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(54) Title: PLATINUM OR PALLADIUM/COBALT MULTILAYER ON A ZINC OXIDE OR INDIUM OXIDE LAYER FOR MAGNETO-OPTICAL RECORDING (57) Abstract This invention provides a magneto-optical recording medium comprised of a substrate, a base layer of zinc oxide or indium oxide sputtered onto the substrate and a multilayer recording film sputtered onto the base layer of zinc oxide or indium oxide, wherein the base layer of zinc oxide or indium oxide is from about 200 Å to about 4500 Å (about 20 nm to about 450 nm) thick, preferably from about 200 Å to about 2000 Å (about 20 nm to about 200 nm) thick, the multilayer recording film is a platinum/cobalt or a palladium/cobalt multilayer film consisting of alternating layers of platinum and cobalt or palladium and cobalt, and the substrate is transparent to the radiation used to record and read.		

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TITLE

PLATINUM OR PALLADIUM/COBALT MULTILAYER
ON A ZINC OXIDE OR INDIUM OXIDE LAYER
FOR MAGNETO-OPTICAL RECORDING

BACKGROUND OF THE INVENTIONField of the Invention

This invention relates to a magneto-optical recording medium comprised of a platinum or palladium/cobalt multilayer film with a zinc oxide or indium oxide base layer between the multilayer film and the substrate.

References

Thin films with perpendicular magnetic anisotropy are potential candidates in high density magnetic and magneto-optical recording. Examples of materials useful in preparing such films include the oxide garnets and ferrites, amorphous rare-earth transition metal alloys, metal alloys such as CoCr, and metal multilayers of platinum/cobalt (Pt/Co) and palladium/cobalt (Pd/Co), as disclosed in P. F. Carcia, U.S. Patent 4,587,176.

In order to be useful for magneto-optical recording, a material must have additional attributes besides perpendicular magnetic anisotropy. These requirements include a square hysteresis loop, a sufficient Kerr effect, a large room temperature coercivity H_C , and switching characteristics compatible with available laser power and magnetic field strength.

Pt/Co multilayers are a promising new candidate for a magneto-optical (MO) recording medium. They have perpendicular magnetic anisotropy, square hysteresis loops, a modest Kerr rotation, and excellent environmental stability. These attributes are discussed in detail in

several recent publications, W. B. Zeper et al., J. Appl. Phys. 65, 4971 (1989), F. J. A. M. Greidanus, Appl. Phys. Lett. 54, 2481 (1989) and P. F. Carcia et al., Mat. Res. Soc. Symp. Proc., 159, 115 (1989). When compared with the
5 rare-earth transition-metal (RE-TM) alloys, the Pt/Co multilayer has superior corrosion resistance and a larger Kerr effect, i.e., a larger magneto-optical signal, at shorter wavelengths which allows higher density recording.

A magnetic coercivity H_C of about 1000 Oe is adequate
10 for some recording applications, but higher coercivities would be more attractive and facilitate practical applications. Pt/Co multilayers prepared by vapor-deposition, (electron-beam evaporation from separate Pt and Co sources) have H_C of about 1000 Oe. Sputtering is the
15 preferred manufacturing process for preparing these multilayer films because it is simpler than other processes and the results obtained are more reproducible. However, sputtered Pt/Co multilayers have coercivities too small for magneto-optical recording. For example, Ochiai et al.,
20 Jap. J. Appl. Phys. 28, L659 (1989) and Ochiai et al., Digest of the Int'l. Mag. Conf.-1989. Wash., D. C., report H_C of only 100-350 Oe for sputtered Pt/Co multilayers which they prepared by using argon as the sputter gas. The commonly assigned patent application, "Improved Process for
25 Sputtering Multilayers for Magneto-optical Recording", S. N. 441,499, filed Nov. 27, 1989, in the name of P. F. Carcia, discloses that sputtering Pt/Co multilayers in krypton or xenon gas instead of argon results in coercivities of the order of 1000 Oe, comparable to vapor
30 deposited films.

A practical magneto-optical disk structure incorporates a transparent dielectric layer, i.e., a base

layer, between the substrate and the magnetic layer. In addition, a similar dielectric layer may be deposited on the magnetic layer. The primary role of the dielectric layer is to enhance by optical interference the Kerr rotation of the magnetic layer and the reading efficiency. For example, Bernstein et al., IEEE Transactions on Magnetics, 21, 1613 (1985), discuss different dielectric configurations to increase the Kerr signal of rare-earth transition metal alloys. When the MO layer is a RE-TM alloy, e.g. TbFeCo, a dielectric layer deposited on the magnetic layer also serves to protect the very sensitive rare earth elements from oxidation, which can compromise their MO properties. Usually nitrides (e.g., Si₃N₄ or AlN) are used because most oxides are easily chemically reduced by the rare earth elements and are consequently no longer protective. Because Pt/Co multilayers are much less sensitive to oxidation, the choice of a dielectric enhancement layer is not restricted to nitrides and a dielectric layer is not needed to protect the magnetic layer from the atmosphere. As a result other materials can be used as the dielectric and a dielectric with a larger optical index of refraction can further increase the Kerr signal. In addition, the dielectric may be used as a base layer.

