

Description

Background of the Invention

The present invention relates to read/write devices for high density magnetic recording.

Conduction of flux, such as in a magnetic head, is achieved by two mechanisms: domain wall motion and domain rotation. Domain wall motion results in flux being transmitted through a head along the walls of a domain, or domains, the flux spreading out along the domain walls as the flux seeks to return to equilibrium. However, while domain wall motion facilitates conduction of flux at low frequencies, it is a poor vehicle for conduction of flux at high frequencies. Furthermore, defects in the material in a head can be the source of Barkhausen noise as wall motion is perturbed by these defects. Such noise can result in erroneous readings of recorded data.

Figure 1a schematically shows a pole tip region 10 of a magnetic transducer, such as a prior art thin film head, configured to achieve conduction by domain rotation when reading flux from a magnetic medium. Pole P1 is provided with central magnetic domains 12, having an axis of anisotropy (easy axis) indicated by the at rest domain state arrows 14 transverse to the longitudinal axis of the pole. Pole P1 has a total width W_t , which includes the width W_c of the center region and the combined width $2W_x$ of the edge domains, such that $W_t = W_c + 2W_x$. It is in the center region where the desired conduction by domain rotation occurs. The probability of Barkhausen noise is inversely related to center region width W_c .

Figure 1b shows a prior art pole piece P1 having a narrow width with a criss-cross domain structure. In such arrangement, the edge domains each still have a width W_x but there is no appreciable width of a center conduction section. Hence, in this case, $W_t = 2W_x$.

Magnetic switching in the pole tips by the rotation mechanism is preferable to switching by domain wall motion. The advantages of switching by rotation include higher frequency response, higher efficiency and low probability of Barkhausen noise.

At rest domain configuration, in part, is controlled by inducing uniaxial anisotropy during deposition. In prior art thin film heads, both positive and negative magnetostriction (in conjunction with anisotropic stress) have been used to reinforce favorable domain configurations induced by a magnetic field during plating of the head pole pieces.

The anisotropy field (H_k) of a typical thin film head may be expressed in terms of effective and intrinsic anisotropy, as follows:

$$H_k(\text{effective}) = H_k(\text{intrinsic}) + \frac{3d\lambda}{M_s}$$

where, d = anisotropic stress, λ = magnetostriction constant, where M_s = saturation magnetization.

Hence, the effective anisotropy field H_k can be increased by controlled application of magnetostriction and anisotropic stress as a result of the deposition process and pole geometry.

Nakamura et al., "Analysis of Domain Structure of Single Pole Perpendicular Head," *IEEE Transactions on Magnetics*, vol. MAG-21, no. 5, September 1985, discloses the relationship between the permeance P of a pole film (normalized by the film width) and the anisotropy field H_k of the pole film, for various track widths. Morisako et al., "Effect of Third Element on Electrodeposited Permalloy Film for Thin-Film Magnetic Head," *Electronics and Communications in Japan*, vol. 61-C, no. 2, 1978, discloses the effects of the addition of eight different "third elements" (including cobalt) to a permalloy film. One of the effects studied is the variation of the anisotropy field H_k as a function of the amount of each third element in the bath used to plate the permalloy film.

Summary of the Invention

The present invention provides a process for forming at least one pole of a magnetic device according to claims 1 and 20.

One aspect of the present invention relates to a process for forming at least one pole of a magnetic device, including the steps of: determining a maximum permeance for a chosen pole width, relating that permeance to expected anisotropy field for a pole having the chosen pole width, relating that anisotropy field to a desired cobalt concentration in a deposition stream, and forming the at least one pole from the stream, the pole having approximately the desired cobalt concentration. Preferably the process includes forming the pole having near zero magnetostriction in the range of about -5.3×10^{-7} to zero and annealing the formed pole.

The invention may include any of the following features: the coercivity of the formed pole is at or below 1 Oersted ($\sim 80\text{A/m}$); the formed pole, at the pole tip, is 3 microns wide, greater than one micron thick and has a permeability of less than 1500; the formed pole anisotropy field is in the range of 3 to 14 Oersteds (239 to 1114A/m); the formed pole anisotropy is 9 Oersteds (716A/m) before annealing and 12 Oersteds (955A/m) after annealing; the formed pole has a ratio of W_c/W_t in the range of about 0.5 to 0.7, with coercivity at or below about 1 Oersted ($\sim 80\text{A/m}$); the formed pole has a saturation flux density of about 1.3 Wb/m²; the formed pole is about 61.5-66% nickel by weight, 13-14.5% iron by weight, and 21-24% cobalt by weight, and preferably is about 64.5% nickel, 13.5% iron, and 22% cobalt by weight after annealing; the formed pole has a transverse easy axis and the annealing is performed by baking the pole in a vacuum at about 240 degree centigrade for about 8 hours in an orienting magnetic field parallel to the

easy axis of the pole, the orienting field preferably at about 1,100 Oersteds ($\sim 87.5\text{kA/m}$) or more.

