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Signed this 13th day of October 1993



R. W. GRAY

For and on behalf of RWS Translations Ltd.

The present invention relates to a magnetic read/write head with an abrasion-resistant layer and, more particularly, a magnetic head which includes on its surface in contact with the magnetic recording medium, a wear-resistant layer. The invention also relates to a process for making such an abrasion-resistant layer.

Magnetic heads produced with a ferrite substrate, such as current home-video (VHS) very-high-definition heads, subjected to tape moving past at 5ms^{-1} , or current digital heads (3.32 ms^{-1}) known by the designation RDAT (Rotary Digital Audio Tape), undergo a slow erosion which renders them unusable after 2,000 hours of use. At the all [sic] of such an operating time, the head can in fact be worn away by 20 micrometers in height.

One solution to the problem of wear is to deposit an abrasion-resistant layer on the head. This idea of producing a protective layer at the surface of a magnetic head is found in document EP-A-0,241,371. Unfortunately, materials such as carbon find it very difficult to cling to the ferrite and, given the heterogeneity of the materials which may form a magnetic head, such as ferrite, alumina or glass, the carbon layer turns out to be difficult to deposit.

The invention makes it possible to solve this problem of depositing an abrasion-resistant layer on a magnetic head and, especially, on the surface of the head in contact with a magnetic recording medium.

The invention therefore relates to a magnetic read/write head comprising two magnetic poles separated by a gap made of non-magnetic material, characterised in that it also includes:

- on each magnetic pole, a layer of a magnetic material having a high coefficient of adhesive bonding to the magnetic poles and to which a carbon-based layer has a high coefficient of adhesive bonding, this layer covering just the magnetic poles alone;

- on both the layers of magnetic material and on the gap, an abrasion-resistant layer of a carbon-based material.

The invention also relates to a magnetic read/write head comprising two magnetic poles separated by a gap made from non-magnetic material, characterised in that it also includes clinging layers, made of a magnetic material having a high coefficient of adhesive bonding to the magnetic poles, covering just the magnetic poles alone, the non-covered zones being occupied by a non-magnetic material, both the clinging layers and the non-magnetic material being covered by an abrasion-resistant layer having a high coefficient of adhesive bonding to the material of the clinging layers.

The invention also relates to a process for making a magnetic read/write head according to any one of the preceding claims, characterised in that it includes the following various steps:

- a first step for making, on the active face of one of the magnetic poles of the magnetic head, a first clinging layer;
- a second step for making, on the first clinging layer, on the gap and on the second magnetic pole, a layer of a non-magnetic material;
- a third step for making, on the layer of non-magnetic material, a second clinging layer;
- a fourth step for machining the second clinging layer and the layer of non-magnetic material until the first clinging layer is reached;
- a fifth step for making, on the two clinging layers and on that part of the layer of non-magnetic material which remains between the two clinging layers, a layer of an abrasion-resistant material until the first clinging layer is reached; [sic]

The various objects and characteristics of the invention will appear more clearly with the aid of the description which follows, given with reference to the appended figures which represent:

- Figure 1, an embodiment of a magnetic head according to the invention;
- Figure 2, an alternative embodiment of the magnetic head of Figure 1;

- Figure 3, a planar magnetic head according to the invention, in plan view;

- Figure 4, a sectional view of a magnetic head made from thin layers,

5 - Figures 5 to 7, various steps of a production process according to the invention.

Referring to Figure 1, one embodiment of a magnetic head according to the invention will first of all be described.

10 This magnetic head includes two magnetic poles P1 and P2 made from ferrite-based magnetic material. The two magnetic poles P1, P2 are separated by a gap E1 made from alumina ($Al_2 O_3$) - or silica ($Si O_2$) - based non-magnetic material.

15 Such a magnetic head has to be covered with a layer made from hard abrasion-resistant material. Such a layer will preferably have a carbon-based composition. However, it is found that carbon clings poorly to the ferrite.

20 According to the invention, as is represented in Figure 1 a clinging layer S1, S2 made from magnetic material is provided on each magnetic pole P1, P2.

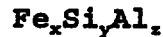
 The material forming the layers S1, S2 has a composition such that it clings well to the ferrite of
25 the magnetic poles S1 [sic], S2 [sic] and such that the abrasion-resistant layer C1 clings equally well to this material.

 An abrasion-resistant layer C1, such as a carbon-based layer, is deposited on the layers S1, S2.

30 The invention intends, and this is important, for the layers S1, S2 to be made from magnetic material in order to avoid these forming additional gaps. They must have the property of adhesively bonding effectively to the magnetic poles and a carbon-based abrasion-resistant
35 layer must also adhesively bond effectively to these layers S1, S2.