It is highly preferred to read and write with laser light incident from the substrate side of the MO structure because the relatively thick substrate defocuses the effects of any surface foreign particles so that they do not obstruct or distort the read/write process. Recording on the air incident side would require adding an additional thick defocusing layer on the magnetic layer.

Some attempts have been made to increase the coercivity of multilayers by using base layers. Y. Ochiai et al., EP 0304873 disclose studies of sputtered Pt/Co multilayers including the use of underlayers to increase H_C . The underlayer (base layer) was formed from a metal, at least one of Cu, Rh, Pd, Ag, Ir, Pt and Au having face-centered cubic structure and W having a body-centered cubic structure, or from dielectric materials, including oxides such as Al_2O_3 , Ta_2O_5 , MgO , SiO_2 , TiO_2 , Fe_2O_3 , ZrO_2 , or Bi_2O_3 , nitrides such as ZrN , TiN , Si_3N_4 , AlN , $AlSiN$, BN , TaN or NbN , or oxide-nitride composite materials, oxynitride compounds. However, generally only marginal improvements in H_C were achieved and the singular best result of 725 Oe requires a 1000 Å (100 nm) thick Pt underlayer. This is impractical for most magneto-optical recording applications because it prohibits reading and writing information from the substrate side, and the large heat capacity and thermal diffusivity of such a thick Pt layer will likely prevent writing with the limited power available with current solid-state lasers. An H_C of 700 Oe was obtained with a 350 Å (35 nm) underlayer of Ta_2O_5 in conjunction with an about 600 Å (60 nm) Ta_2O_5 upper layer, i.e., on top of the multilayer, plus a Pt reflective layer on the Ta_2O_5 upper layer. Large increases in the H_C of Pd/Co multilayers were achieved with Pt or Pd underlayers and H_C increased from 825 Oe with no Pd underlayer to 3750 Oe with a 400 Å (40 nm) Pd underlayer. However, the Kerr effect for the Pd/Co multilayers is lower and therefore Pd/Co multilayers are less attractive than Pt/Co multilayers.

S. Hashimoto et al., Proceedings of the 13th Conference of the Applied Magnetics Association of Japan,

p. 56 (1989), disclose the increase in H_C of sputtered Pt/Co and Pd/Co multilayers by a metal base layer when the metal is a face-centered cubic metal or the body-centered cubic W. Pt and Pd were most effective. The maximum H_C of about 1000 Oe for Pt/Co multilayers was obtained when the base layer thickness reached 400-500 Å (40-50 nm). Thicker base layers resulted in no further increase in H_C . If the multilayers are sputtered in krypton or xenon gas instead of argon as disclosed in the commonly assigned application discussed above, much larger coercivities can be achieved with the same Pt base layer thickness. However, as discussed above, such thick Pt layers are undersirable in most MO structures.

Y. Ochiai et al., Proceedings of the 13th Conference of the Applied Magnetics Association of Japan, p. 57 (1989), disclose the use of dielectric films as base layers for sputtered Pt/Co multilayers and present data that appears to be essentially the same as that discussed above in connection with Y. Ochiai et al., EP 0304873.

Y. Iwasaki et al., Proceedings of the 13th Conference of the Applied Magnetics Association of Japan, p. 129 (1989), state that if it were possible to increase the coercivity of Pt/Co multilayers using a nonmetallic transparent base layer to the degree shown by S. Hashimoto et al. (discussed above) using a Pt base layer, such films would be useful as MO disk materials. Y. Iwasaki et al. disclose the use of optically isotropic cubic metal oxides such as Co, Fe and Ni oxides as base layer materials. When a 400-600 Å (40-60 nm) base layer of cubic wustite-phase CoO is used, the coercivity of Pt/Co multilayer has increased to about 1000 Oe. If prepared properly a 200 Å

(20 nm) base layer of CoO results in an H_C of 800 Oe. Fe or Ni oxide base layers resulted in an H_C of 600 Oe.

In the commonly co-assigned application, "Method of Thermomagnetic Recording of Information and Optical Readout of the Stored Information and Also A Recording Element Suitable for Use in this Method", S. N. 384,587, filed July 24, 1989, dielectric layers of an inorganic oxide, nitride, selenide, etc. between the multilayer and the substrate are discussed. Examples of suitable materials are Si_3N_4 , AlN, SiO, SiO₂, ZnO, Zn₃N₂, ZnSi₃N₂, ZnSe, ZrO₂, TiO₂, and AlZrN₂. Only AlN is exemplified.