A preferred deposition stream includes a nickel iron plating bath with cobalt content in the range of about 20-25% by weight, and preferably having cobalt chloride hexahydrate at about 3.65 grams per liter. The bath preferably is a modified Watt's bath including nickelous chloride, sodium saccharin, ferrous chloride, and cobaltous chloride.

In another aspect of the invention, a process for producing a thin film head includes the steps of: defining a pole pattern on a metallized surface of a wafer, mounting the wafer on a cathode fixture and immersing it in a plating bath, forming a cobalt alloy pole according to the pole pattern while maintaining magnetostriction near zero and controlling cobalt content to achieve a desired pole permeance, and annealing the formed pole. Preferably at least one pole is annealed with the ratio of W_o/W_t of the at least one pole in the range of 0.5 to 0.7.

Other advantages and features will become apparent from the following description of the preferred embodiment and from the claims.

Preferred Embodiment of the Invention

We first briefly describe the drawings.

Fig. 1a shows the domain configuration in the pole tip region of a magnetic pole capable of conduction of flux by rotation.

Fig. 1b shows a criss-cross domain structure of a magnetic pole.

Fig. 2 is a plot of permeance as a function of anisotropy field in a plated film.

Fig. 2a is a plot of plated film coercivity as a function of weight percent cobalt in a plated film.

Fig. 2b is a plot of plated film anisotropy field H_k as a function of weight percent cobalt in a plated film.

Fig. 2c is a plot of the change in anisotropy field H_k due to anneal as a function of weight percent cobalt in a plated film.

Figs. 3a, 3b show a preferred deposition method and apparatus.

High density recording requires a head design with narrow track width, and preferably with the domain configuration shown in Fig. 1a. This is achieved by reducing the width W_t of the pole(s). However, as the head pole width W_t is narrowed down to around three microns, the central flux conduction region width W_o tends to approach zero, with the domain structure thus assuming the known configuration shown in Fig. 1b. At this point, domain rotation fails as a functional mechanism of flux conduction and the head becomes less efficient. Therefore, the ratio of W_o/W_t appears to have significance in narrow track head design. Our preferred ratio of W_o/W_t is in the range of 0.5 to 0.7, with an acceptable level of coercivity (H_c) at about one Oersted (80A/m) or less, at

least for maintaining domain rotation in a narrow track head about three microns wide.

We believe that approximately one Oersted (80A/m) is near the high end of an acceptable coercivity level for a narrow track (e.g., three microns) read/write head, but the actual desirable value will depend upon specific widths and applications. For purposes of the present invention, the acceptable level of coercivity for a given geometry may be defined as that level which permits a transverse at rest domain state orientation to resume prior to reading when cycling between reading and writing.

We have found that increasing the magnetic anisotropy field relative to an acceptable level of coercivity (i.e., H_k relative to H_c) in an alloy magnetic head improves the W_o/W_t ratio, thus to better assure achieving the domain configuration of Fig. 1a. Hence, if the ratio of H_k/H_c is kept relatively high (with H_k and H_c at acceptable levels discussed below) then the domain structure of Fig. 1a can be obtained.

We have recognized that the H_k/H_c ratio can be favorably controlled. More specifically, we have found that as cobalt is added to a nickel-iron alloy, both the H_c and H_k increase, although at different rates. This can be discerned from a comparison of graphs 2a and 2b. In graph 2a, H_c , in Oersteds (1 Oersted $\simeq 80\text{A/m}$), is plotted as a function of weight percent of cobalt in the deposited film. In Figure 2b, plated film H_k , in Oersteds, is plotted as a function of weight percent cobalt in the film. It will thus be seen that the rate of increase in H_c becomes more rapid where cobalt content is above approximately 25% by weight, while H_k increases rather monotonically as percent cobalt content increases. Hence, by prudent selection of cobalt content, acceptable levels of H_k and H_c will be obtained at around or below 25% cobalt by weight, in a nickel-iron alloy pole. Thus, by adjusting cobalt, the H_k/H_c ratio can be optimized for a given pole.

In addition, we have also discovered that annealing further improves the H_k/H_c ratio in plated films. In fact, while there is little or no change in H_c upon annealing, there is significant increase in H_k . The change in H_k due to the anneal appears to be a linear function of the cobalt content. Our test results confirm such belief, at least within the range of zero to about forty-three percent cobalt by weight, as indicated in Fig. 2c.

Furthermore, we believe that too little cobalt can yield a pole with too low H_k , with low permeance, with high Barkhausen noise and lack of consistent process results. Too much cobalt can raise coercivity too high and can substantially reduce permeability, thus yielding a pole with low permeance.

