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(54) Abstract Title
Low permeability non-planar ferromagnetic sputter targets

(57) A low permeability, non-planar ferromagnetic sputter targets for use in the magnetron cathode sputtering of magnetic thin films provided by applying a deformation method that essentially bends the target material in at least a portion of the target. The low magnetic permeability of the ferromagnetic materials used for the sputter targets of the present invention results in a significant increase in the magnetic leakage flux at the surface of the ferromagnetic targets and a lowering of the argon pressure needed to obtain stable plasma. The low permeability of the ferromagnetic materials further allows for an increase in target thickness, which produces a longer target life and decreases the frequency of target replacements. The low permeability enables high rate deposition at an equivalent or lower magnetron field strength, which contributes to improved film magnetic properties, and the uniformity of the film thickness is improved. Low permeability targets also lead to wider sputtering erosion grooves, and hence higher target utilization, which is extremely important in reducing waste for targets made of expensive materials. The deformation may be carried out by spinning, press forming, roll forming, deep drawing, shallow drawing, deep extrusion, stamping, drop hammer forming or explosive forming. The material of the target may be Co, CoCr, CoCrPt, CoCrTa, CoNiCr, CoCrPtTa, CoCrPtTaNb, CoCrPtTaB, CoCrPtTaMo, CoFe, CoNiFe, CoNb, CoNbZr, CoTaZr, CoZrCr, Ni, NiFeCo, Fe, FeTa, FeCo or FeNi.

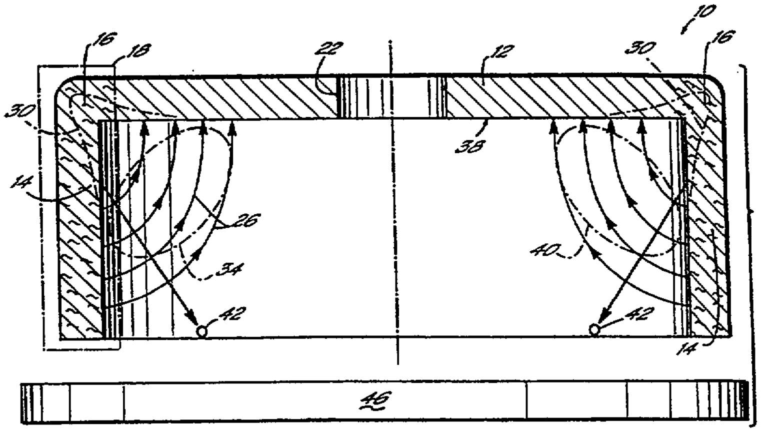

FIG. 1

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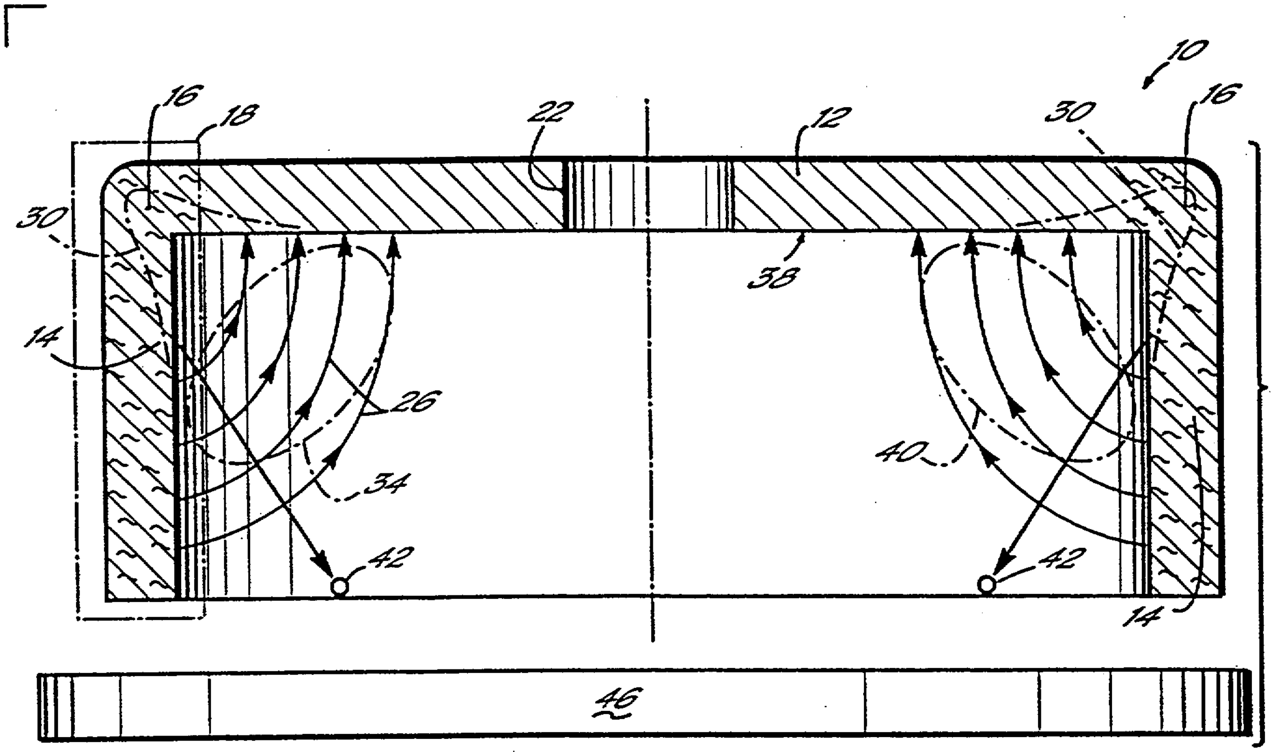
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FIG. 1