The instant invention provides a base layer that is transparent, has a relatively large index of refraction ($n > 1.8$) and enhances the coercivity of Pt/Co multilayers to thereby provide a structure especially suitable for magneto-optical recording.

Summary of the Invention

This invention provides a magneto-optical recording medium comprised of a substrate, a base layer of zinc oxide or indium oxide sputtered onto the substrate and a multilayer recording film sputtered onto the base layer, wherein the zinc oxide or indium oxide film is from about 200 Å to about 4500 Å (about 20 nm to about 450 nm) thick, preferably from about 200 Å to about 2000 Å (about 20 nm to about 200 nm) thick, the multilayer recording film is a platinum/cobalt (Pt/Co) or a palladium/cobalt (Pd/Co) multilayer film consisting of alternating layers of platinum and cobalt or palladium and cobalt, and the substrate is transparent to the radiation used to record and read. Argon, krypton, xenon or a mixture thereof can be used as the sputter gas when sputtering the multilayer, but it is preferred to use krypton, xenon or a mixture thereof

as the sputter gas and to use a sputtering gas pressure of about 2 to about 12 mTorr (about 0.27 to about 1.6 Pa). Preferred is a platinum/cobalt multilayer film and more preferred is a platinum/cobalt multilayer film wherein all the cobalt layers have substantially the same thickness d_{Co} and all the platinum layers have substantially the same thickness d_{Pt} , d_{Co} is less than about 12 Å (1.2 nm), d_{Pt} is less than about 24 Å (2.4 nm) and the total thickness of the platinum/cobalt multilayer film is less than about 750 Å (75 nm). Especially preferred is the platinum/cobalt multilayer film wherein d_{Co} is from about 2 to about 5 Å (0.2 to about 0.5 nm) and d_{Pt}/d_{Co} is from about 1 to about 5.

Surprisingly, the zinc oxide or indium oxide base layer not only enhances the Kerr rotation of the multilayer recording film but also enhances the magnetic coercivity. High coercivities and square magnetic hysteresis loops have been achieved with the magneto-optical recording medium of the invention. Coercivities as high as 3000 Oe have been observed with a Pt/Co multilayer film.

Brief Description of the Drawing

The Drawing consists of two Figures. Figure 1 shows a comparison of the squareness of a hysteresis loop obtained with a Pt/Co multilayer sputtered onto a non-etched zinc oxide base layer which has been exposed to room atmosphere with that obtained with a Pt/Co multilayer sputtered onto a similar zinc oxide base layer which has been etched after the exposure to room atmosphere.

Figure 2 shows a hysteresis loop obtained with a Pt/Co multilayer sputtered onto a non-etched zinc oxide base layer which has not been exposed to room atmosphere.

Detailed Description of the Invention

The instant invention provides a superior magneto-optical (MO) recording medium. The presence of a base layer of zinc oxide or indium oxide between the multilayer recording film and the substrate provides this improvement over MO recording medium of the prior art. Zinc oxide and indium oxide are transparent to the radiation used in recording and reading and have indices of refraction, n , of about 2. It has now been found that a base layer of zinc oxide or indium oxide not only enhances the Kerr effect, but also significantly increases the coercivity of the multilayer recording film. Tin oxide may also be useful as a base layer to enhance both the Kerr effect and the magnetic coercivity. These oxides are preferably deposited onto the substrate by sputtering. Si_3N_4 is the most commonly used dielectric layer to enhance the Kerr effect, but no enhancement of the coercivity has been observed when it is used.

The oxide film can be deposited upon a variety of substrates, e. g., glass, quartz or a transparent plastic such as polycarbonate or polymethylmethacrylate. The substrate must be transparent to the radiation used to record on the multilayer recording film, as well as to the radiation used to read.

The multilayer recording film is deposited onto the oxide film by sputtering alternate layers of platinum and cobalt or palladium and cobalt. Argon, krypton, xenon or a mixture thereof can be used as the sputter gas when sputtering the multilayer, but it is preferred to use krypton, xenon or a mixture thereof as the sputter gas and to use a sputtering gas pressure of about 2 to about 12 mTorr (about 0.27 to about 1.6 Pa).

Pt/Co multilayers are preferred over Pd/Co multilayers because they exhibit a higher Kerr effect. As a result, the preferred magneto-optical recording medium of the invention is comprised of a substrate, a base layer of zinc oxide or indium oxide sputtered onto the substrate and a multilayer recording film sputtered onto the base layer, wherein the zinc oxide or indium oxide film is from about 200 Å to about 4500 Å (about 20 nm to about 450 nm) thick, preferably from about 200 Å to about 2000 Å (about 20 nm to about 200 nm) thick, the multilayer recording film is a platinum/cobalt multilayer film consisting of alternating layers of platinum and cobalt, and the substrate is transparent to the radiation used to record and read.