Permeance P is defined as the product of permeability μ , pole width W_t (affected by mask dimensions) and pole thickness T (affected by deposition parameters). Permeance is functionally related to H_k for a given

en pole width W_p , as shown in Fig. 2. A maximum value of P for a given pole width can be obtained by testing samples having various levels of permeability and thickness (having that pole width). Permeance can be measured in a conventional manner.

Thus we can now relate domain configuration, cobalt content, H_k , H_c , their ratio, P , and the W_o/W_t ratio. In the example of a three micron nickel-iron alloy, if cobalt content is low, H_k will be low (see Fig. 2b); since H_k is low, P will be relatively low (see region A of Fig. 2, curve $W_t = 3\mu$) and the H_k/H_c ratio will be relatively low (compare Figs. 2a, 2b). If cobalt is high, H_k will be high (see Fig. 2b); since H_k is high, P will be relatively low (see region B of Fig. 2, curve $W_t = 3\mu$); and since H_c also will be high (see Fig. 2a), the H_k/H_c ratio again will be relatively low.

Permeance will be highest in such pole (see region C of Fig. 2, curve $W_t = 3\mu$) when an appropriate value of H_k is selected for a given pole permeability, thickness and width. The H_k/H_c ratio can be optimized when an appropriate cobalt content is selected according to Figs. 2a, 2b. The highest H_k/H_c ratio will be obtained after adjusting cobalt content by annealing. Thus, the W_o/W_t ratio, which reflects the H_k/H_c ratio, also will be favorably improved resulting in a non-zero W_o/W_t ratio (preferably in the range of .5 to .7), with H_c at an acceptably low level, so as to avail the desired domain configuration of Fig. 1a.

In practice of the present invention, a preferred method for forming at least one pole of a magnetic transducer for a chosen pole width includes determining maximum desired P , relating that P to a target H_k as in Fig. 2, relating that target H_k (as an annealed value) to a known cobalt bath concentration which yields test samples having the target H_k (after anneal), and then forming a pole in a bath having that concentration, the pole then being annealed to achieve the target H_k of Fig. 2.

A preferred method and apparatus will now be described in relation to Figs. 3a, 3b, and includes electrodeposition of a cobalt-containing nickel-iron alloy 23 from bath 34 through the openings of a microlithographically defined resist mask pole pattern 24 onto a conductive metallized surface 26 on a wafer substrate 22. The wafer 22 is mounted on a cathode fixture 28, and is immersed in plating bath 34 in plating cell 30. An anode 32 is provided in the bath to complete the plating circuit.

Current is supplied to the cell by means of an external power supply (I) to induce deposition of the metal film from the plating bath 34. The plating bath includes metal salts of nickel, iron and cobalt, as well as buffering agent, stress controlling agent and surfactant, and may be otherwise operated in a conventional manner.

Magnetic source 36 is arranged about plating cell 30 so that the surface of wafer 22 is within a uniform uniaxial orienting magnetic field (arrow F) during

electrodeposition. The field is applied parallel to the easy axis (arrow EA) of the pole, and perpendicular to pole length (arrow L).

The present invention may be practiced with a modified Watt's bath. A preferred bath which yielded favorable results is shown below:

109g/l nickelous chloride (hydrated),

25g/l boric acid,

.8g/l sodium saccharin,

.2g/l sodium lauryl sulphate,

1-2g/l ferrous chloride (hydrated),

0-9.75g/l cobaltous chloride (hydrated and preferably 3.65g/l),

pH~2.5,

T~25C, and Current density in the range of 5-10 milliamp/cm².

Alternative methods for producing desired films might include, but are not restricted to: sputter deposition, vacuum evaporation, ion plating, sput cooling, and electroless deposition. Furthermore, other bath compositions and other alloys than described above are contemplated within the spirit and scope of the present invention.

In the post-deposition stage, the wafer is annealed preferably in a vacuum in a magnetic field greater than the calculated demagnetization field of the pole tip. The axis of the applied field is parallel to the easy axis of the plated film. This process results in the change in H_k as shown in Fig. 2c.

In one embodiment, we sought to produce a film with a final H_k of 12 Oersteds (955A/m). We plated films in a bath with a concentration of cobalt chloride hexahydrate of 3.65 grams per liter, which resulted in films having an H_k of 9 Oersteds (716A/m). Several samples had an H_k of 12 Oersteds (955A/m) after annealing at about 240 degrees centigrade for about eight hours in a magnetic field of approximately 1100 Oersted (87.5kA/m) parallel to the pole easy axis. The cobalt content in our samples ranged from 21 to 24 weight percent. One film composition which yielded a post-anneal H_k of 12 Oersteds (955A/m) was about 64.5 percent nickel, 13.5 percent iron and 22 percent cobalt by weight.