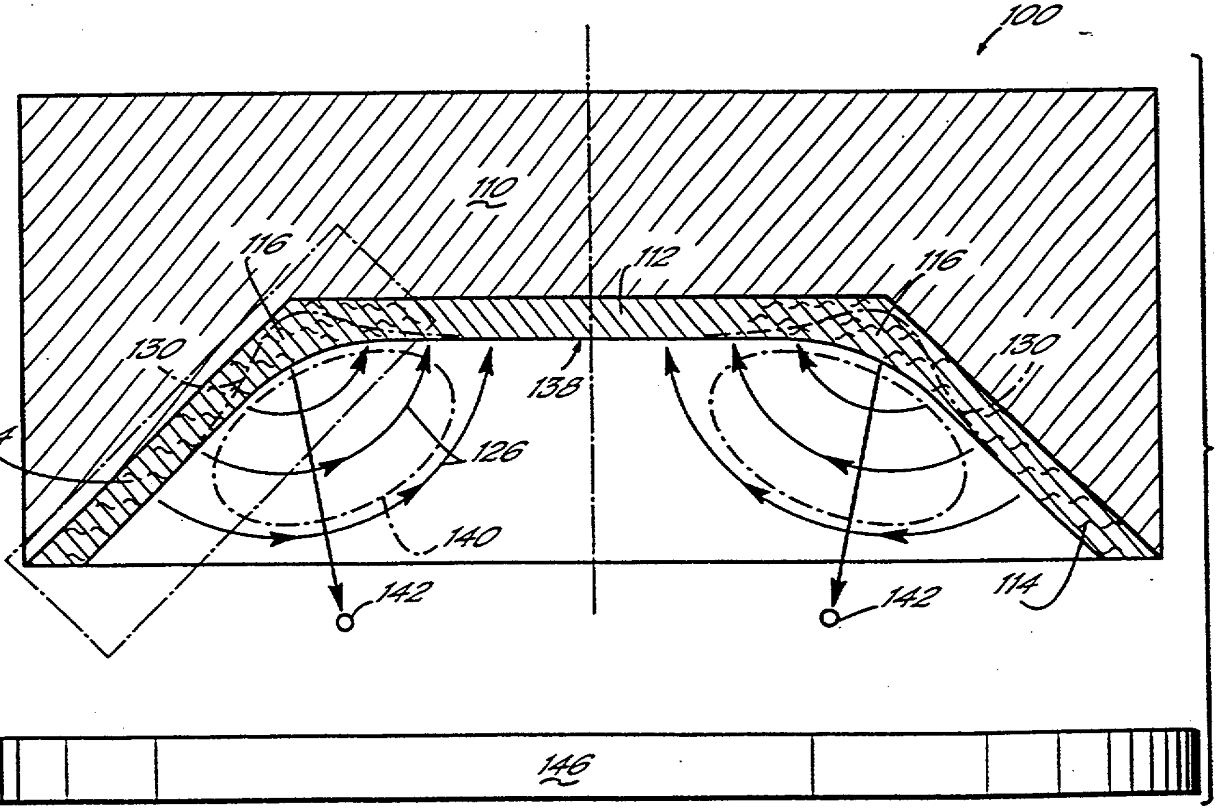
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FIG. 2

LOW PERMEABILITY NON-PLANAR FERROMAGNETIC SPUTTER TARGETS

This invention relates to ferromagnetic non-planar sputter targets having low magnetic permeability thereby improving target performance, and method of manufacturing same.