The platinum/cobalt multilayer film is deposited by sputtering alternate layers of platinum and cobalt. Preferably all cobalt layers within the multilayer film have substantially the same thickness d_{Co} and all said platinum layers within the multilayer film have substantially the same thickness d_{Pt} . Preferably d_{Co} is less than about 12 Å (1.2 nm), d_{Pt} is less than about 24 Å (2.4 nm) and the total thickness of the multilayer film is less than about 750 Å (75 nm). Most preferably d_{Co} is from about 2 to about 5 Å (0.2 to about 0.5 nm) and d_{Pt}/d_{Co} is from about 1 to about 5. The preferred ranges set forth herein identify structures having the most suitable characteristics for magneto-optical recording.

DC or RF magnetron sputtering can be used to deposit the platinum/cobalt multilayer film. The substrates with the zinc oxide or indium oxide base layer are typically placed on a rotating table and exposed to the Pt and Co sputtering fluxes in alternate, repeating fashion. The motion of the table can be programmed to permit the table

to pause for preselected periods during Pt and Co deposition. In this manner, the relative thicknesses of Pt and Co can be controlled. Preferably the Co and Pt targets are physically separated to eliminate the possibility of overlap of their sputtered fluxes. While argon, krypton, xenon or a mixture thereof can be used as the sputter gas when sputtering the Pt/Co multilayer, it is preferred to use krypton, xenon or a mixture thereof as the sputter gas and to use a sputtering gas pressure of about 2 to about 12 mTorr (about 0.27 to about 1.6 Pa).

EXAMPLES OF THE INVENTION

EXAMPLES 1 - 33

In these Examples of the invention, the zinc oxide thin films were sputtered onto glass substrates in a diffusion-pumped vacuum system whose background pressure was about 5×10^{-6} Torr (6.7×10^{-4} Pa). Films were sputtered at a total argon plus oxygen pressure of 8 mTorr (1.1 Pa). An oxygen partial pressure of 1 mTorr (0.13 Pa) was used for Examples 1 - 9, 2 mTorr (0.27 Pa) was used for Examples 10 - 21, and 4 mTorr (0.53 Pa) was used for Examples 22 - 32. Zinc oxide film thicknesses ranged from 500 Å to 4000 Å (50 nm to 400 nm). X-ray diffraction results verified that all films were ZnO with the c-axis oriented perpendicular to the thin film plane. After the zinc oxide films were sputtered onto the glass substrates, the substrates were removed from this chamber, thereby exposing the zinc oxide film to the laboratory environment, and then transferred into another vacuum chamber for deposition of Pt/Co multilayers.

Several essentially identical zinc oxide films were prepared and prior to sputtering the multilayers, some of

these zinc oxide films were sputter-etched under different, but mild, conditions in order to create a clean zinc oxide surface layer, i.e., to remove any contamination which may have occurred when the zinc oxide was exposed to the atmosphere during the transfer process.

Pt/Co multilayers were subsequently sputtered at 7 mTorr (0.94 Pa) of Kr on to uncoated and zinc oxide-coated glass and silicon substrates. All multilayer films were prepared by DC magnetron sputtering from separate 6.5" (16.5 cm) diameter Co and Pt targets. Forty watts was the sputtering power to each target. Substrates were on a rotatable table and were alternately coated by each metal. The substrate to target distance was about 3" (7.6 cm). There was no significant difference in results obtained with a glass substrate and those obtained with a polished silicon substrate. Glass substrates were used for the examples and experiments described herein. During deposition the rotating table was programmed to remain stationary under each target for a given time by controlling the substrate motion with a computer. Prior to deposition the vacuum chamber was pumped to a background pressure of about 2×10^{-7} Torr (2.7×10^{-5} Pa) before admitting the sputtering gas.

A pair of adjacent layers of Pt and Co is referred to as a bilayer. The number of Pt layers and the number of Co layers are of course each equal to the number of bilayers. In all the Examples, 10 bilayers were used. The thickness d_{Pt} of the Pt layers is 11.0 Å (1.1 nm) and the thickness d_{Co} of the Co layers is 3.5 Å (0.35 nm).

The perpendicular magnetic hysteresis loops of films on zinc oxide-coated and uncoated glass substrates were measured and H_C noted. All of these multilayer films have

an easy axis of magnetization perpendicular to the film plane and a magnetic squareness equal to one, that is, the remanent magnetization at zero applied field equals the saturation value.

5 The composition of the sputter gas used in sputtering the zinc oxide films, the thickness of the zinc oxide films, the sputter cleaning conditions, i.e., the voltage and time of sputtering, used to etch the zinc oxide films and the H_C are shown in Table I. For comparison, the same
10 multilayer on a glass substrate with no base layer has an H_C of about 850 Oe.