In practice of the present invention, the H_k/H_c ratio, at least for cobalt between about zero and 25 percent weight, is preferably in the range of 25 to 118. At 22 percent cobalt by weight, we achieved a H_k/H_c ratio of about 109.

In practice of the present invention, it is possible to raise saturation flux density (B_s) of the plated pole to provide an extra writing ability for high linear density applications. In particular, the B_s of a plated nickel-iron film increases as cobalt content of the film increases, since high B_s cobalt is substituted for lower B_s nickel-iron. Hence, our higher cobalt films favorably exhibit a raised B_s , perhaps up to about 1.3 Wb/m² (13,000 Gauss).

In addition to the foregoing, a preferred embodi-

ment of the present invention further includes minimizing the effect of the $\frac{3d\lambda}{M_s}$ factor in the effective H_k ,

to ease process requirements, while we boost the intrinsic H_k of the formed device for an acceptably low level of H_c to achieve a desirable W_c/W_t ratio in a high permeance pole with lowered probability of Barkhausen noise. Preferably, magnetostriction is maintained on the negative side of, and near, zero, preferably in the range of -5.3×10^{-7} to zero, at least for cobalt at or below 25 percent by weight. We measure magnetoelastic sensitivity of a sample plated film and then adjust nickelous chloride and ferrous chloride bath concentrations accordingly and in a conventional manner so that the next sample is at or closer to desired magnetostrictive composition.

While the above discussion has been addressed to magnetic poles, a distinction may be drawn between pole tip and pole yoke regions. The values of P , H_k , and H_c may differ from pole tip to pole yoke, and optimization of these variables for a given device must be considered in the light of such differences.

Other embodiments are within the claims.

Claims

1. A process for forming and annealing at least one pole of a magnetic device, comprising the steps of:
 - a) determining a desired permeance (P) for a chosen pole width (W_p), and
 - b) relating that permeance (P) to an anisotropy field (H_k) for a pole having the chosen pole width (W_p),
 the process further being characterised by comprising the steps of:
 - c) determining a concentration of cobalt that is needed in a mixture of deposition material from which the pole is to be formed so that the pole, after being annealed, will have approximately said anisotropy field (H_k) that is related to the desired permeance (P),
 - d) forming the at least one pole from the mixture of deposition material, the pole having approximately the desired cobalt concentration and having an initial anisotropy field of a strength less than that of said anisotropy field (H_k) that is related to the desired permeance (P), and
 - e) annealing the pole in a manner selected to cause the initial anisotropy field of the pole to increase to approximately said anisotropy field (H_k) that is related to the desired permeance (P).
2. The process of claim 1 wherein said desired per-

meance (P) is a maximum permeance for said chosen pole width (W_p).

3. The process of claim 1 where the coercivity (H_c) of the formed pole is at or below 1 Oersted (80A/m).
4. The process of claim 1 wherein the formed pole, at the pole tip, is about 3 microns wide.
5. The process of claim 4 wherein the formed pole, at the pole tip, is greater than one micron thick and has a permeability (μ) of less than 1500.
6. The process of claim 1 wherein the anisotropy field (H_k) that is related to the desired permeance (P) is in the range of 3 to 14 Oersteds (239 to 1114A/m)
7. The process of claim 1 wherein the pole anisotropy is about 9 Oersteds (716A/m) before annealing.
8. The process of claim 1 wherein the pole anisotropy is about 12 Oersteds (955A/m) after annealing.
9. The process of claim 1 wherein the mixture of deposition material is a nickel-iron-cobalt plating bath (34) that produces a deposit (23) having cobalt content that is no greater than about 25 % by weight.
10. The process of claim 1 wherein the formed pole has a cobalt that is no greater than about 25 % by weight.
11. The process of claim 1 wherein step d) includes forming the pole having magnetostriction in the range of about -5.3×10^{-7} to zero.
12. The process of claim 1 wherein step d) includes the substep of forming the pole in a bath concentration having cobalt chloride hexahydrate at about 3.65 grams per litre.
13. The process of claim 1 wherein the composition of the annealed pole product has a cobalt content that is no greater than about 25% by weight.
14. The process of claim 1 wherein step d) includes obtaining a ratio of W_c/W_t in the range of about 0.5 to 0.7.
15. The process of claim 1 wherein the mixture of deposition material is a modified Watt's bath (34) including nickelous chloride,



ment of the present invention further includes minimizing the effect of the $\frac{3d\lambda}{M_s}$ factor in the effective H_k ,

to ease process requirements, while we boost the intrinsic H_k of the formed device for an acceptably low level of H_c to achieve a desirable W_o/W_i ratio in a high permeance pole with lowered probability of Barkhausen noise. Preferably, magnetostriction is maintained on the negative side of, and near, zero, preferably in the range of -5.3×10^{-7} to zero, at least for cobalt at or below 25 percent by weight. We measure magnetoelastic sensitivity of a sample plated film and then adjust nickelous chloride and ferrous chloride bath concentrations accordingly and in a conventional manner so that the next sample is at or closer to desired magnetostrictive composition.

