We have discovered that texture bumps can be formed in NiNb having a height of 20 to 30 nm. Even for NiNb films 100 nm thick, We have found that texture bumps of 20 to 25 nm can be formed.

In one embodiment, laser texturing is accomplished using a vanadate laser, a laser pulse duration of 14 to 260 ns, an energy per pulse of 0.1 to 10 microjoules, and a spot size of 6 to 11 microns.

Fig. 5 illustrates a series of laser bumps labeled 41 to 59 formed in a 500 nm thick sputtered NiNb film in accordance with our invention. The laser was the same as that used to form the bumps in Figs. 2a and 2b. The substrate included a 25 nm thick Cr layer. The energy used to form the bumps in group 41 was 1.44 microjoules, with each succeeding group of bumps formed with 10% more energy.



We have found that NiAl forms sombrero bumps for pulse durations of 14 to 270 ns and spot sizes of 4 to 11 microns. The height of the sombrero bumps increases with laser power. (The sombrero bumps formed in NiAl differ from sombrero bumps formed in other materials in the following respects. First, sombrero bumps generally have a depression surrounding a hill. The sombrero bumps in NiAl have a much less pronounced depression than other sombrero bumps. Second, sombrero texture features are generally "volume-conserving," i.e., the amount of material that forms the hill in a sombrero is usually substantially equal to the amount of material taken out of the depression. The sombrero bumps formed in NiAl are typically not "volume-conserving.")

Once again, it is seen that the size and profile of the laser bumps can be controlled by adjusting the laser pulse duration and laser power. One skilled in the art, in light of this specification, can select those parameters which will produce texture bumps as required. However, laser power should not be so great as to burn through the NiAl layer. Fig. 9 shows the relationship between laser layer thickness (the x-axis of Fig. 10) and the amount of energy per



pulse required to burn through a NiNb layer (the Y axis of Fig. 10).

In Fig. 8, the NiNb layer was sputtered onto a 25 nm Cr layer formed on a glass substrate. The spot size and pulse duration of the laser pulse used to collect the data of Fig. 8 were as follows:

<u>Curve in Fig. 8</u>	<u>Pulse Duration</u>	<u>Spot Size</u>
60	14 ns	6 microns
61	14 ns	11 microns
62	270 ns	6 microns
63	270 ns	11 microns

As can be seen, the thicker the layer being textured, the greater the energy needed to burn therethrough.

After texturing, the disk is completed by forming underlayer 120, magnetic layer 122 and protective overcoat 124 as discussed above.

In another embodiment, NiNb is sputtered directly onto substrate 112.

As stated above, we have discovered that NiNb has a unique combination of characteristics that make it superior to other materials. It is hard, it resists cracking and burn-through during laser texturing, it resists corrosion and adheres strongly to glass. One can form excellent texture features with NiNb even when the NiNb is thin (e.g. 100 to 150 nm thick). The laser

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bump height does not change too much if laser power varies, so it is easy to control disk manufacturing processes if NiNb is used. Also, NiNb produces excellent, reproducible texture features without

5 "splats".

In one embodiment, the Nb content of the NiNb film is between 16 and 60 at. %. The Ni content is between 84 and 40%. In another embodiment, the Nb content is between 45 and 55 at. %, and the Ni content is between
10 55 and 45 at. %. (If the Nb content is too high, the bumps will be too low. If the Nb content is too low, the bump heights in the NiNb film will be too sensitive to variations in laser power.)

In lieu of NiNb, other materials can also be used,
15 e.g. alloys having a first constituent comprising one of Ni, Pd, Pt, Re and Fe and a second constituent comprising one of Nb, Ta, Zr, Ti, W and V. Such a material should be hard and have good impact resistance. When sputtered, these materials tend to
20 deposit in amorphous form.

In another embodiment, an alloy having a first constituent comprising one of Ni, Co, Fe and Mo and a second constituent comprising one of P, B, Se and Sb can be used. Such alloys are also sputter deposited in
25 amorphous form.

In another embodiment, a crystalline film having a high melting point can be used, e.g. Co and Ni based



alloys. Silicides such as silicides of Ni, Nb and Pt .
can be used.

Preferably, a texture layer (such as NiNb or the
materials listed above) in accordance with this

5 embodiment has a thickness between 10 and 1000 nm.

Thinner layers are preferable for economic reasons.

Sputtering can be by DC magnetron, RF or RF magnetron
sputtering at high rates (e.g. 2 to 20 nm/seconds) and
low pressures (1 to 20 mtorr). The texture layer

10 should be smooth prior to laser texturing. This is
important because texturing is typically only performed
in the CSS zone, and the data zone of the disk should
remain smooth.

