

20 JAN 2000

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HEAD SLIDER SUSPENSION AND HEAD ASSEMBLY,
AND METHOD OF MANUFACTURING THE SAME

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BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a slider suspension for mounting a head slider having at least either a magnetic recording head element or a magnetic reproducing head element in an information recording and reproducing apparatus such as a magnetic disk apparatus or a magneto-optical disk apparatus and a head assembly having the slider suspension and the head slider mounted thereon, and a method of manufacturing the same.

2. Description of the Related Art

Generally, a head assembly has a constitution in which a head slider having a head element is supported by a slider suspension (hereinafter referred to as a suspension). While the head slider is levitated through the suspension at a fixed distance from a surface of a magnetic recording medium, information is reproduced from or recorded on the recording medium such as a magnetic disk.

Such a levitation-type head assembly has been heretofore assembled in the following manner: the head slider is bonded onto the suspension by resin adhesive, and a bonding pad that is a signal connection portion on the head-slider side is connected to a bonding pad that is a signal connection portion on the suspension side by means of ball bonding for which

gold (Au) or the like is used.

When this type of head assembly is practically used, static electricity may be generated due to several causes such as a slide of the levitated surface of the head slider on the disk surface, and a very short distance between the head slider and the surface of a disk rotating at high speed. The static electricity generated when the head assembly is used causes damage to the head element because the head element is typically formed by a thin-film technique. To prevent this damage, the head slider is electrically connected to the suspension by the ball bonding by using a soldering contact pad, whereby the static electricity generated on the head slider is released to a ground through the suspension, as disclosed in, for example, Japanese Non-examined Patent Publication No. Sho 63-113917. Alternatively, the head slider is bonded to the suspension and then conductive resin is externally applied between a rear end surface of the head slider and the suspension, whereby the head slider is electrically connected to the suspension.

The following disclosures summarized below seem to be relevant to the present invention: Japanese Non-examined Patent Publication No. Sho 63-226999 discloses a flexible shield wire board with a configuration in which an anisotropic conductive sheet is welded onto an insulating substrate having an electrode terminal so that the sheet is electrically connected to the terminal on the insulating substrate side. Japanese Non-examined Patent Publication No. Hei 9-115125 teaches a method in which the head is bonded to the suspension by use of an anisotropic conductive film (sheet).

Moreover, Japanese Non-examined Patent Publication No. Hei 9-282824 of common assignment, which also seems to be relevant to the present invention, proposes a head slider suspension mechanism having a partition pattern for avoiding the contact of plural types of adhesives used for bonding the head slider to the suspension.

The above-described methods achieve their advantages by electrically connecting the head slider to the suspension. However, the method in which the head slider is connected to the suspension by the ball bonding by using the soldering contact pad has a problem that the suspension is deformed when more pressure than specified is applied to the pad in a ball bonding process. This deformation has an influence on the levitation property of the head slider and thus causes a disadvantageous reduction in a yield. The method in which the conductive resin is applied requires an additional process of applying the conductive resin as well as a process of bonding the head slider to the suspension. This additional process increases a lead time. Moreover, the head assembly is manufactured through many processes as described above and therefore the head element may be damaged by static electricity at the time of handling.

In order to avoid these disadvantages caused by the ball bonding process or other additional processes as the prevention of static electricity, it seems possible that the anisotropic conductive sheet disclosed in, for example, Japanese Non-examined Patent Publication No. Sho 63-226999 is applied to the method disclosed in, for example, Japanese Non-examined Patent Publication No. Hei 9-115125. However, at present, it is very

difficult to connect the head slider to the suspension through the anisotropic conductive sheet because the head slider is as minute as about $1.0\text{ mm} \times 1.2\text{ mm}$, for instance. Moreover, the method using such an anisotropic conductive film requires highly accurate alignment for connecting the head to the suspension by laminating the anisotropic conductive film. Furthermore, this method requires two additional processes, i.e., temporary bonding and final bonding. This increases the number of the manufacturing processes, causing a difficulty in reducing a manufacturing lead time.