While the above discussion has been addressed to magnetic poles, a distinction may be drawn between pole tip and pole yoke regions. The values of P , H_k , and H_c may differ from pole tip to pole yoke, and optimization of these variables for a given device must be considered in the light of such differences.

Other embodiments are within the claims.

Claims

1. A process for forming and annealing at least one pole of a magnetic device, comprising the steps of:

- a) determining a desired permeance (P) for a chosen pole width (W_i), and
- b) relating that permeance (P) to an anisotropy field (H_k) for a pole having the chosen pole width (W_i).

the process further being characterised by comprising the steps of:

- c) determining a concentration of cobalt that is needed in a mixture of deposition material from which the pole is to be formed so that the pole, after being annealed, will have approximately said anisotropy field (H_k) that is related to the desired permeance (P),

- d) forming the at least one pole from the mixture of deposition material, the pole having approximately the desired cobalt concentration and having an initial anisotropy field of a strength less than that of said anisotropy field (H_k) that is related to the desired permeance (P), and

- e) annealing the pole in a manner selected to cause the initial anisotropy field of the pole to increase to approximately said anisotropy field (H_k) that is related to the desired permeance (P).

2. The process of claim 1 wherein said desired per-

meance (P) is a maximum permeance for said chosen pole width (W_i).

3. The process of claim 1 where the coercivity (H_c) of the formed pole is at or below 1 Oersted (80A/m).

4. The process of claim 1 wherein the formed pole, at the pole tip, is about 3 microns wide.

5. The process of claim 4 wherein the formed pole, at the pole tip, is greater than one micron thick and has a permeability (μ) of less than 1500.

6. The process of claim 1 wherein the anisotropy field (H_k) that is related to the desired permeance (P) is in the range of 3 to 14 Oersteds (239 to 1114A/m)

7. The process of claim 1 wherein the pole anisotropy is about 9 Oersteds (716A/m) before annealing.

8. The process of claim 1 wherein the pole anisotropy is about 12 Oersteds (955A/m) after annealing.

9. The process of claim 1 wherein the mixture of deposition material is a nickel-iron-cobalt plating bath (34) that produces a deposit (23) having cobalt content that is no greater than about 25 % by weight.

10. The process of claim 1 wherein the formed pole has a cobalt that is no greater than about 25 % by weight.

11. The process of claim 1 wherein step d) includes forming the pole having magnetostriction in the range of about -5.3×10^{-7} to zero.

12. The process of claim 1 wherein step d) includes the substep of forming the pole in a bath concentration having cobalt chloride hexahydrate at about 3.65 grams per litre.

13. The process of claim 1 wherein the composition of the annealed pole product has a cobalt content that is no greater than about 25% by weight.

14. The process of claim 1 wherein step d) includes obtaining a ratio of W_o/W_i in the range of about 0.5 to 0.7.

15. The process of claim 1 wherein the mixture of deposition material is a modified Watt's bath (34) including nickelous chloride,



sodium saccharin,
ferrous chloride, and
cobaltous chloride.

16. The process of claim 1 wherein the product of step d) has a saturation flux density of about 1.3 Wb/m² (13000 Gauss).

17. The process of claim 1 wherein the pole has a transverse easy axis and the annealing is performed by baking the pole in a vacuum at about 240 degrees centigrade for about 8 hours in an orienting magnetic field parallel to the easy axis of the pole.

18. The process of claim 17 wherein the orienting field is about 1,100 Oersteds (87.5kA/m) or more.

19. The process of claim 1 wherein the pole is formed by sputter deposition onto a substrate, vacuum evaporation, ion plating, sput cooling, electro-deposition onto a substrate, or electroless deposition onto a substrate.

20. A process for forming a pole of a magnetic device, comprising the steps of:

a) determining a desired permeance (P) for a chosen pole width (W_p), and

b) relating that permeance (P) to an anisotropy field (H_k) for a pole having the chosen pole width (W_p),

the process by which said pole is produced being further characterised by comprising the steps of:

c) determining a concentration of cobalt that is needed in a mixture of deposition material from which the pole is to be formed so that the pole will have approximately said anisotropy field (H_k) that is related to the desired permeance (P), and

d) forming a cobalt alloy pole from the mixture of deposition material while maintaining magnetostriction in the range of about -5.3×10^{-7} to zero and controlling cobalt content to select the strength of the anisotropy field (H_k) of the pole, the anisotropy field (H_k) of the pole being such that the pole has approximately the desired pole permeance (P).