 According to the invention, the layers S1, S2 will be based on a material of the type known in the art by the name Sendust. Sendust is a magnetic material of

general formula:



in which, for example:

- x lies between 70 and 85 (i.e. 80, for example)
- 5 - y lies between 5 and 15 (i.e. 10, for example)
- z lies between 5 and 15 (i.e. 10, for example).

It has been found, and confirmed experimentally, that Sendust clings very well to the ferrite and carbon to Sendust. For the compositions indicated hereinabove it possesses the magnetic properties of the ferrite. However, any intermediate composition is possible. In particular, it is possible to add a fourth element, such as carbon, which gives a general formula:



15 in which: $x + y + z + t = 100$

and, since in the formulae the iron, silicon and aluminum compositions are substantially the same as previously, t lies between 0 and 15.

The layers S1, S2 may also be made from another magnetic material having the adhesive-bonding properties described previously. For example, this material may be an alloy of Nickel and Iron, NiFe, such as commonly designated in the technical literature by the name Permalloy.

25 Since the magnetic poles P1, P2 made from ferrite are covered with clinging layers S1 and S2, an abrasion-resistant layer C1 covering the layers S1 and S2 will protect the magnetic head from wear by a magnetic recording medium, such as a magnetic tape B1 running past the head and rubbing on the abrasion-resistant layer C1.

30 In Figure 1, it should be noted that the clinging layers S1, S2 are separated at the location of the gap E1 by a space forming a gap E2. The abrasion-resistant layer C1 therefore fills this gap.

35 In order to avoid, as represented in Figure 1, the surface of the abrasion-resistant layer C1 having a hollow in the region of the gap E2, it is intended to polish the abrasion-resistant layer C1. It is also intended, according to the alternative embodiment in

Figure 2, for the gap E2 to include a non-magnetic material, such as alumina, Al_2O_3 , or silica (SiO_2) or a material based on one of these compositions. The surface of the abrasion-resistant layer C1 is then an even surface.

Figure 3 represents a plan view of the planar magnetic head.

Two magnetic poles P1, P2, located on a substrate, face each other and are separated by a gap E1.

As previously, the magnetic poles are covered with clinging layers S1, S2. These layers are separated by a gap E2 and both these layers and the gap are covered by an abrasion-resistant layer.

However, such a planar head has to have a gap width L (1 to 3 micrometres) which is smaller than the substrate. The magnetic poles therefore have narrowed regions at the approaches of the gap, as represented in Figure 3. The clinging layers S1, S2 must cover just the magnetic poles alone and must not extend beyond the substrate carrying the poles in order to prevent these clinging layers S1, S2, which are made from magnetic material, from increasing the width L of the gap E1 or from short-circuiting the gap E1.

The zones not covered by the magnetic poles P1, P2 on either side of the narrowed regions, are therefore occupied by a non-magnetic material V1, V2, such as a silica (SiO_2) - or alumina (Al_2O_3) - based material. This material is flush with the upper part of the clinging layers S1, S2 so as to form a smooth surface.

Both the clinging layers S1, S2 and the non-magnetic material (V1, V2) are covered with the abrasion-resistant layer C1 (not shown in Figure 3) as shown in Figure 2. A planar-magnetic-head surface is obtained which is perfectly smooth and has a high resistance to any wear due to rubbing against the recording medium.

The magnetic heads of Figures 1 and 2 can be of the type comprising metal layers on each side of the gap, of the MIG (Metal in Gap) type. The invention applies likewise to such magnetic heads.

The invention is also applicable to a magnetic head made from thin layers, as represented by Figure 4. The magnetic head of Figure 4 includes two layers P1, P2 made from magnetic material forming the magnetic poles. 5 These layers P1, P2 are firmly attached to support materials A1, A2, such as alumina, and are separated by a gap E1. The active part of the magnetic head supports two clinging layers S1, S2, made from sendust for example, which are separated by a gap E2. Both the layers 10 S1, S2 and the gap E2 are covered with an abrasion-resistant layer C1.

Referring to Figures 5 to 7, a process will be described for making the clinging layers S1, S2 and the abrasion-resistant layer C1 according to the invention.

15 The process of the invention is applied, in the description that follows, to any of the magnetic heads described previously.

During a first step, a clinging layer S1, the composition of which is of the type described previously, 20 is made on the active surface of a magnetic head which includes two magnetic poles P1 and P2 separated by a gap E1, and more particularly on the active face of the pole P1.

During a second step, the layer S1 and the 25 magnetic pole P2 are covered with a layer E3 of a non-magnetic material. A structure shown in Figure 5 is thus obtained.

During a third step, the layer E3 is covered with a layer S2 made from material identical to that of the 30 layer S1, as is shown in Figure 6.

During a fourth step, the layers E3 and S2 are machined until the layer S1 is reached. No material of the layer E3 thus remains on the magnetic pole S1. On the other hand, between the layers S1 and S2, a part of the 35 layer E3 remains making a gap E2 between the layers S1 and S2.