Sputter targets made of ferromagnetic materials are critical to thin film deposition in industries such as data storage and VLSI (very large scale integration)/semiconductors. Magnetron cathode sputtering is one means of sputtering magnetic thin films.

The cathode sputtering process involves ion bombardment of a target composed of a ferromagnetic material. The ferromagnetic target forms part of a cathode assembly in an evacuated chamber containing an inert gas, such as argon. An electric field is applied between the cathode assembly and an anode in the chamber, and the gas is ionized by collision with electrons ejected from the surface of the cathode, forming a plasma between the target surface and the substrate. The positive gas ions are attracted to the cathode surface, and particles of material dislodged when the ions strike the target then traverse the enclosure and deposit as a thin film onto a substrate or substrates positioned on a support maintained at or near anode potential.

Although the sputtering process can be carried out solely in an electric field, substantially increased deposition rates are possible with magnetron cathode sputtering, in which an arched magnetic field, formed in a closed loop over the surface of the sputter target, is superimposed on the electric field. The arched closed-loop magnetic field traps electrons in an annular region adjacent to the surface of the target, thereby multiplying the collisions between electrons and gas atoms to produce a corresponding increase in the number of ions in that region. The magnetic field is typically created by placing one or more magnets behind the target. This produces a leakage magnetic field on the surface of the target so that the plasma density may be increased.

Erosion of particles from the sputter target surface generally occurs in a relatively narrow ring-shaped region corresponding to the shape of the closed-loop magnetic field. Only the portion of the total target material in this erosion groove, the so-called "race track" region, is consumed before the target must be replaced. The result is that typically only 18-25% of the target material is utilized. Thus, a considerable amount of material, which is generally very expensive, is either wasted or must be recycled. Furthermore, a considerable amount of deposition equipment "down-time" occurs due to the necessity of frequent target replacement.

To solve these disadvantages of the magnetron sputtering process, various possible solutions have been pursued. One potential solution is to increase the thickness of the target. If the target is relatively thick, then sputtering can proceed for a longer period of time before the race track region is consumed. Ferromagnetic materials, however, present a difficulty not encountered with non-ferromagnetic materials. For magnetron sputtering, the magnetic leakage flux (MLF) or leakage magnetic field at the target sputter surface must be high enough to start and sustain the plasma. Under normal sputtering conditions, such as an argon pressure of 5-10 mTorr, the minimum MLF must be approximately 150 gauss, and preferably about 200 gauss for high speed sputtering. For normal sputtering conditions, a magnet strength of at least about 1,000 gauss is needed. The cathode magnet strength in part determines the MLF. The higher the magnet strength, the higher the MLF. In the case of ferromagnetic sputter targets, however, the high intrinsic magnetic permeability of the material effectively shields the magnetic field from the magnets behind the target and hence reduces the MLF on the target surface.

For air and non-ferromagnetic materials, magnetic permeability is very close to 1.0. Ferromagnetic materials, as referred to herein are those materials having an intrinsic magnetic permeability greater than 1.0. Magnetic permeability describes the response (magnetization) of a material under a magnetic field. In CGS units, it is defined as:

$$\text{Permeability} = 1 + 4\pi(M/H)$$

where M is the magnetization and H is the magnetic field. For currently available sputter targets, the permeability ranges from close to 1.0 to 100 or higher. The value depends on the particular material and manufacturing process. For example, a machined Co sputter target has a permeability of less than about 10, whereas machined NiFe and Fe sputter targets have permeabilities greater than 20.

Because of high permeability and thus low MLF, ferromagnetic sputter targets are generally made much thinner than non-magnetic sputter targets to allow enough magnetic field to be leaked out to sustain the plasma necessary for magnetron sputtering. Non-ferromagnetic targets are typically 0.25 inch or greater, whereas ferromagnetic targets are generally less than 0.25 inch. With some ferromagnetic materials, particularly those with higher permeability, the targets have to be machined to 0.0625 inch or less to achieve an MLF of 150 gauss, and some very high permeability materials are impossible to magnetron sputter because an MLF of 150 gauss simply cannot be achieved. Thus, not only can these ferromagnetic targets not simply be made thicker so as to reduce equipment down-time, they must actually be made thinner. To increase thickness, the MLF must somehow be increased.

U.S. Patent No. 4,401,546 discloses a planar ferromagnetic target that achieves a thickness of 0.20 inch (5 mm) by means of a segmented target, where the segments are separated by gaps through which the magnetic field leaks to produce an MLF of 200 gauss on the surface of the target. This is described as being an improvement over conventional ferromagnetic targets that could be machined to no thicker than 0.055 inch (1.4 mm), preferably no thicker than 0.028 inch (0.7 mm), to produce an MLF of 200 gauss.