15 Other Examples

Example 1

Substrates were prepared by depositing 20 nm
thick Cr on a borosilicate glass substrate. An
amorphous NiP layer having a thicknesses of 1
20 micron was sputtered onto the Cr layer, and laser
textured. The laser energy was between 0.1 and
2.63 microjoules per pulse, each pulse lasting 14
ns. The spot size was 11 microns.

Fig. 6 shows a sombrero bump formed in a 1
25 micron thick layer of NiP (15.5 wt. % P) sputtered
onto a 80 nm Cr layer, which was sputtered onto a
glass substrate. The pulse duration was 14 ns,



and the spot size was 11 microns. The pulse energy was 0.59 microjoules.

Fig. 7 shows a ridge bump, also formed in a layer of 1 micron thick NiP (15.5 wt. % P) sputtered onto 80 nm Cr, which was sputtered onto a glass substrate. The pulse duration was 14 ns and the spot size was 11 microns. The pulse energy was 0.94 microjoules. It is thus seen that for the case of a 14 ns pulse duration and an 11 micron spot size, one can form either ridge or sombrero bumps in sputtered NiP, depending on the laser pulse energy.

Example 2

A substrate was prepared by depositing 20 nm thick Cr as a borosilicate glass substrate. Amorphous NiNb layers having thicknesses of 100 nm, 500 nm and 1 micron were sputtered on the Cr layer and laser textured. The NiNb was 50% Ni by mole. Laser pulses of 0.5 to 13 microjoules, 25 to 264 ns in duration, and spot sizes of 6 to 11 microns were used. Sombrero shaped bumps were formed under all conditions, but size and height increased with power. By reducing film thickness, one could use less power to make bumps of a given size. If laser power was too great, the laser would burn through the NiNb film. The thinner the



5 film, the less energy was needed to burn through the NiNb. Also, the smaller the spot size, the less energy was needed to burn through the NiNb. However, this is not a problem, because texture bumps having heights between 0 and 100 nm can be formed using laser power that was not so great as to burn through the NiNb.

Example 3

10 A substrate was prepared by depositing 20 nm thick Cr on a borosilicate substrate. Crystalline NiAl layers having thicknesses of 100 nm, 500 nm and 1 micron were sputtered on the Cr layer and laser textured. The NiAl was a 50% Ni by mole.
15 Laser pulse energy of 0.93 to 6.3 microjoules, a pulse duration of 25 ns and a 10 micron spot size were used. Sombrero bumps tended to form in NiAl films having thicknesses of 100 nm and 500 nm. Ridge bumps tended to form in the 1 micron thick
20 NiAl film.

NiAl films cracked for laser powers above 1.0, 3.6 and 4.0 microjoules for NiAl thicknesses of 100, 500 and 1000 nm, respectively (for pulses of 25 ns duration and a 10 micron spot size).
25 Cracking is undesirable, and is believed to be due to film stress. It is further believed that film

stress (and therefore cracking) can be avoided by adjusting sputter conditions of the NiAl.

Other Examples

5 In one embodiment, a 100 to 500 nm thick magnetic (CoNiPtTaTiSiO₂) is sputtered onto a 25 nm thick Cr adhesion layer which in turn sputtered onto a glass substrate. The CoNiPtTaTiSiO₂ layer is then laser textured.

10 In another embodiment, a 100 to 500 nm thick Cu layer was deposited on a Ta adhesion layer which in turn was sputtered on a glass substrate. The Cu was then laser textured.

15 In another embodiment, a 130 nm thick NiSi (81 at. % Ni, 19 at. % Si) layer was sputtered onto a glass substrate and then laser textured.

20 In another embodiment, 100 to 500 nm thick Cr is sputtered onto a glass substrate and laser textured. (Although one can form bumps on Cr, the bumps tend to be small. At higher laser power, the Cr tends to crack or burn through.)

In another embodiment, 125 to 600 nm thick Ta is sputtered onto a glass substrate and then laser textured.

25 In another embodiment, 100 to 500 nm thick Al is sputtered onto a Ta adhesion layer. The Al is then laser textured. (Although one can form texture features in Al, Al is relatively soft, and



therefore other harder materials may be more desirable.)

Although different metallic materials can be used in our invention, we have found that the combination of qualities found in NiNb is superior. For example, NiNb is harder than Al, more corrosion-resistant than Cu, does not burn through as readily as Cr, and forms better texture feature shapes than Ta.

Bump Height Variation as a Function of Laser Energy

As mentioned above, bump heights increase with increases in laser energy. It is generally desirable that for the material and laser parameters being used, the bump height not vary by more than 1 nm per 1% fluctuation in laser power.