Therefore, the inventors propose a method utilizing anisotropic conductive adhesive or the like to bond the head slider fixedly to the suspension to electrically connect the head slider to the suspension, as disclosed in, for example, Japanese Patent Application No. 9-347678. This method can ensure the bonding and conduction between the head slider and the suspension by only one process. Thus, the manufacturing lead time can be reduced.

However, it is not always easy with this method to effectively prevent the damage by static electricity while ensuring good workability and sufficient adhesive strength. This is because the anisotropic conductive adhesive is produced by kneading a conductive material such as silver powders into insulating bonding resin. If the anisotropic conductive adhesive contains more conductive material, the adhesive becomes more viscous and thus the workability is deteriorated. The adhesive also has less adhesion and thus durability becomes difficult to be improved. On the

contrary, if the anisotropic conductive adhesive contains less conductive material, electrical conductivity of the adhesive is reduced (resistance is increased) and thus the sufficient continuity between the head slider and the suspension cannot be obtained.

SUMMARY OF THE INVENTION

The present invention is made in view of the above problems. It is an object of the invention to provide a head slider suspension and a head assembly which can effectively prevent the damage to a head element by static electricity while simplifying a manufacturing process, improving workability and enhancing durability, and a method of manufacturing the same.

A head slider suspension of the present invention comprises a slider suspension member as a base for supporting a head slider having a head element for at least either recording or reproducing information on/from a predetermined recording medium; and a conductive pattern formed so as to spread over the slider suspension member, for maintaining the head slider at a ground potential when the head slider is mounted on the slider suspension member.

In the head slider suspension of the present invention, the head slider is maintained at the ground potential by the conductive pattern formed so as to spread over the slider suspension member, when the head slider is mounted on the slider suspension member.

Another head slider suspension of the present invention may

further comprise at least one insulating spacer selectively formed on a surface of the slider suspension member, for creating a space to be filled with adhesive between the head slider and the slider suspension member when the head slider is mounted on the slider suspension member. In this case, at least the surface of the slider suspension member may be maintained at the ground potential. Furthermore, the conductive pattern may be formed so as to spread across an area extending from an upper surface of the spacer to the surface of the slider suspension member. In this case, the spacer can be formed as the pattern which is divided into a plurality of portions.

A head assembly of the present invention comprises a head slider having a head element for at least either recording or reproducing information on/from a predetermined recording medium; a slider suspension member as a base for supporting the head slider; and a conductive pattern formed so as to spread over the slider suspension member, for maintaining the head slider at a ground potential. In the head assembly of the present invention, the head slider is maintained at the ground potential by the conductive pattern formed so as to spread over the slider suspension member.

Another head assembly of the present invention may further comprise at least one insulating spacer selectively formed on the surface of the slider suspension member, for creating a space to be filled with adhesive between the head slider and the slider suspension member. In this case, at least the surface of the slider suspension member may be maintained at the ground potential. Furthermore, the conductive pattern may be formed so as

to spread across an area extending from the upper surface of the spacer to the surface of the slider suspension member. The head slider may be fixedly bonded to the slider suspension member by the adhesive filled into the space to be filled with the adhesive. In this case, the spacer can be formed as the pattern which is divided into a plurality of portions. Preferably, the adhesive is conductive. The adhesive can be made of resin containing at least silver, for example.

In still another head slider suspension or head assembly of the present invention, the head slider suspension or the head assembly may further comprise a wiring pattern for transmitting a signal inputted to or outputted from the head element, and the conductive pattern may be formed from the same material and in the same process as the material and process of the wiring pattern.

In still another head slider suspension or head assembly of the present invention, the head slider suspension or the head assembly may further comprise a wiring pattern for transmitting a signal inputted to or outputted from the head element and an insulating pattern provided for the wiring pattern from the slider suspension member, and the spacer may be formed from the same material and in the same process as the material and process of the insulating pattern.

In still another head slider suspension or head assembly of the present invention, the conductive pattern can include a conductive thin film having at least one layer. In this case, the conductive thin film can be made of metal. Preferably, the metal contains at least either copper or gold.

In still another head slider suspension or head assembly of the present invention, the spacer can be made of insulating resin. Preferably, polyimide, for example is used as the insulating resin.