U.S. Patent No. 4,412,907 also discloses, in the embodiment of FIG. 4, a segmented planar ferromagnetic target up to 1 inch thick (25 mm) with individual segments having sloped portions so as to produce angled gaps through which the magnetic field leaks to produce an MLF at the surface of the target of up to 730 gauss.

U.S. Patent No. 5,827,414 discloses a planar ferromagnetic target that claims to achieve a thickness of 0.16-1.0 inch (4-25 mm), also by gaps in the target. The gaps in this configuration are radial gaps formed by slots in the target body that are perpendicular to the flux of the magnetron, thereby producing a more effective and homogeneous leakage magnetic field on and parallel to the surface of the target body so that the sputtering plasma density may be increased.

These methods of machining slots into the target body and assembling a target from individual segments so as to increase the MLF, although allowing for thicker targets, are undesirable because the gaps allow for the sputtering and deposition of foreign particles, such as from the backing plate. Foreign particles in the thin film sacrifice the integrity of the object. Furthermore, this solution of increasing target thickness does nothing to decrease the amount of target material waste.

Another solution to the above described problem is to alter the design of the target to either eliminate target portions outside the race track region or to increase the efficiency of erosion in the race track region. It is known in the art that initial sputtering from a completely flat target face in certain applications tends to be non-uniform because of the effect of the arched closed-loop magnetic field. As sputtering progresses, an eroded valley is formed on the target surface in the region of the closed-loop magnetic field. The deposition of material sputtered from the target tends to become more uniform as the valley shape becomes stabilized. Thus, a non-planar target having pre-formed notches, grooves or curvatures machined into the race track region may be used to obtain uniform sputtering from the start. Dish or cup-shaped targets have proven especially useful for various reasons, such as the curvature being designed to correspond to the valley shape that would have naturally formed, and unnecessary material in the center of the race track region being eliminated prior to sputtering. These non-planar target configurations reduce waste of target material, increase efficiency, and increase uniformity of the deposited films, but they do nothing to increase target thickness of ferromagnetic targets so as to reduce the time needed for target replacement. Moreover, these non-planar targets are typically formed from a rectangular or circular target blank by machining with lathes or the like. Machining is simply a material removal process, and thus still results in an unnecessary amount of material waste prior to magnetron sputtering.

In general, the higher the permeability of the ferromagnetic material, the thinner the sputter target is required to be. Such a limitation on target thickness, however, leads to a shorter target life, waste of material and a need for more frequent target replacement. Furthermore, the high permeability and low MLF of a ferromagnetic target can cause problems of high impedance, low deposition rates, narrow erosion grooves, poor film uniformity and poor film performance. It is thus desirable to provide a low permeability, high MLF, non-planar ferromagnetic sputter target that may be made relatively thick without sacrificing film integrity.

Summary of the Invention

The present invention provides a non-planar ferromagnetic sputter target for use in the magnetron cathode sputtering of magnetic thin films, wherein the ferromagnetic material has a magnetic permeability lower than the intrinsic magnetic permeability of the material in at least a portion of the target. To this end, and in accordance with a preferred embodiment, a non-planar configuration is formed from a solid, unitary target blank comprising cobalt, nickel, iron or an alloy thereof by a deformation technique that essentially bends the material in at least the portion of the target where the majority of sputtering will occur. By this deformation process, the intrinsic magnetic permeability of the material, which is at least 1.0, is lowered such that an increase in leakage of the magnetic field occurs in at least the deformed region. The ferromagnetic sputter targets are thus capable of starting and sustaining a plasma for magnetron sputtering.

A further feature of the method is the ability to increase the thickness of the non-planar targets while still achieving a high enough magnetic leakage flux to start and sustain the plasma, which greater thickness increases target life and decreases the frequency of target changes. Ferromagnetic targets of any ferromagnetic material may be made by the method with a thickness of at least about 0.05 inch to produce a minimum MLF of about 150 gauss. The impedance of the target material is also lessened, such that lower argon pressures may be used to obtain stable plasmas which may be maintained throughout the sputtering process.

The invention will now be further described by way of example with reference to the accompanying drawings in which:

FIG. 1 depicts a cross-sectional side view of a non-planar target of the present invention having a right angle configuration; and

FIG. 2 depicts a cross-sectional view of a non-planar target of the present invention having a curved configuration.