This is because laser power for typical lasers fluctuates during use, and it is desirable to minimize the resulting bump height variation. Fig. 9 illustrates the relationship between bump height and laser pulse energy for NiP-plated Al (curve 80), 100 nm thick NiNb sputtered onto 25 nm thick Cr sputtered onto glass (curve 81), and 100 nm thick CoNiPtTaTiSiO₂ sputtered onto 25 nm thick Cr sputtered onto glass (curve 82). (CoNiPtTaTiSiO₂ is a magnetic alloy, and would

generally be undesirable as a texture layer for .
that reason.) The Y axis of Fig. 9 is in
nanometers, while the X axis represents laser
pulse energy in microjoules. In curve 81, the
5 slope is generally less than 1 nm per 1% change in
pulse energy. In curve 82, for pulses less than 1
microjoule, the slope is also less than 1 nm per
1% change in pulse energy for curve 80, operating
near the top of curve 80 provides the benefit of
10 near insensitivity to laser pulse energy
fluctuations. (Operating near the top of curve 80
also prevents the bump heights from being chosen
arbitrarily as it can be in curves 81 and 82).
The bumps in Fig. 9 had the following shapes:

- 15 80 sombreros
 81 ridges
 82 sombreros

Impact Resistance

20 As demonstrated above, a laser can be used to
texture a metallic film on a glass substrate. One
advantage of this method is that glass substrates
exhibit greater impact resistance than NiP-plated
aluminum. Fig. 10 shows the force needed to dent
25 substrates having the following structures:

1. An aluminum substrate plated with 8
micron thick NiP (labeled "NiP/Al" in Fig. 10);

2. Glass covered with 20 nm thick Cr
(labeled "G/Cr" in Fig. 10);

3. Glass covered with 1 micron thick NiAl
(labeled "G/NiAl" in Fig. 10); and

5 4. Glass covered with 20 nm thick Cr, 200
nm thick Al (subjected to a zincating process),
and 8 nm thick NiP (labeled "G/Cr/Al/NiP" in Fig.
10).

10 During the test corresponding to Fig. 10, a
disk with a 50% slider resting thereon was
accelerated and then suddenly stopped. (The term
"50% slider" is well known in the art, and refers
to the size of the slider.) Since the disk
rapidly decelerated, the slider resting on the
15 disk was rapidly decelerated by the force exerted
by the disk surface against the slider. This
force was measured in "G's", and is set forth on
the Y axis of Fig. 10. (1 G is the force that
decelerates an object 9.8 meters per second
20 squared, i.e. the force of gravity.) This test
can be used to simulate the force exerted on a
disk and slider if one inadvertently drops a disk
drive on the floor. The X's in Fig. 10 indicate
those test trials which resulted in unacceptable
25 dents in the disk surface. The diamond marks
indicate those test trials which did not result in
unacceptable dents in the disk surface.



As can be seen, it took 180 G's to dent the NiP-plated aluminum substrate, and about 250 G's to dent the glass substrates. Thus, glass substrates are more impact resistant than NiP-plated Al.

Industrial Application

Fig. 11 illustrates a magnetic disk drive 100 including a magnetic disk 102 constructed in accordance with our invention. Disk 102 is coupled to a motor 104 for rotating disk 102. In one embodiment, disk 102 rotates at a speed between 5000 and 10,000 rpm. A pair of read-write heads 106a, 106b are mounted on arms 108a, 108b, which in turn are moved by actuators (not shown) for positioning heads 106a, 106b over selected data tracks on disk 102.

Heads 106a, 106b "fly" over disk 102 during use. Heads 106a, 106b may be inductive read-write heads or magneto-resistive read-write heads.

In alternative embodiments disk drive 100 may contain several magnetic disks. The components of disk drive 100 are all conventional except for disk 102. Details concerning disk drives are discussed in U.S. Patents 4,949,202 (Kim); 5,025,335 (Stefansky); and 5,027,241 (Hitachi), each of which is incorporated herein by reference.

While the invention has been described with respect to specific embodiments, those skilled in the art will recognize that changes can be made in form and detail without departing from the spirit and scope of the invention. For example, the present invention can be used in accordance with non-metallic substrates or non-conductive substrates other than glass. See, for example, Perettie, "Alternative Substrates: The Critical Issues", IDEMA Insight, November/December 1995, incorporated herein by reference. In addition, the various layers on the disk can be formed by any of several methods, e.g. sputtering, evaporation, etc. The invention is not limited by deposition parameters, such as pressures and deposition rates. The invention can be used to zone texture a magnetic disk, or to texture the entire surface of a magnetic disk. In the alternative, the invention can be used to form a rough texture having large bumps in CSS zone and a smoother texture having small bumps in a data zone. Although the invention can be practiced with metallic texture layers having a high melting point, the present invention can be practiced with other laser texture layer materials such as Al or



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Cu. Accordingly, all such changes come within
the present invention.