A method of manufacturing a head slider suspension according to the present invention comprises the steps of forming a slider suspension member as a base for supporting a head slider having a head element for at least either recording or reproducing information on/from a predetermined recording medium; and forming a conductive pattern on the slider suspension member, for maintaining the head slider at a ground potential when the head slider is mounted on the slider suspension member.

A method of manufacturing a head assembly according to the present invention comprises the steps of manufacturing a head slider having a head element for at least either recording or reproducing information on/from a predetermined recording medium; manufacturing a slider suspension member as a base for supporting the head slider; and forming a conductive pattern on the slider suspension member, for maintaining the head slider at a ground potential.

Other and further objects, features and advantages of the invention will appear more fully in the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of an external constitution of a magnetic head assembly according to one embodiment of the present invention;

Fig. 2 is a cross sectional view taken in the direction of arrows along

line II-II of Fig. 1;

Fig. 3 is a plan view of the magnetic head assembly shown in Fig. 1;

Fig. 4 is a cross sectional view taken in the direction of arrows along line IV-IV of Fig. 3; and

Fig. 5 is a perspective view of the external constitution of a magnetic disk apparatus which the head assembly according to one embodiment of the present invention is applied to.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of the present invention will be described in detail below with reference to the accompanying drawings.

[Head assembly according to the embodiment of the invention]

Fig. 5 shows an external constitution of a magnetic disk apparatus which a head assembly according to one embodiment of the present invention is applied to. This magnetic disk apparatus comprises a magnetic head slider (hereinafter also referred to as a magnetic head or a head) 11 having a substrate and a head core portion formed on the substrate, and a magnetic disk (hereinafter also referred to as a disk) 110 as a recording medium. The magnetic disk 110 is rotated by a spindle motor 111. The magnetic head slider 11 is supported by a tip of one end of a suspension 12. The other end of the suspension 12 is attached to a driving arm 131. The magnetic head slider 11 is arranged facing a surface of the magnetic disk 110. The driving arm 131 is made of, for example, die casting in which aluminum is used.

This magnetic disk apparatus also comprises a carriage section 120

provided on the base side of the driving arm 131, for positioning the magnetic head slider 11 on a track of the magnetic disk 110. The carriage section 120 includes a pivot 121, a carriage 122 capable of turning round the pivot 121 and an actuator 123 comprising a voice coil motor or the like. The actuator 123 drives the carriage 122 so that the carriage 122 turns round the pivot 121, whereby the magnetic head slider 11 can be moved in a radial direction of the magnetic disk 110. The magnetic head slider 11 and the suspension 12 constitute a principal part of the head assembly according to the present invention.

For purposes of illustration, only one magnetic head assembly 10 is shown in Fig. 5. In an actual magnetic disk apparatus, one magnetic head assembly may be provided for each surface of a plurality of magnetic disks 110, as necessary.

Figs. 1 to 4 show the principal part of the head assembly according to one embodiment of the present invention and specifically show a partial constitution of the magnetic head slider 11 and the suspension 12 shown in Fig. 5. Since a head slider suspension according to the embodiment of the present invention is embodied by the head assembly according to this embodiment, the head slider suspension will be described below together with the head assembly. Fig. 1 is a perspective view of the principal part of the magnetic head assembly which is placed with a surface facing a recording medium (hereinafter referred to as an air bearing surface) 11b of the magnetic head slider 11 upward, as viewed obliquely from above. Fig. 2 is a cross sectional view taken in the direction of arrows along line II-II of Fig.

1. Fig. 3 is a plan view of the magnetic head assembly, as viewed from above. Fig. 4 is a cross sectional view taken in the direction of arrows along line IV-IV of Fig. 3. In Fig. 3, the magnetic head slider 11 is not shown and a position in which the magnetic head slider 11 is to be mounted is indicated by a phantom line (chain double-dashed line).

As shown in Figs. 1 and 2, the magnetic head assembly 10 comprises the magnetic head slider 11 and the suspension 12 for supporting the magnetic head slider 11. The suspension 12 includes a flexure 12A as an flexible suspension and a load beam 12B as a rigid suspension. The magnetic head slider 11 corresponds to "a head slider" of the present invention. The suspension 12 corresponds to "a slider suspension member" of the present invention.