The present invention provides low permeability, non-planar ferromagnetic sputter targets. The low permeability is achieved by applying a deformation method as described herein. The low magnetic permeability of the ferromagnetic materials used for the sputter targets of the present invention results in a significant increase in the MLF at the surface of the ferromagnetic targets and a lowering of the argon pressure needed to obtain stable plasma. The low permeability of the ferromagnetic materials further allows for an increase in target thickness, which produces a longer target life and decreases the frequency of target replacements. The low permeability enables high rate deposition at an equivalent or lower magnetron field strength, which contributes to improved film magnetic properties, and the uniformity of the film thickness is improved. Low permeability targets also lead to wider sputtering erosion grooves or zones, and hence higher target utilization, which is extremely important in reducing waste for targets made of expensive materials.

Ferromagnetic materials contemplated by the present invention include, by way of example, but not limitation:

a.) Pure Co and Co-based alloys, such as CoCr, CoCrPt, CoCrTa, CoNiCr, CoCrPtTa, CoCrPtTaNb, CoCrPtTaB, and CoCrPtTaMo, used for magnetic recording media, and CoFe, CoNiFe, CoNb, CoNbZr, CoTaZr, CoZrCr, used in magnetic recording heads;

b.) Pure Ni and Ni-based alloys, such as NiFe and NiFeCo;

c.) Pure Fe and Fe-based alloys, such as FeTa, FeCo and FeNi; and d.) Other binary, ternary, quaternary and higher degree of elemental alloys comprising Ni, Fe, Co and other elements having an intrinsic magnetic permeability of greater than 1.0.

In accordance with the principles of the present invention, the ferromagnetic materials are formed into a non-planar, solid, unitary sputter target configuration by a deformation process as described herein. Non-planar sputter targets as used herein is meant to include any sputter target with a non-flat configuration, such as a concave dish-type configuration, in which sputtering occurs at or near a curved or angled region of the target. These non-planar configurations have proven to have numerous advantages over planar configurations for certain applications.

The ferromagnetic targets of the present invention are manufactured by deforming a target blank, either in its entirety or only in regions where sputtering will occur, whereby the permeability of the ferromagnetic material is lowered from its intrinsic value in the deformed region. Thus, "low permeability" ferromagnetic targets of the present invention, as used herein, refers to sputter targets comprising a material of intrinsic magnetic permeability greater than 1.0 and having a deformed region in which the magnetic permeability is greater than 1.0 but less than the intrinsic magnetic permeability of the material. The curved or angled regions of the non-planar targets, in particular, are formed by deformation (as opposed to material removal by machining) in the race track region. The stresses and strains introduced into the material by the deformation, in particular by the bending of the material by the deformation process, cause a decrease in the permeability of ferromagnetic materials in the deformed region. Without being bound by theory, it is believed that stress and strain introduced into the material changes the magnetic energy of the material, which in turn changes the permeability. Thus, the non-planar targets will have, at the very least, a low permeability in the curved or angled portions of the target, which by design are in the race track region where the sputtering occurs. Because high permeability in a ferromagnetic target will block or shield the magnetic field from the magnets, the decrease in the permeability of the target material in the deformed regions will allow the magnetic field to leak through the target material, resulting in a higher MLF on the target surface to thus sustain the plasma. If desired, the whole target may be deformed, which will produce a reduced permeability throughout the target material, rather than just in the sputtering region. This will likewise result in an increased MLF at the surface of the ferromagnetic target.

By way of example and not limitation, a NiFe target blank machined by conventional processes displayed a uniform permeability of 20.5. The same NiFe target blank deformed according to the principles of the present invention displayed a permeability of 19 in the deformed regions. At a thickness of 0.110 inch, a magnet strength of 1,000 gauss, and an argon pressure of about 5-10 mTorr, the conventional NiFe sputter target has an MLF at the sputtering surface of about 300 gauss, while two 0.110 inch NiFe targets of the present invention have an MLF at the sputtering surface of 380 gauss and about 350 gauss, respectively.

The deformation techniques of the present invention include any deformation process that introduces stress, strain or other microstructural or physical changes into the material to produce a uniform or localized change in magnetic permeability. The bending, compressing, stretching or other deformation action may affect the whole or part of the target blank material. By way of example, and not intended in any way to limit the scope of the invention, the deformation technique may be any of spinning, press forming, roll forming, deep or shallow drawing, deep extrusion, stamping, punching, drop hammer forming, and explosive forming. Of these techniques, spinning, press forming, deep extrusion and drop hammer forming seem to offer the best results and/or the most efficient and economical approach. For deformation techniques effecting a bending of the material, a change preferably of about 10° or greater will introduce sufficient stress and/or strain to cause a change in permeability.

The spinning technique forms the target blank into a seamless hollow cylinder, with or without a bottom, or other circular shape by a combination of rotation and force. In general, curved or angled sputter targets are formed with an end surface-bottom.