21. The process of claim 20 further comprising the steps of defining a pole pattern (24) on a metallized surface (26) of a wafer (22), mounting the wafer (22) on a cathode fixture (28), immersing it in a plating bath (34), and forming the pole in accordance with the pole pattern (24), and

the bath (34) is a modified Watt's bath including nickelous chloride, sodium saccharin, ferrous chloride, and cobaltous chloride.

Patentansprüche

1. Verfahren zum Ausbilden und Ausglühen wenigstens eines Pols einer magnetischen Vorrichtung, das folgende Schritte aufweist:

a) Bestimmen einer gewünschten Permeanz (P) für eine gewählte Polbreite (W_p), und

b) Beziehen jener Permeanz (P) auf ein anisotropes Feld (H_k) für einen Pol mit der gewählten Polbreite (W_p), wobei das Verfahren weiterhin durch folgende Schritte gekennzeichnet ist:

c) Bestimmen einer Kobaltkonzentration, die in einer Mischung eines Ablagerungsmaterials nötig ist, aus dem der Pol auszubilden ist, so daß der Pol, nachdem er ausgeglüht ist, in etwa das anisotrope Feld (H_k) aufweisen wird, auf das die gewünschte Permeanz (P) bezogen ist,

d) Ausbilden des wenigstens einen Pols aus der Mischung des Ablagerungsmaterials, wobei der Pol in etwa die gewünschte Kobaltkonzentration aufweist und ein anfängliches anisotropes Feld einer Stärke aufweist, die geringer als jene des anisotropen Feldes (H_k) ist, auf das die gewünschte Permeanz (P) bezogen ist, und

e) Ausglühen des Pols auf eine Weise, die derart ausgewählt wird, daß das anfängliche anisotrope Feld des Pols veranlaßt wird, sich in etwa auf das anisotrope Feld (H_k) zu erhöhen, auf das die gewünschte Permeanz (P) bezogen ist.

2. Verfahren nach Anspruch 1, wobei die gewünschte Permeanz (P) für die gewählte Polbreite (W_p) eine maximale Permeanz ist.

3. Verfahren nach Anspruch 1, wobei die Koerzitivkraft (H_c) des ausgebildeten Pols bei oder unter 1 Oersted (80 A/m) ist.

4. Verfahren nach Anspruch 1, wobei der ausgebildete Pol an der Polspitze etwa 3 Mikron breit ist.

5. Verfahren nach Anspruch 4, wobei der ausgebildete Pol an der Polspitze eine größere Dicke als ein Mikron und eine Permeabilität (μ) von weniger als 1500 hat.

6. Verfahren nach Anspruch 1, wobei das anisotrope Feld (H_k), auf das die gewünschte Permeanz (P) bezogen ist, eine Feldstärke in dem Bereich von 3 bis 14 Oersted (239 bis 1114 A/m) hat.