During a fifth step the assembly is covered with an abrasion-resistant layer C1. A structure as shown in Figure 7 is thus obtained.

According to an alternative embodiment of the process of the invention, if it is desired to prevent any material of the layer E3 from remaining on the magnetic pole P2, provision is made, after the second step for making the layer E3, for a phase for etching the layer E3 allowing just the material necessary to make the gap E2 so as has [sic] obtain an embodiment in accordance with, for example, Figures 2 and 4.

By way of example, the thickness of the Sendust-based clinging layer can be 100 Ångströms and that of the carbon-based abrasion-resistant layer also 10 nanometres (100 Ångströms).



CLAIMS

1. Magnetic read/write head comprising two magnetic poles (P1, P2) separated by a gap (E1) made of non-magnetic material, characterised in that it also
5 includes:
- on each magnetic pole (P1, P2), a layer (S1, S2) of a magnetic material having a high coefficient of adhesive bonding to the magnetic poles (P1, P2) and to which a carbon-based layer has a high coefficient of adhesive
10 bonding, this layer covering just the magnetic poles alone;
- on both the layers (S1, S2) of magnetic material and on the gap (E1), an abrasion-resistant layer (C1) of a carbon-based material.
- 15 2. Magnetic read/write head according to Claim 1, characterised in that the magnetic poles are made from ferrite.
3. Magnetic read/write head according to Claim 1, characterised in that the said layer of magnetic material
20 is based on $\text{Fe}_x\text{Si}_y\text{Al}_z$.
4. Magnetic read/write head according to Claim 1, characterised in that the said layer of magnetic material is based on Permalloy (Ni F_t).
5. Magnetic read/write head according to Claim 2, characterised in that the magnetic material is based on
25 $\text{Fe}_x\text{Si}_y\text{Al}_z\text{C}_t$ [lacuna] includes the following proportions:
- x = 70 to 85 per cent of iron
- y = 5 to 15 per cent of silicon
- z = 5 to 15 per cent of aluminium
30 - t = 0 to 15 per cent of carbon
the sum, $x + y + z + t$, being equal to 100.
6. Magnetic read/write head of planar shape, according to Claim 1, comprising two magnetic poles (P1, P2) made from thin layers deposited on a substrate (1) and
35 separated by a gap (E1), characterised in that the abrasion-resistant layer (C1) covers equally the zone or zones of the substrate (1) not covered by the magnetic poles P1, P2 and by the gap (E) [sic].



7. Magnetic read/write head according to Claim 1, characterised in that the layers (S1, S2) of magnetic material covering each magnetic pole (P1, P2) are separated from each other by a non-magnetic material (E2).
- 5 8. Magnetic read/write head according to Claim 6, characterised in that the said non-magnetic material (E2) is a silica-based material.
9. Magnetic read/write head according to Claim 6, characterised in that the said non-magnetic material (E2)
- 10 is an alumina-based material.
10. Process for making a magnetic read/write head according to any one of the preceding claims, characterised in that it includes the following various steps:
- a first step for making, on the active face of

15 one of the magnetic poles (P1) of the magnetic head, a first clinging layer (S1);

 - a second step for making, on the first clinging layer (S1), on the gap (E1) and on the second magnetic pole (P2), a layer (E3) of a non-magnetic material;

20 - a third step for making, on the layer (E3) of non-magnetic material, a second clinging layer (S2);

 - a fourth step for machining the second clinging layer (S2) and the layer (E3) of non-magnetic material until the first clinging layer (S1) is reached;

25 - a fifth step for making, on the two clinging layers (S1, S2) and on that part (E2) of the layer of non-magnetic material which remains between the two clinging layers (S1, S2), a layer (C1) of an abrasion-resistant material.
- 30 11. Process according to Claim 10, characterised in that it includes, between the second and the third step, a phase for etching the layer E3 of non-magnetic material so as to keep just that said part (E2) of this layer which is to remain between the two clinging layers (S1,
- 35 S2).
12. Magnetic read/write head comprising two magnetic poles (P1, P2) separated by a gap (E1) made from non-magnetic material, characterised in that it also includes clinging layers (S1, S2), made of a magnetic material



5 having a high coefficient of adhesive bonding to the magnetic poles, covering just the magnetic poles (P1, P2) alone, the non-covered zones being occupied by a non-magnetic material (V1, V2), both the clinging layers (S1, S2) and the non-magnetic material (V1, V2) being covered by an abrasion-resistant layer (C1) having a high coefficient of adhesive bonding to the material of the clinging layers.

10 13. Magnetic read/write head according to Claim 12, characterised in that the upper surface of the non-magnetic material (V1, V2) is flush with the upper surface of the clinging layers (S1, S2) so as to form a smooth surface.