

A BURNISH HEAD

FIELD

- 5 This invention relates to burnishing of a disc, in particular, to a burnish head for levelling irregularities on a disc surface.

BACKGROUND

- 10 Digital data is commonly stored in hard disc drives in concentric circular tracks on the disc surface. Reading and writing of data are carried out by a read/write head which is held very close to a disc and moved from track to track as the disc is spun, such that the head effectively flies over the disc, at a distance commonly known as the flying height. To increase recording density of a disc, individual bit sizes naturally have to be decreased. This requires the flying height to be
15 correspondingly decreased, bringing the head closer to the disc. At such close proximity, the disc surface needs to have a certain smoothness to minimize inadvertent contact between the head and any irregularities such as asperities on the disc surface during normal reading/writing operations.

- Burnishing is a process by which a certain level of smoothness of the disc can be achieved, by
20 reducing irregularities on the disc surface. This is typically carried out by flying a burnish head at a predetermined height over a spinning disc, commonly known as burnish head flying height. This height is necessarily lower than the operational flying height of a read/write head, so that, as the disc spins, any asperities on the disc surface that extend to above the burnish head flying height are mechanically removed by the burnish head. It is essential that the burnish head flying height be
25 well controlled to maintain the proper distance between the burnish head and the disc surface during the burnishing process. This is because the disc is coated with a thin media overcoat for protection, which may be destroyed and lead to disc corrosion if the burnish head flies too close to the disc.

- 30 Burnish heads typically comprise a slider having a plurality of pads. These pads are usually made of the same material as the slider, such as $\text{TiC-Al}_2\text{O}_3$, and can range from 0.2 mm to 0.5 mm. The pads are disposed on a surface of the slider that is facing the disc, which can be called the slider air bearing surface. During burnishing, at least one of these pads comes into contact with the disc to level surface irregularities such as asperities. The pads also generate a positive air pressure that is
35 useful for allowing flying height to be regulated by varying angular velocity of the disc. There

have also been disclosed burnish heads having two air bearing rails, each rail coinciding with the leading edge of the slider and one side of the slider. These rails are intended to provide aerodynamic lift to the slider.

- 5 In the past, burnish heads were manufactured by wheel grinding. This limited the design of the pads to simple geometrical shapes such as diamonds, rectangles and triangles. The most commonly used head used to be one with diamond-shaped pads, having a waffle pattern cut directly into the slider air bearing surface by wheel grinding.
- 10 Today, ion-milling has overtaken wheel grinding as it can produce pads with more complex shapes such as teardrops, ellipses and circles. During ion milling, areas designated to become pads are masked, while unmasked areas are etched away to leave raised pads on the air bearing surface. While pads of such shapes have been reported to reduce disc damage during burnishing, the more fundamental issues of maintaining the burnish head flying height and ensuring flying stability to
- 15 reduce extraneous burnish head movement still need to be addressed in order to improve disk smoothness.

SUMMARY

- 20 According to one aspect, there is provided a burnish head for burnishing a disc. The burnish head comprises a slider having an air bearing surface, a leading edge and a trailing edge. A plurality of pads are disposed on the air bearing surface, and at least one of the plurality of pads is a curved elongated pad.
- 25 According to a second aspect, there is provided an apparatus for levelling surface irregularities on a disc. The apparatus comprises a head assembly supported by suspensions; the suspensions being attached to actuator head mounting arms. The apparatus further comprises a burnish head mounted on the head assembly. The burnish head comprises a slider having an air bearing surface, a leading edge and a trailing edge. A plurality of pads are disposed on the air bearing surface, and at least
- 30 one of the plurality of pads is a curved elongated pad.

BRIEF DESCRIPTION OF THE DRAWINGS

- These and other aspects and advantages of the present invention are described with reference to the
- 35 accompanying drawings, in which:

Figure 1 is a plan view of an air bearing surface of a burnish head in accordance with a preferred embodiment of the present invention;

Figure 2 is a three-dimensional view of the air bearing surface of Figure 1;

5 Figure 3 is a simulated air pressure distribution on the air bearing surface of Figure 2;

Figure 4 is a side view of the air bearing surface of Figure 1 showing simulated air pressure distribution;

Figure 5 is a simulated air flow on the air bearing surface of Figure 1; and

10 Figure 6 is a plan view of an air bearing surface of a burnish head in accordance with a second embodiment of the present invention.

DETAILED DESCRIPTION

15 In accordance with the preferred embodiment of the present invention, Figure 1 and Figure 2 show a slider 12 of a burnish head with an air bearing surface 14 having a leading edge 16 and a trailing edge 18. The slider air bearing surface 14 is 2.0 mm by 1.6 mm in size. The plurality of pads are disposed on the air bearing surface 14 in an array laterally symmetrical about the midline 20 of the slider 12, this midline 20 being parallel to the direction of motion of the burnish head relative to the disc. The plurality of pads include a row of air bearing pads 22 disposed adjacent the leading edge 16 and a row of burnish pads 26 disposed adjacent the trailing edge 18. Two curved elongated pads 28, 30 are also disposed on the air bearing surface 14 substantially between the air bearing pads 22 and the burnish pads 26. The curved elongated pads 28, 30 are also disposed laterally symmetrical about a midline 20. This is to achieve symmetrical air pressure distribution on the slider 12, as shown in Figure 3, in order to minimise roll. Each curved elongated pad 28, 30 begins substantially in the middle of the slider 12 adjacent the midline 20, and curves outwardly to end adjacent the trailing edge 18 away from the midline 20.