7. Verfahren nach Anspruch 1, wobei die Pol-Anisotropie vor dem Ausglühen etwa 9 Oersted (716 A/m) ist.



8. Verfahren nach Anspruch 1, wobei die Pol-Anisotropie nach dem Ausglühen etwa 12 Oersted (955 A/m) ist.
9. Verfahren nach Anspruch 1, wobei die Mischung des Ablagerungsmaterials ein Nickel-Eisen-Kobalt-Plattierungsbad (34) ist, das eine Ablagerung (23) mit einem Kobaltinhalt erzeugt, der nicht größer als etwa 25 Gew.-% ist.
10. Verfahren nach Anspruch 1, wobei der ausgebildete Pol Kobalt von nicht mehr als etwa 25 Gew.-% aufweist.
11. Verfahren nach Anspruch 1, wobei der Schritt d) ein Ausbilden des Pols mit einer Magnetostriktion in dem Bereich von etwa $-5,3 \times 10^{-7}$ bis Null enthält.
12. Verfahren nach Anspruch 1, wobei der Schritt d) den Unterschritt des Ausbildens des Pols in einem Bad mit Kobalt-Chlorid-Hexahydrat mit einer Konzentration von etwa 3,65 Gramm pro Liter enthält.
13. Verfahren nach Anspruch 1, wobei die Zusammensetzung des ausgeglühten Pol-Produkts einen Kobaltinhalt von nicht mehr als etwa 25 Gew.-% hat.
14. Verfahren nach Anspruch 1, wobei der Schritt d) ein Erhalten eines Verhältnisses von W_d/W_t in dem Bereich von etwa 0,5 bis 0,7 enthält.
15. Verfahren nach Anspruch 1, wobei die Mischung des Ablagerungsmaterials ein modifiziertes Wattssches Bad (34) ist, das folgendes enthält:
Nickel-(II)-Chlorid,
Natrium-Saccharin,
Eisen-(II)-Chlorid, und
Kobalt-(II)-Chlorid.
16. Verfahren nach Anspruch 1, wobei das Produkt des Schrittes d) eine Sättigungsflußdichte von etwa $1,3 \text{ Wb/m}^2$ (13000 Gauß) hat.
17. Verfahren nach Anspruch 1, wobei der Pol eine transversale leicht zugängliche Achse hat, und das Ausglühen durch Backen des Pols in Vakuum bei etwa 240 Grad Celsius für etwa 8 Stunden in einem ausrichtenden Magnetfeld parallel zu der leicht zugänglichen Achse des Pols durchgeführt wird.
18. Verfahren nach Anspruch 17, wobei das ausrichtende Feld eine Feldstärke von etwa 1,100 Oersted (87,5 kA/m) oder mehr hat.
19. Verfahren nach Anspruch 1, wobei der Pol durch eine Sputterablagerung auf ein Substrat, eine Vakuumverdampfung, ein Ionenplattieren, ein SpritzKühlen, eine Elektroablagerung auf ein Substrat oder eine elektrolytische Ablagerung auf ein Substrat ausgebildet wird.
20. Verfahren zum Ausbilden eines Pols einer magnetischen Vorrichtung, das folgende Schritte aufweist:
 - a) Bestimmen einer gewünschten Permeanz (P) für eine gewählte Polbreite (W_p), und
 - b) Beziehen jener Permeanz (P) auf ein anisotropes Feld (H_k) für einen Pol mit der gewählten Polbreite (W_p), wobei das Verfahren, durch das der Pol hergestellt wird, weiterhin dadurch gekennzeichnet ist, daß es folgende Schritte aufweist:
 - c) Bestimmen einer Kobaltkonzentration, die in einer Mischung eines Ablagerungsmaterials nötig ist, aus dem der Pol auszubilden ist, so daß der Pol in etwa das anisotrope Feld (H_k) aufweisen wird, auf das die gewünschte Permeanz (P) bezogen ist, und
 - d) Ausbilden eines Kobaltlegierungs-Pols aus der Mischung des Ablagerungsmaterials, während eine Magnetostriktion in dem Bereich von etwa $-5,3 \times 10^{-7}$ bis Null beibehalten wird, und Steuern des Kobaltinhaltes, um die Feldstärke des anisotropen Feldes (H_k) des Pols auszuwählen, wobei das anisotrope Feld (H_k) des Pols derart ist, daß der Pol in etwa die gewünschte Pol-Permeanz (P) aufweist.
21. Verfahren nach Anspruch 20, das weiterhin folgende Schritte aufweist: Definieren eines Pol-Musters (24) auf einer metallisierten Oberfläche (26) eines Wafers (22), Anbringen des Wafers (22) an einer Kathoden-Befestigungseinrichtung (28), Eintauchen davon in ein Plattierungsbad (34), und Ausbilden des Pols in Übereinstimmung mit dem Pol-Muster (24), wobei das Bad (34) ein modifiziertes Wattssches Bad ist, das Nickel-(II)-Chlorid, Natrium-Saccharin, Eisen-(II)-Chlorid und Kobalt-(II)-Chlorid enthält.

Revendications

1. Procédé pour former et recuire au moins un pôle d'un dispositif magnétique, comprenant les étapes qui consistent à :
 - a) déterminer une perméance (P) voulue pour une largeur de pôle (W_p) choisie, et
 - b) établir une relation entre cette perméance (P) et un champ d'anisotropie (H_k) pour un pôle ayant la largeur de pôle (W_p) choisie, le procédé étant, en outre, caractérisé en ce