Multilayer films sputtered on zinc oxide had substantially larger coercivities than those sputtered directly on glass. The magnitude of H_C depends only weakly
15 on the zinc oxide preparation conditions and the zinc oxide thickness, and more strongly on the sputter-etch or cleaning conditions. In general, when the zinc oxide had been exposed to the atmosphere, etching the zinc oxide layer improved the squareness of the magnetic hysteresis
20 loop compared to that of unetched zinc oxide layers. Figure 1 illustrates this improvement and shows a plot of the hysteresis loops obtained from Example 30 with no etching and that of Example 31 with etching before the deposition of the multilayer. Milder etching conditions
25 only slightly affected the magnitude of H_C , either increasing it or decreasing it slightly relative to the H_C obtained with the unetched zinc oxide. Larger etch voltages and longer etch times always decreased H_C , although they improved the square shape of the hysteresis
30 loop. If the etching voltage is too large or the etching time too long, the zinc oxide surface may become roughened and this consequently decreases the coercivity. It is

believed that the key role of etching is to clean and restore the zinc oxide surface to its condition prior to removing the film from the vacuum chamber in which it was deposited. Therefore depositing the zinc oxide layer and the Pt/Co multilayers in the same vacuum chamber may eliminate the need for sputter-etching to clean the zinc oxide surface. This is demonstrated in Example 33 in which essentially the same Pt/Co multilayer film sputtered in all the other Examples was deposited onto a 1000 Å (100 nm) zinc oxide layer in the same vacuum chamber without exposing the zinc oxide to the atmosphere and without etching the zinc oxide. Fig. 2 shows the square hysteresis loop obtained. The H_C is about 3100 Oe. Etching may also play a role in helping to nucleate a Pt/Co microstructure favorable for high coercivity.

EXAMPLES 34 - 39

In these Examples of the invention, the indium oxide thin films were sputtered onto glass substrates in a diffusion-pumped vacuum system whose background pressure was about 5×10^{-6} Torr (6.7×10^{-4} Pa). Films were sputtered at a total argon plus oxygen pressure of 8 mTorr (1.1 Pa). An oxygen partial pressure of 2 mTorr (0.27 Pa) was used. Indium film thicknesses ranged from 1000 Å to 1800 Å (100 nm to 180 nm). After the indium oxide films were sputtered onto the glass substrates, the substrates were removed from this chamber, thereby exposing the indium oxide film to the laboratory environment, and then transferred into another vacuum chamber for deposition of Pt/Co multilayers.

Several essentially identical indium oxide films were prepared and prior to sputtering the multilayers, some of

these indium oxide films were sputter-etched under different, but mild, conditions in order to create a clean indium oxide surface layer, i.e., to remove any contamination which may have occurred when the indium oxide was exposed to the atmosphere during the transfer process.

Pt/Co multilayers were subsequently sputtered at 7 mTorr (0.94 Pa) of Kr on to indium oxide-coated glass and silicon substrates. All multilayer films were prepared by DC magnetron sputtering from separate 6.5" (16.5 cm) diameter Co and Pt targets. Forty watts was the sputtering power to each target. Substrates were on a rotatable table and were alternately coated by each metal. The substrate to target distance was about 3" (7.6 cm). There was no significant difference in results obtained with a glass substrate and those obtained with a polished silicon substrate. Glass substrates were used for the examples and experiments described herein. During deposition the rotating table was programmed to remain stationary under each target for a given time by controlling the substrate motion with a computer. Prior to deposition the vacuum chamber was pumped to a background pressure of about 2×10^{-7} Torr (2.7×10^{-5} Pa) before admitting the sputtering gas.

In all the Examples, 10 bilayers were used. The thickness d_{Pt} of the Pt layers is 11.0 Å (1.1 nm) and the thickness d_{Co} of the Co layers is 3.5 Å (0.35 nm).

The perpendicular magnetic hysteresis loops of films on indium oxide-coated were measured and H_C noted. All of these multilayer films have an easy axis of magnetization perpendicular to the film plane and a magnetic squareness equal to one, that is, the remanent magnetization at zero applied field equals the saturation value.

The composition of the sputter gas used in sputtering the indium oxide films, the thickness of the indium oxide films, the sputter cleaning conditions, i.e., the voltage and time of sputtering, used to etch the indium oxide films and the H_C are shown in Table II. For comparison, the same multilayer on a glass substrate with no base layer has an H_C of about 850 Oe.