The air bearing pads 22 are substantially elliptical and typically larger than the burnish pads 26 which have a substantially tear-drop shape. The tear-drop shape can increase pad area coming into contact with the disc for burnishing, while smoothening air flow to minimize any accumulation of debris around the pads. Each of the air bearing pads 22 has a graduated surface formed by having a step 24 on its surface facing the disc. Each step 24 descends from the trailing portion of the pad to the leading portion of the respective pad, as shown in Figure 2. The air bearing pads 22 generate lift on the slider 12 when, during burnishing, the burnish head is brought into its operating position at a predetermined flying height above the disc and the disc is spun. The generated lift tilts the

slider 12 so that the trailing edge 18 is positioned nearer to the disc than the leading edge 16 is. In this way, at least some of the burnish pads 26 as well as the curved elongated pads 28, 30 come into contact with asperities or unwanted particles on the disc surface, removing them when the disc is spun.

During burnishing, it can be seen from Figure 3 that air pressure is positive over the pads 22, 26 and also the curved elongated pads 28, 30. Positive air pressure at the leading edge 16 helps to stabilise the pitch of the slider 12, while greater air pressure at the outermost portions of the trailing edge 18 increases air bearing stiffness to stabilize the flying height and the roll. At the same time, as can be seen from Figure 4, the curved elongated pads 28, 30 create a region of negative air pressure 40 located nearer the trailing edge 18 than the leading edge 16 of the slider air bearing surface 14. This negative air pressure tends to draw the trailing portion of the slider 12 towards the disc. Together, the positive and negative air pressures acting on the slider 12 increase air bearing stiffness and flying stability of the slider 12, especially on the trailing portion of the air bearing surface 14. This is especially helpful to resist bouncing vibrations of the burnish head, minimising extraneous head movement and providing better control of flying height to reduce the probability of disk damage.

In the preferred embodiment, the slider 12, including the air bearing surface 14, is made of TiC- Al_2O_3 . The air bearing surface 14 having a plurality of pads with some pads having steps, and the curved elongated pads 28, 30 is created mainly by two ion-milling processes. In the first ion-milling process, areas designated as pads 22, 26 and curved elongated pads 28, 30 on the air bearing surface 14 are masked. It should be noted that areas designated as steps on the pads are specifically left unmasked. Ion-milling is then performed, etching away about 300 nanometers from the unmasked areas. The first ion-milling process thus creates the steps 24. In the second ion-milling process, areas designated as pads 22, 26 and curved elongated pads 28, 30 on the air bearing surface 14 are masked, including the areas designated as steps 24. Ion-milling is then performed, etching away the unmasked areas to a depth of about 5 μm from the original air bearing surface 14. The second ion-milling process thus creates the pads 22, 26 and the curved elongated pads 28, 30 having a height of 5 μm on the etched air bearing surface 14, with the pads 22 having the steps 24 created by the first ion-milling process.

In the preferred embodiment as shown in Figures 1 and 2, all the steps 24 have a curved edge that is laterally symmetrical about the major axis of the elliptical pads. Each step 24 is typically several hundreds of nanometers in height, ranging from 100 nanometers to 500 nanometers. The ideal

height for the desired pitch depends on the head linear velocity during burnishing as well as other factors such as the gram load on the suspension supporting the burnish head and pad sizes affecting air flow.

5 As can be seen in Figure 2, the plurality of pads and the curved elongated pads 28, 30 have a fillet 50 where they join the air bearing surface 14, so as to smoothen air flow on the air bearing surface 14, as shown in Figure 5. This is to minimise any accumulation of debris around the plurality of pads and the curved elongated pads 28, 30 and on the air bearing surface 14. In addition, the curved elongated pads 28, 30 can direct the majority of air flow away from the midline 20 of the slider 12, towards either side of the air bearing surface 14, further reducing the probability of particles accumulating around the burnish pads 26. To improve their wear performance and thus increase operational life of the burnish head, the plurality of pads and the curved elongated pads 28, 30 can be coated with diamond-like carbon.

10 In another embodiment of the burnish head, as shown in Figure 6, the curved elongated pads 28, 30 each have an asymmetrical U-shape, beginning adjacent the burnish pads 26 and the midline 20 of the slider 12, extending towards the leading edge 16 alongside the midline 20 and finally arching backwards from substantially the middle of the slider 12 to the trailing edge 18 away from the midline 20.

20 Another aspect of the invention relates to an apparatus for burnishing a disc. The apparatus comprises a head assembly supported by suspensions, and the suspensions are attached to actuator head mounting arms. The apparatus also comprises a burnish head mounted on the head assembly, the burnish head being as described in any of the above embodiments.