The press forming technique applies pressure on a pressing ram to force and deform the target blank into the pressing die, such that a non-planar target of a shape designed to match the die and ram is produced. During this deformation process, the ram speed and holding pressure can be closely controlled.

The roll forming technique uses three or more rolls to deform the target blank into a non-planar configuration having a seam. The roll forming technique involves bending of the material, as opposed to other rolling methods using two opposing rolls that merely reduce the thickness of the material. The seam, however, may cause some non-uniformity in the deposited film.

The deep and shallow drawing techniques use an edge-opposing punch and a die (drawing ring) to deform the target blank to produce a cup, cone or similar configuration.

The deep extrusion technique involves the displacement of the ferromagnetic material by plastic flow under steady, though not uniform, pressure. The relative motion between the punch an die causes the ferromagnetic material to flow in a required direction. The ferromagnetic materials are work hardened when deformed at temperatures below their recrystallization temperature.

The stamping technique forms shallow impressions in the target blank by compression between a punch and die. Uniform thickness in all areas of the target generally is maintained, but some stretching may occur.

The punching technique is similar to stamping and pressing. During the deformation, the shape or contour of the target is controlled by the mating die sections.

The drop hammer forming technique deforms the target blank by sudden impact in which a high rate of deformation energy is released from the drop hammer. The forging hammer depends on gravity for its force.

The explosive forming technique shapes the target blank by instantaneous high pressure resulting from the detonation of an explosive. This detonation operation may occur in a confined or unconfined system.

By reducing the permeability of the ferromagnetic material and thereby increasing the MLF at the surface of the target, the ferromagnetic targets of the present invention may be made thicker than previously machined ferromagnetic targets. The magnetic field, no longer being shielded by high permeability, can now leak through thicker target materials. The targets of the present invention are also formed as unitary pieces, such that no foreign particles are introduced into the deposited film due to gaps in the target configuration.

The specific thicknesses and configurations of the targets of the present invention will differ according to customer specifications and the particular ferromagnetic material used. In general, any target of any configuration and material may be made thicker if deformed according to the principles of the present invention.

Cobalt and its alloys inherently have a lower permeability than nickel and iron, so greater thicknesses will generally be obtained with cobalt-base targets, with or without the deformation technique of the present invention, as compared to nickel-base and iron-base targets. The present invention is of particular benefit in the production of nickel-base and iron-base targets in which the magnetic permeability of the starting material is so high that an MLF of 150 gauss could not previously be achieved and so magnetron sputtering could not be used, or those targets which had to be machined to very thin dimensions to allow sufficient leakage of the magnetic field. These materials are now capable of being formed into relatively thick targets that can leak sufficient magnetic field to start and sustain the plasma, and even higher amounts to increase the deposition rate, with the same magnetron field strength.

By way of example and not limitation, FIG. 1 depicts in cross-section a center-mountable, right angle dish-shaped target 10 (shown in the inverted in-use position) having a ring-shaped bottom portion 12, a side wall portion 14 and an angled region 16 between the bottom and side wall portions to form a seamless, unitary configuration. The target 10 was formed from a circular target blank (not shown) by a deformation technique, such as spinning, in which the majority of deformation was applied to the portion 18 of material finally comprising the angled region 16 and side wall 14. The magnetic permeability of the material is thereby lowered most significantly in this deformed portion 18, and adjacent thereto, with the decrease in permeability becoming less pronounced in a direction toward the middle 22 of the bottom portion 12. The majority of leakage of the magnetic field from the magnets (not shown) behind the target 10 occurs, as shown by magnetic flux lines 26, in the deformed region 18 where the magnetic permeability is lowest. As shown in phantom, deformed region 18 includes the region in which the erosion zone or groove 30 will form, the so-called race track region of these specially designed targets. The dense plasma 34 is thereby sustained adjacent this race track region, where the gas ions continuously strike the sputter surface 38 and eject target particles 42, which are then deposited on the substrate 46 as a magnetic thin film, until the target material is sputtered through.

By way of further example, FIG. 2 depicts in cross-section an alternative embodiment of the present invention of a curved dish-shaped target 100 (shown in the inverted in-use position) mounted to a supporting backing tray 110, where the target 100 has a bottom portion 112, a side wall portion 114 and a curved region 116 between the bottom and side wall portions to form a seamless, unitary configuration. Deformation was applied to the portion 118 of material finally comprising the curved region 116 and side wall 114. Again, the majority of leakage of the magnetic field occurs, as shown by magnetic flux lines 126, in the deformed region 118. A dense plasma 134 is thereby obtained in the region adjacent where the erosion groove 130, shown in phantom, will form, such that target particles 142 are continuously dislodged from sputter surface 138 and deposited onto substrate 146 as a magnetic thin film.