Multilayer films sputtered on indium oxide had substantially larger coercivities than those sputtered directly on glass. The magnitude of H_C depends only weakly on the indium oxide preparation conditions and the indium oxide thickness, and more strongly on the sputter-etch or cleaning conditions. In general, when the indium oxide had been exposed to the atmosphere, etching the zinc oxide layer improved the squareness of the magnetic hysteresis loop compared to that of unetched indium oxide layers. Milder etching conditions had little effect on the magnitude of H_C . Larger etch voltages and longer etch times reduce H_C , although they improved the square shape of the hysteresis loop. If the etching voltage is too large or the etching time too long, the indium oxide surface may become roughened and this consequently decreases the coercivity. It is believed that the key role of etching is to clean and restore the indium oxide surface to its condition prior to removing the film from the vacuum chamber in which it was deposited. Therefore depositing the indium oxide layer and the Pt/Co multilayers in the same vacuum chamber may eliminate the need for sputter-etching to clean the indium oxide surface. Etching may also play a role in helping to nucleate a Pt/Co microstructure favorable for high coercivity.

Table I

		Zinc oxide	Thickness	Etch	Etch	H_c (Oe)
Example		Sputter Gas	(nm)	Voltage (V)	Time (min)	
5		No Base Layer				850
		7 mTorr Ar				
		1 mTorr O ₂				
10	1		180	0	-	2245
	2		180	-50	10	2900
	3		180	-100	10	1600
	4		100	0	-	2270
	5		100	-50	5	2190
15	6		100	-100	5	1242
	7		50	0	-	2105
	8		50	-50	5	1770
	9		50	-100	5	1150
		6 mTorr Ar				
		2 mTorr O ₂				
20	10		400	0	-	1860
	11		400	-50	10	2105
	12		400	-100	10	1250
	13		100	0	-	1890
25	14		100	-50	10	1435
	15		100	-75	7.5	1000
	16		100	-100	5	1285
	17		50	0	-	1510
	18		50	-50	5	1835
30	19		50	-50	10	1425
	20		50	-75	7.5	1090
	21		50	-100	5	1390
		4 mTorr Ar				
		4 mTorr O ₂				
35	22		300	0	-	2100
	23		300	-50	5	2715
	24		300	-50	10	2015
	25		300	-100	5	1450
	26		100	0	-	2055
40	27		100	-50	5	2200
	28		100	-50	10	1685
	29		100	-100	5	1465
	30		50	0	-	1755
	31		50	-50	5	2055
45	32		50	-100	5	1400

Table II

Example	Indium oxide Sputter Gas	Thickness (nm)	Etch Voltage (V)	Etch Time (min)	H _C (Oe)
5	No Base Layer				850
	6 mTorr Ar				
10	2 mTorr O ₂				
	34	180	0	-	1535
	35	180	-50	5	1530
	36	180	-50	10	1300
	37	180	-100	5	1140
15	38	100	0	-	2380
	39	100	-50	5	2320

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CLAIMS

The Invention Being Claimed Is:

1. A magneto-optical recording medium comprised of
5 a substrate, a base layer of zinc oxide or indium oxide
sputtered onto said substrate and a multilayer recording
film sputtered onto said base layer of zinc oxide or indium
oxide, wherein said base layer of zinc oxide or indium
oxide is from about 200 Å to about 4500 Å (about 20 nm to
10 about 450 nm) thick, said multilayer recording film is a
platinum/cobalt multilayer film or a palladium/cobalt
multilayer film consisting of alternating layers of
platinum and cobalt or palladium and cobalt, said substrate
is transparent to the radiation used to record and read,
15 and the sputter gas used in sputtering said multilayer film
is argon, krypton, xenon or a mixture thereof.

2. The magneto-optical recording medium of Claim 1
wherein said base layer is zinc oxide.

3. The magneto-optical recording medium of Claim 2
20 wherein said multilayer recording film is a platinum/cobalt
multilayer film consisting of alternating layers of
platinum and cobalt.

4. The magneto-optical recording medium of Claim 3
wherein all said cobalt layers of said platinum/cobalt
25 multilayer film have substantially the same thickness d_{Co}
and all said platinum layers of said platinum/cobalt
multilayer film have substantially the same thickness d_{Pt} ,
 d_{Co} is less than about 12 Å (1.2 nm), d_{Pt} is less than
about 24 Å (2.4 nm) and the total thickness of the
30 platinum/cobalt multilayer film is less than about 750 Å
(75 nm).

5. The magneto-optical recording medium of Claim 4 wherein d_{Co} is from about 2 to about 5 Å (0.2 to about 0.5 nm) and d_{Pt}/d_{Co} is from about 1 to about 5.

6. The magneto-optical recording medium of Claim 2
5 wherein said base layer of zinc oxide is from about 200 Å to about 2000 Å (about 20 nm to about 200 nm) thick.

7. The magneto-optical recording medium of Claim 6 wherein said multilayer recording film is a platinum/cobalt multilayer film consisting of alternating layers of
10 platinum and cobalt.