25 Whilst there has been described in the foregoing description preferred embodiments of the present invention, it will be understood by those skilled in the technology concerned that many variations or modifications in details of design or construction may be made without departing from the present invention. For example, although two symmetrical curved elongated pads are depicted, symmetry is not a necessary condition. The number of air bearing pads and burnish pads, as well as their distribution pattern, may be varied. The height of the curved elongated pads and plurality of pads with respect to the air bearing surface of the slider may also be varied. The shapes of the pads may be other shapes such as circles or rectangles. The pads may or may not have a graduated surface each, and the graduated surface may be other embodiments such as a slope or curved

gradients. For pads having steps, the steps may have differently shaped edges instead of the simple curve, such as an oblique straight edge.

CLAIMS

1. A burnish head for burnishing a disc, the burnish head comprising:
a slider having an air bearing surface, a leading edge and a trailing edge; and
5 a plurality of pads disposed on the air bearing surface, at least one of the plurality of pads
being a curved elongated pad.
2. The burnish head according to claim 1, wherein the at least one of the plurality of pads
10 comprises two curved elongated pads disposed laterally symmetrical about a midline of the
slider, the midline being parallel to direction of motion of the burnish head relative to the disc.
3. The burnish head according to claim 2, wherein each of the two curved elongated pads begins
adjacent the midline of the slider and curves outwardly to end adjacent the trailing edge away
15 from the midline of the slider.
4. The burnish head according to claim 3, wherein each of the two curved elongated pads further
begins substantially from the middle of the slider.
5. The burnish head according to claim 3, wherein each of the two curved elongated pads further
20 begins adjacent a row of pads disposed adjacent the trailing edge, extends towards the leading
edge alongside the midline, and arches backwards from substantially the middle of the slider.
6. The burnish head according to claim 2, wherein the plurality of pads comprises a row of air
bearing pads disposed adjacent the leading edge.
- 25 7. The burnish head according to claim 6, wherein each air bearing pad comprises a leading
portion and a trailing portion, and each air bearing pad has graduated surface.
8. The burnish head according to claim 6, wherein the air bearing pads are substantially elliptical
30 in shape.
9. The burnish head according to claim 6, wherein the plurality of pads further comprises burnish
pads disposed adjacent the trailing edge.

10. The burnish head according to claim 9, wherein the burnish pads have a substantially tear-drop shape that tapers towards the leading edge.

5 11. The burnish head according to claim 9, wherein the air bearing pads are larger in size than the burnish pads.

12. The burnish head according to claim 1, wherein the plurality of pads are disposed laterally symmetrical about the midline of the slider, the midline being parallel to direction of motion of the burnish head relative to the disc.

10 13. The burnish head according to claim 1, wherein the plurality of pads and at least one curved elongated pad are coated with a diamond-like carbon coating.

14. An apparatus for levelling surface irregularities on a disc, the apparatus comprising:
15 a head assembly supported by suspensions; the suspensions being attached to actuator head mounting arms; and
a burnish head mounted on the head assembly, the burnish head comprising:
a slider having an air bearing surface, a leading edge and a trailing edge; and
a plurality of pads disposed on the air bearing surface, at least one of the plurality of pads
20 is a curved elongated pad.

15. The apparatus according to claim 14, wherein the at least one of the plurality of pads comprises two curved elongated pads disposed laterally symmetrical about a midline of the slider, the midline being parallel to direction of motion of the burnish head relative to the disc.

25 16. The apparatus according to claim 15, wherein each of the two curved elongated pad begins adjacent the midline of the slider and ends adjacent the trailing edge away from the midline.

17. The apparatus according to claim 16, wherein each of the two curved elongated pad further
30 begins substantially from the middle of the slider.

18. The apparatus according to claim 16, wherein each of the two curved elongated pad further begins adjacent a row of pads disposed adjacent the trailing edge, extends towards the leading edge alongside the midline, and arches backwards from substantially the middle of the slider.

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19. The apparatus according to claim 15, wherein the plurality of pads comprises a row of air bearing pads disposed adjacent the leading edge.
- 5 20. The apparatus according to claim 19, wherein each air bearing pad comprises a leading portion and a trailing portion, and each air bearing pad has a graduated surface.
21. The apparatus according to claim 19, wherein the air bearing pads are substantially elliptical in shape.
- 10 22. The apparatus according to claim 19, wherein the plurality of pads further comprises burnish pads disposed adjacent the trailing edge.
23. The apparatus according to claim 22, wherein the burnish pads have a substantially tear-drop shape that tapers towards the leading edge.
- 15 24. The apparatus according to claim 22, wherein the air bearing pads are larger in size than the burnish pads.
- 20 25. The apparatus according to claim 14, wherein the plurality of pads are disposed laterally symmetrical about a midline of the slider, the midline being parallel to direction of motion of the burnish head relative to the disc.
26. The apparatus according to claim 14, wherein the plurality of pads and at least one curved elongated pad are coated with a diamond-like carbon coating.
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