- qu'il comprend les étapes qui consistent à :
- c) déterminer une concentration de cobalt nécessaire dans un mélange de matériau de dépôt à partir duquel le pôle doit être formé afin que celui-ci ait, une fois recuit, approximativement ledit champ d'anisotropie (H_k) en relation avec la perméance (P) voulue,
 - d) former ledit pôle à partir du mélange de matériau de dépôt, le pôle ayant approximativement la concentration de cobalt voulue et un champ d'anisotropie initial doté d'une force inférieure à celle dudit champ d'anisotropie (H_k) en relation avec la perméance (P) voulue, et
 - e) recuire le pôle d'une manière sélectionnée pour provoquer une augmentation du champ d'anisotropie initial du pôle afin qu'il atteigne approximativement ledit champ d'anisotropie (H_k) en relation avec la perméance (P) voulue.
2. Procédé selon la revendication 1, dans lequel ladite perméance (P) voulue est une perméance maximale pour ladite largeur de pôle (W_p) choisie.
 3. Procédé selon la revendication 1, dans lequel la coercitivité (H_c) du pôle formé se situe au niveau ou au-dessous de 1 Oersted (80A/m).
 4. Procédé selon la revendication 1, dans lequel le pôle formé a, au niveau de sa pointe polaire, une largeur d'environ 3 microns.
 5. Procédé selon la revendication 4, dans lequel le pôle formé a, au niveau de sa pointe polaire, une épaisseur supérieure à un micron et une perméabilité (μ) inférieure à 1500.
 6. Procédé selon la revendication 1, dans lequel le champ d'anisotropie (H_k) en relation avec la perméance (P) voulue se situe dans la plage de 3 à 14 Oersteds (239 à 1114A/m).
 7. Procédé selon la revendication 1, dans lequel l'anisotropie du pôle est d'environ 9 Oersteds (716A/m) avant recuit.
 8. Procédé selon la revendication 1, dans lequel l'anisotropie du pôle est d'environ 12 Oersteds (955A/m) après recuit.
 9. Procédé selon la revendication 1, dans lequel le mélange de matériau de dépôt est un bain de métallisation de nickel-fer-cobalt (34) qui produit un dépôt (23) ayant une teneur en cobalt ne dépassant pas environ 25% en poids.
 10. Procédé selon la revendication 1, dans lequel le pôle formé a une teneur en cobalt qui ne dépasse pas environ 25% en poids.
 11. Procédé selon la revendication 1, dans lequel l'étape d) comprend la formation du pôle qui a une magnétostriction dans la plage d'environ $-5,3 \times 10^{-7}$ à zéro.
 12. Procédé selon la revendication 1, dans lequel l'étape d) comprend la sous-étape de formation du pôle dans un bain ayant une concentration d'hexahydrate de chlorure de cobalt d'environ 3,65 grammes par litre.
 13. Procédé selon la revendication 1, dans lequel la composition du pôle recuit produit a une teneur en cobalt ne dépassant pas environ 25% en poids.
 14. Procédé selon la revendication 1, dans lequel l'étape d) comprend l'obtention d'un rapport de W_p/W_t qui se situe dans la plage d'environ 0,5 à 0,7.
 15. Procédé selon la revendication 1, dans lequel le mélange de matériau de dépôt est un bain de Watt modifié (34) contenant du chlorure de nickel de la saccharine de sodium du chlorure ferreux, et du chlorure de cobalt.
 16. Procédé selon la revendication 1, dans lequel le produit de l'étape d) a une densité de flux de saturation d'environ $1,3 \text{ Wb/m}^2$ (13000 Gauss).
 17. Procédé selon la revendication 1, dans lequel le pôle a un axe d'aimantation facile transversal, et le recuit est exécuté par une cuisson du pôle sous vide à environ 240 degrés centigrade pendant environ 8 heures dans un champ magnétique d'orientation parallèle à l'axe d'aimantation facile du pôle.
 18. Procédé selon la revendication 17, dans lequel le champ d'orientation est d'environ 1100 Oersteds (87,5kA/m) ou plus.
 19. Procédé selon la revendication 1, dans lequel le pôle est formé par pulvérisation cathodique d'un dépôt sur un substrat, évaporation sous vide, métallisation ionique, refroidissement par aspersion, dépôt électrolytique sur un substrat, ou dépôt sans courant sur un substrat.
 20. Procédé pour former un pôle d'un dispositif magnétique, comprenant les étapes qui consistent à :
 - a) déterminer une perméance (P) voulue pour une largeur de pôle choisie (W_p), et
 - b) établir une relation entre cette perméance



(P) et un champ d'anisotropie (H_k) pour un pôle ayant la largeur de pôle (W_p) choisie, le procédé à l'aide duquel ledit pôle est produit étant, en outre, caractérisé en ce qu'il comprend les étapes qui consistent à :

c) déterminer une concentration de cobalt nécessaire dans un mélange de matériau de dépôt à partir duquel le pôle doit être formé afin que celui-ci ait approximativement ledit champ d'anisotropie (H_k) en relation avec la perméance (P) voulue, et

d) former un pôle en alliage de cobalt à partir du mélange de matériau de dépôt tout en maintenant une magnétostriction dans la plage d'environ $-5,3 \times 10^{-7}$ à zéro et en contrôlant la teneur en cobalt pour sélectionner la force du champ d'anisotropie (H_k) du pôle, le champ d'anisotropie (K_k) du pôle étant tel que le pôle a approximativement la perméance polaire (P) voulue.

21. Procédé selon la revendication 20, comprenant, en outre, les étapes qui consistent à définir un motif de pôle (24) sur une surface métallisée (26) d'une plaquette (22), à monter la plaquette (22) sur un support de cathode (28), à l'immerger dans un bain de métallisation (34), et à former le pôle conformément au motif de pôle (24), le bain (34) étant un bain de Watt modifié contenant du chlorure de nickel, de la saccharine de sodium, du chlorure ferreux, et du chlorure de cobalt.

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