8. The magneto-optical recording medium of Claim 7 wherein all said cobalt layers of said platinum/cobalt multilayer film have substantially the same thickness d_{Co} and all said platinum layers of said platinum/cobalt
15 multilayer film have substantially the same thickness d_{Pt} , d_{Co} is less than about 12 Å (1.2 nm), d_{Pt} is less than about 24 Å (2.4 nm) and the total thickness of the platinum/cobalt multilayer film is less than about 750 Å (75 nm).

20 9. The magneto-optical recording medium of Claim 8 wherein d_{Co} is from about 2 to about 5 Å (0.2 to about 0.5 nm) and d_{Pt}/d_{Co} is from about 1 to about 5.

10. The magneto-optical recording medium of Claim 2 wherein said sputter gas used in sputtering said multilayer
25 film is krypton, xenon or a mixture thereof. 11. The magneto-optical recording medium of Claim 10 wherein the gas pressure of said sputtering gas is about 2 to about 12 mTorr (about 0.27 to about 1.6 Pa).

12. The magneto-optical recording medium of Claim 11
30 wherein said multilayer recording film is a platinum/cobalt multilayer film consisting of alternating layers of platinum and cobalt.

13. The magneto-optical recording medium of Claim 12 wherein all said cobalt layers of said platinum/cobalt multilayer film have substantially the same thickness d_{Co} and all said platinum layers of said platinum/cobalt multilayer film have substantially the same thickness d_{Pt} , d_{Co} is less than about 12 Å (1.2 nm), d_{Pt} is less than about 24 Å (2.4 nm) and the total thickness of the platinum/cobalt multilayer film is less than about 750 Å (75 nm).

14. The magneto-optical recording medium of Claim 13 wherein d_{Co} is from about 2 to about 5 Å (0.2 to about 0.5 nm) and d_{Pt}/d_{Co} is from about 1 to about 5.

15. The magneto-optical recording medium of Claim 6 wherein said sputter gas used in sputtering said multilayer film is krypton, xenon or a mixture thereof. 16. The magneto-optical recording medium of Claim 15 wherein the gas pressure of said sputtering gas is about 2 to about 12 mTorr (about 0.27 to about 1.6 Pa).

17. The magneto-optical recording medium of Claim 16 wherein said multilayer recording film is a platinum/cobalt multilayer film consisting of alternating layers of platinum and cobalt.

18. The magneto-optical recording medium of Claim 17 wherein all said cobalt layers of said platinum/cobalt multilayer film have substantially the same thickness d_{Co} and all said platinum layers of said platinum/cobalt multilayer film have substantially the same thickness d_{Pt} , d_{Co} is less than about 12 Å (1.2 nm), d_{Pt} is less than about 24 Å (2.4 nm) and the total thickness of the platinum/cobalt multilayer film is less than about 750 Å (75 nm).

19. The magneto-optical recording medium of Claim 18 wherein d_{Co} is from about 2 to about 5 Å (0.2 to about 0.5 nm) and d_{Pt}/d_{Co} is from about 1 to about 5.

20. The magneto-optical recording medium of Claim 1 wherein said base layer is indium oxide.

21. The magneto-optical recording medium of Claim 20 wherein said multilayer recording film is a platinum/cobalt multilayer film consisting of alternating layers of platinum and cobalt.

22. The magneto-optical recording medium of Claim 21 wherein all said cobalt layers of said platinum/cobalt multilayer film have substantially the same thickness d_{Co} and all said platinum layers of said platinum/cobalt multilayer film have substantially the same thickness d_{Pt} , d_{Co} is less than about 12 Å (1.2 nm), d_{Pt} is less than about 24 Å (2.4 nm) and the total thickness of the platinum/cobalt multilayer film is less than about 750 Å (75 nm).

23. The magneto-optical recording medium of Claim 22 wherein d_{Co} is from about 2 to about 5 Å (0.2 to about 0.5 nm) and d_{Pt}/d_{Co} is from about 1 to about 5.

24. The magneto-optical recording medium of Claim 20 wherein said base layer of indium oxide is from about 200 Å to about 2000 Å (about 20 nm to about 200 nm) thick.

25. The magneto-optical recording medium of Claim 24 wherein said multilayer recording film is a platinum/cobalt multilayer film consisting of alternating layers of platinum and cobalt.

26. The magneto-optical recording medium of Claim 25 wherein all said cobalt layers of said platinum/cobalt multilayer film have substantially the same thickness d_{Co} and all said platinum layers of said platinum/cobalt

multilayer film have substantially the same thickness d_{Pt} , d_{Co} is less than about 12 Å (1.2 nm), d_{Pt} is less than about 24 Å (2.4 nm) and the total thickness of the platinum/cobalt multilayer film is less than about 750 Å (75 nm).

27. The magneto-optical recording medium of Claim 26 wherein d_{Co} is from about 2 to about 5 Å (0.2 to about 0.5 nm) and d_{Pt}/d_{Co} is from about 1 to about 5.