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We claim:

1. A method for making a magnetic disk
comprising the steps of:

5 depositing a texture layer on a glass or
glass ceramic substrate;
laser texturing said texture layer; and
depositing an underlayer, magnetic layer and
protective overcoat on said texture layer.

10 2. Method of claim 1 wherein said texture
layer is metallic.

15 3. Method of claim 2 wherein said texture
layer is formed by electroless plating.

4. Method of claim 3 further comprising the
step of depositing an initiation layer on said
substrate, said initiation layer initiating
electroless plating of said texture layer onto
20 said substrate.

25 5. Method of claim 4 wherein said
initiation layer comprises a material selected
from the group consisting of Zn, Pd, Co, Fe, Rh,
Be, NiP and Ni.

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6. Method of claim 5 wherein said initiation layer is an alloy of at least one material selected from the group consisting of Zn, Pd, Co, Fe, Rh, Be, NiP and Ni.

5

7. Method of claim 4 wherein said initiation layer is formed by vacuum deposition.

10

8. Method of claim 7 wherein said initiation layer is formed by sputtering.

15

9. Method of claim 4 wherein said initiation layer comprises Zn, and said step of depositing said initiation layer comprises the steps of:

depositing a metallic layer on said substrate; and

20

subjecting said substrate to a zincating process, whereby said metallic layer is at least partially consumed.

25

10. Method of claim 9 wherein said metallic layer comprises a material selected from the group consisting of Al, Mg, Al alloys and Mg alloys.

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11. Method of claim 1 further comprising the step of forming an adhesion layer between said substrate and said texture layer.

5 12. Method of claim 1 wherein said texture layer is formed by vacuum deposition.

10 13. Method of claim 12 wherein said texture layer is an alloy comprising a first material selected from the group consisting of Ni, Pd, Pt, Re and Fe and a second material selected from the group consisting of Nb, Ta, Zr, Ti, W and V.

15 14. Method of claim 12 wherein said texture layer is an alloy comprising a first material selected from the group consisting of Ni, Co, Fe and Mo and a second material selected from the group consisting of P, B, Se and Sb.

20 15. Method of claim 12 wherein said texture layer is a Co or Ni based alloy.

25 16. Method of claim 12 wherein said texture layer is a silicide of a material selected from the group consisting of Ni, Nb and Pt.





17. The magnetic disk manufactured by the method of claim 1.

18. A method for manufacturing a magnetic disk comprising the steps of:

depositing a metallic initiation layer onto a glass or glass ceramic substrate;

electroless plating a NiP layer onto said substrate after said step of depositing said metallic initiation layer, said initiation layer initiating said electroless plating of NiP;

laser texturing said NiP layer; and

depositing an underlayer, magnetic layer and protective overcoat onto said NiP layer after said step of laser texturing.

19. Method of claim 18 further comprising the step of forming an adhesion layer between said substrate and initiation layer, said adhesion layer comprising a material selected from the group of materials consisting of Cr, Ta, Mo, W, V and Nb, said underlayer comprising a sputtered material selected from the group consisting of NiP and Cr.

20. A method for manufacturing a magnetic disk comprising:

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depositing an initiation layer on a
glass or glass ceramic substrate;

electroless plating a layer on said
initiation layer; and

5 depositing an underlayer, magnetic layer
and protective overcoat on said electroless plated
layer.

10 21. Method of Claim 20 wherein said
electroless plated layer comprises NiP, said
method further comprising the step of laser
texturing said NiP layer, depositing said
underlayer on said NiP layer, and depositing said
magnetic layer on said underlayer.

15 22. Method for manufacturing a magnetic disk
comprising the steps of providing a substrate;
providing a layer comprising Ni and Nb
on the substrate; and
20 laser texturing the layer comprising Ni
and Nb.

25 23. Method of Claim 22 wherein said
substrate comprises a material selected from the
set of materials comprising glass, glass ceramic,
SiC, Si or sputtered carbon.

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24. Method of Claim 22 wherein said layer .
comprising Ni and Nb is a NiNb alloy between 50 to
500 nm thick.

5 25. Method of Claim 22 wherein said layer
comprising Ni and Nb is between 16 and 60 at.% Nb
and between 84 and 40 at. % Ni.

10 26. A disk manufactured by the method of
Claim 22.

15 27. A disk drive comprising:
a disk as manufactured by the method of
Claims 1, 20 or 22;
a motor coupled to the disk for rotating
the disk;
a read-write head held in proximity to
said disk for reading data from and writing
data to the disk.

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