The low permeability targets of the present invention enable higher rates of deposition with the same or lower magnetron field strength. High-rate deposition is found in many cases helpful to improve film magnetic properties. Low permeability targets also lead to a more uniform film thickness and wider sputtering erosion grooves and hence higher target utilization. Thus, the targets of the present invention decrease the frequency of target replacement and reduce target material waste, in addition to providing uniform, high purity magnetic thin films.

An additional benefit of the present invention is that with an increase in the MLF of the target there is a corresponding decrease in sputtering impedance, which likewise decreases the minimum argon pressure necessary for obtaining a stable plasma. High impedance causes plasma arcing, which may render the plasma unstable, making the target more difficult to sputter. By lowering the impedance of the targets of the present invention, a stable plasma may be obtained and maintained throughout the sputtering process at lower minimum argon pressures.

To demonstrate the effect of the present invention, two (2) NiFe sputter targets having an ash-tray-type shape and a thickness of 0.110 inch were sputtered under sub-normal conditions by magnetron cathode sputtering. The cathode included standard S-gun magnets with the plasma confined near the corners of the inner ash-tray ring. Standard S-gun magnets, such as those available from Sputter Film, Inc. of Santa Barbara, California, have a magnet strength of only about 400 gauss and are typically used for sputtering non-ferromagnetic materials, such as aluminum. The standard S-gun magnets produce a much weaker magnetic flux at the corners of the magnet and hence at the target surface. The minimum argon pressure that was required to obtain a stable plasma, and the magnetic flux at the surface of the target, are provided in Table 1 for a conventional, uniform permeability target and a target of the present invention.

Table 1

	Magnetic Flux (gauss)	**Minimum Ar Pressure (mTorr)**
Conventional NiFe Target	37	20
Improved NiFe Target	61	16
% Improvement	65%	20%

As Table 1 demonstrates, for targets of equal thickness and configuration, less argon pressure was needed to obtain a stable plasma for the improved NiFe target of the present invention. Upon achieving and maintaining this stable plasma, significantly higher MLF occurred at the surface of the target of the present invention, specifically 65% more than at the surface of the conventional target.

To achieve a MLF of at least about 150 gauss, the ferromagnetic targets should be sputtered under normal conditions. To achieve normal conditions, a magnet strength of at least 1,000 gauss is typically required, although this may be less for ferromagnetic targets having low permeability regions approaching 1.0, or for relatively thin targets. An example of a cathode magnet having a strength of about 1,000 gauss, which may be used in accordance with the principles of the present invention, is the Model RMX-34 magnet available from Materials Research Corporation, Orangeburg, New York. Higher strength magnets may also be used in accordance with the principles of the present invention for higher MLF readings or greater target thicknesses, such as the 2,000-3,000 gauss Model SYM-4B magnet from Sony Corporation, Tokyo, Japan. Using the high strength magnets designed for ferromagnetic targets, argon pressures on the order of only 5-10 mTorr or less will be necessary to achieve and maintain stable plasma.

While the present invention has been illustrated by the description of embodiments thereof, and while the embodiments have been described in considerable detail, ____

____________ additional advantages and modifications will readily appear to those skilled in the art. For example, while certain deformation techniques were described herein, other techniques may also be used in accordance with the principles of the present invention if such technique is effective to cause a reduction in the magnetic permeability of the material in the deformed region of the target.

CLAIMS

1. A method of making a low permeability non-planar ferromagnetic sputter target for use in magnetron cathode sputtering, comprising forming a target blank from a ferromagnetic material of intrinsic magnetic permeability greater than 1.0, and deforming the target blank into a non-planar sputter target, whereby the magnetic permeability of the ferromagnetic material is decreased from the intrinsic value in at least a portion of the sputter target.

2. The method of Claim 1, wherein the ferromagnetic material is cobalt, nickel, iron or an alloy thereof.

3. The method of claim 2, wherein the ferromagnetic material is selected from the group consisting of: Co, CoCr, CoCrPt, CoCrTa, CoNiCr, CoCrPtTa, CoCrPtTaNb, CoCrPtTaB, CoCrPtTaMo, CoFe, CoNiFe, CoNb, CoNbZr, CoTaZr, CoZrCr, Ni, NiFe, NiFeCo, Fe, FeTa, FeCo and FeNi.

4. The method of any preceding claim, wherein the target blank is deformed into a dish-shaped configuration having a bottom portion, a side wall portion and a curved or angled region by deforming at least the material of the target blank that will become the curved or angled region of the sputter target, whereby the magnetic permeability of the ferromagnetic material is decreased

from the intrinsic magnetic permeability in at least the curved or angled region of the sputter target.