28. The magneto-optical recording medium of Claim 20 wherein said sputter gas used in sputtering said multilayer film is krypton, xenon or a mixture thereof.

29. The magneto-optical recording medium of Claim 28 wherein the gas pressure of said sputtering gas is about 2 to about 12 mTorr (about 0.27 to about 1.6 Pa).

30. The magneto-optical recording medium of Claim 29 wherein said multilayer recording film is a platinum/cobalt multilayer film consisting of alternating layers of platinum and cobalt.

31. The magneto-optical recording medium of Claim 30 wherein all said cobalt layers of said platinum/cobalt multilayer film have substantially the same thickness d_{Co} and all said platinum layers of said platinum/cobalt multilayer film have substantially the same thickness d_{Pt} , d_{Co} is less than about 12 Å (1.2 nm), d_{Pt} is less than about 24 Å (2.4 nm) and the total thickness of the platinum/cobalt multilayer film is less than about 750 Å (75 nm).

32. The magneto-optical recording medium of Claim 31 wherein d_{Co} is from about 2 to about 5 Å (0.2 to about 0.5 nm) and d_{Pt}/d_{Co} is from about 1 to about 5.

33. The magneto-optical recording medium of Claim 24 wherein said sputter gas used in sputtering said multilayer film is krypton, xenon or a mixture thereof.

34. The magneto-optical recording medium of Claim 33
5 wherein the gas pressure of said sputtering gas is about 2 to about 12 mTorr (about 0.27 to about 1.6 Pa).

35. The magneto-optical recording medium of Claim 34 wherein said multilayer recording film is a platinum/cobalt multilayer film consisting of alternating layers of
10 platinum and cobalt.

36. The magneto-optical recording medium of Claim 35 wherein all said cobalt layers of said platinum/cobalt multilayer film have substantially the same thickness d_{Co} and all said platinum layers of said platinum/cobalt
15 multilayer film have substantially the same thickness d_{Pt} , d_{Co} is less than about 12 Å (1.2 nm), d_{Pt} is less than about 24 Å (2.4 nm) and the total thickness of the platinum/cobalt multilayer film is less than about 750 Å (75 nm).

20 37. The magneto-optical recording medium of Claim 36 wherein d_{Co} is from about 2 to about 5 Å (0.2 to about 0.5 nm) and d_{Pt}/d_{Co} is from about 1 to about 5.

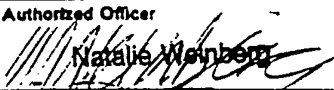
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INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 91/00881

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC IPC ⁵ : G 11. B 11/10, G 11 B 13/04, G 11 B 5/62, G 11 B 5/716		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC ⁵	G 11 B 5/00, G 11 B 11/00, G 11 B 13/00, H 01 F 1/00	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹		
Category ¹⁰	Citation of Document, ¹¹ with Indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
A	US, A, 4 587 176 (CARCIA) 06 May 1986 (06.05.86), see abstract. (cited in the application)	1,3,4, 7,8, 12,13, 17,18, 21,22, 25,26, 30,31, 35,36
A	US, A, 4 472 248 (KOSKENMAKI) 18 September 1984 (18.09.84), see abstract.	1,3,4, 7,8, 12,13, 17,18, 21,22, 25,26, 30,31, 35,36
A	DE, A1, 3 042 330 (VEB KOMBINAT ROBOTRON) 16 July 1981 (16.07.81), see abstract.	1,4, 13,18, 22,31, 36
¹⁴ Special categories of cited documents: ¹⁵ "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
06 May 1991	02. 07. 91	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	 Natalia Weinberg	

ANHANG
zum internationalen Recherchen-
bericht über die internationale
Patentanmeldung Nr.

ANNEX
to the International Search
Report to the International Patent
Application No.

ANNEXE
au rapport de recherche inter-
national relatif à la demande de brevet
international n°

PCT/US91/00881 SAE 45030

In diesem Anhang sind die Mitglieder
der Patentfamilien der im obenge-
nannten internationalen Recherchenbericht
angeführten Patentdokumente angegeben.
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This Annex lists the patent family
members relating to the patent documents
cited in the above-mentioned inter-
national search report. The Office is
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Im Recherchenbericht angeführtes Patentdokument Patent document cited in search report Document de brevet cité dans le rapport de recherche	Datum der Veröffentlichung Publication date Date de publication	Mitglied(er) der Patentfamilie Patent family member(s) Membre(s) de la famille de brevets	Datum der Veröffentlichung Publication date Date de publication
US-A - 4587176	06-05-86	Keine - None - Rien	
US-A - 4472248	18-09-84	Keine - None - Rien	
DE-A1- 3042330	16-07-81	SU-A1- 1308972 DD- T- 154460 FR-A1- 2473740 FR-B3- 2473740	07-05-87 24-03-82 17-07-81 18-12-87