5. The method of any preceding claim, wherein the target blank is deformed by a method selected from the group consisting of: spinning, press forming, roll forming, deep drawing, shallow drawing, deep extrusion, stamping, punching, drop hammer forming, and explosive forming.

6. The method of any preceding claim, wherein the target is deformed to a thickness of at least 0.05 inch.

7. The method of any preceding claim, wherein the target is deformed by at least 10°.

8. A non-planar ferromagnetic sputter target for use in magnetron cathode sputtering made by the method of any preceding claim, comprising a solid, unitary material selected from the group consisting of cobalt, nickel, iron and alloys thereof, and having a magnetic permeability lower than the intrinsic magnetic permeability of the material in at least a portion of the target.

9. A non-planar ferromagnetic sputter target for use in magnetron cathode sputtering comprising a material selected from the group consisting of cobalt, nickel, iron and alloys thereof, having a magnetic permeability lower

than the intrinsic magnetic permeability of the material in at least a portion of the target.

10. The sputter target of Claim 9, wherein the magnetic permeability of the material is lower in at least a region of the target where a majority of sputtering will occur.

11. The sputter target of either Claim 9 or Claim 10, wherein the sputter target has a dish-shaped configuration having a bottom portion, a side wall portion and a curved or angled region and the magnetic permeability of the ferromagnetic material is less than the intrinsic magnetic permeability of the material in at least the curved or angled region of the sputter target.

12. The sputter target of any one of Claims 9 to 11, wherein the sputter target has a thickness of at least 0.05 inch.

13. The sputter target of any one of Claims 8 to 12, wherein the sputter target has a magnetic leakage flux of at least 150 gauss on a sputter surface of the sputter target.

14. A non-planar ferromagnetic sputter target for use in magnetron cathode sputtering comprising a material of intrinsic magnetic permeability greater than 1.0, and said target comprising a deformed region having a

magnetic permeability lower than the intrinsic magnetic permeability of the material.

15. The sputter target of any one of Claims 8 to 14, wherein the material is selected from the group consisting of: Co, CoCr, CoCrPt, CoCrTa, CoNiCr, CoCrPtTa, CoCrPtTaNb, CoCrPtTaB, CoCrPtTaMo, CoFe, CoNiFe, CoNb, CoNbZr, CoTaZr, CoZrCr, Ni, NiFe, NiFeCo, Fe, FeTa, FeCo and FeNi.

16. A method of making a low permeability non-planar ferromagnetic sputter target for use in magnetron cathode sputter substantially as hereinbefore described and illustrated in the accompanying drawings.

17. A non-planar ferromagnetic sputter target substantially as hereinbefore described and illustrated in the accompanying drawings.

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Application No:	GB 0016774.2	**Examiner:**	Pete Beddoe
Claims searched:	1-17	**Date of search:**	24 November 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): C7F (FCAS, FCAV, FEAB)

Int Cl (Ed.7): C23C (14/34, 14/35); H01J 37/34

Other: Online: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP 0825276 A2	(APPLIED) see esp col4 lines 43-58 & fig 2	9 at least
X	WO 99/10548 A1	(ALTA) see esp p5 lines 2-20	1,8,9 at least
X	WO 99/03623 A1	(TOSOH) see esp p3 lines 11-14	1,8,9 at least
X	WO 96/21750 A1	(BOC) see esp figs 2A-2c & claim 1	9 at least
X	US 5799860	(APPLIED) see esp col15 line 64 - col16 line 22	1,8,9 at least
X	US 5688381	(BALZERS) see esp col3 lines 10-45 & figs	9 at least
X	US 5687600	(JOHNSON MATTHEY) see esp col2 line 60 - col3 line 49	1,8,9 at least
X	US 5490915	(BALZERS) see esp col3 lines 1-31 & figs	9 at least
X	US 5460708	(TEXAS) see esp fig 7	9 at least
X	US 4855033	(MATERIALS) see esp col3 line 62 - col4 line 18 & figs	1,8,9 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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Application No:	GB 0016774.2	**Examiner:**	Pete Beddoe
Claims searched:	1-17	**Date of search:**	24 November 2000

Category	Identity of document and relevant passage	Relevant to claims
X	US 4752335 (SCHWARZKOPF) see esp col4 lines 17-47	1,8,9 at least
X	DE 4438202 A1 & WPI Accession no 96-222760 (LEYBOLD) see esp page 2 & English abstract	1,8,9 at least
X	WPI accession no 88-310886 & JP 63227775 A (KOBE) see abstract	1,8,9 at least

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