As shown in Fig. 1, the magnetic head slider 11 is substantially a rectangular parallelepiped. A magnetic head element 14 and bonding pads 15a-15d for inputting and outputting a signal are formed on an element forming surface 11a which is one side end surface of the magnetic head slider 11. The magnetic head element 14 includes at least either an inductive magnetic transducer for writing or a magneto resistive element (MR element) for reading-out, for example. The magnetic head element 14 corresponds to "a head element" of the present invention.

The flexure 12A, which is a part of the suspension 12, is made of a thin stainless steel sheet having a thickness of, for example, about 25 μm . The flexure 12A is fixed to an edge of the load beam 12B so that the flexure 12A operates as a gimbal integrally with the magnetic head slider 11. Four

lead patterns 16a-16d as input/output signal lines are formed approximately along the length of the flexure 12A with an insulating pattern 31f (refer to Figs. 3 and 4) in between. The insulating pattern 31f is not shown in Figs. 1 and 2. The lead patterns 16a-16d correspond to "wiring patterns" of the present invention. The insulating pattern 31f corresponds to "an insulating pattern" of the present invention.

The lead patterns 16a-16d are formed using copper (Cu) or gold (Au), or alternatively, a thin film pattern having copper and gold which are stacked. One ends of the lead patterns 16a-16d are connected to four bonding pads 17a-17d formed on the flexure 12A, respectively. The other ends of the lead patterns 16a-16d are connected to connecting terminals (not shown) for connecting to an external circuit. The bonding pads 17a-17d are electrically connected to the bonding pads 15a-15d on the magnetic head slider 11 side, respectively, by, for example, a gold ball 21 or the like. The gold ball 21 is not shown in Fig. 1.

The load beam 12B is made of a thick stainless steel sheet having a thickness of, for example, about 62-76 μm . The flexure 12A is fixedly bonded to the load beam 12B at a plurality of spot welding points (e.g., a spot 18) by, for example, laser welding. A convex dimple 19 for pressing a back surface 11c of the magnetic head slider 11 is formed near the tip of the load beam 12B. The dimple 19 is in point contact with a gimbal portion 12Aa of the flexure 12A. To the gimbal portion 12Aa is fixedly bonded the back surface 11c of the magnetic head slider 11, thereby preventing the magnetic head slider 11 from moving in the direction in which the magnetic head

slider 11 is levitated from the disk (downward in the figures).

As shown in Figs. 3 and 4, a group of spacers 31a-31e composed of insulating resin such as polyimide, acrylics or the like are selectively formed in a predetermined pattern in an area of the surface of the gimbal portion 12Aa, which is a part of the flexure 12A. The magnetic head slider 11 is to be placed in this area on the gimbal portion 12Aa with the spacers 31a-31e in between. The spacers 31a-31e are for keeping the back surface 11c of the magnetic head slider 11 parallel to an upper surface of the gimbal portion 12Aa when the magnetic head slider 11 is placed on the gimbal portion 12Aa of the flexure 12A. If the magnetic head slider 11 is placed directly on the gimbal portion 12Aa using adhesive without the spacers 31a-31e, the magnetic head slider 11 may be fixedly bonded to the gimbal portion 12Aa while being inclined in accordance with the form of the applied adhesive. However, there is a space previously created to be filled with the adhesive between the magnetic head slider 11 and the gimbal portion 12Aa by the spacers 31a-31e, as in this embodiment, whereby such a problem is avoided. Preferably, the spacers 31a-31e are formed from the same insulating material and in the same process as the insulating material and process of the insulating pattern 31f as described below, for example. The thickness of the spacers 31a-31e is set to about 10-20 μm , for example. The spacers 31a-31e correspond to "insulating spacers" of the present invention.

In this embodiment, both of the spacers 31a and 31c are T-shaped in plan view. The spacers 31a and 31c are arranged so that their protrusions face each other. Both of the spacers 31b and 31d are rectangular in plan

view. The spacers 31b and 31d are arranged so that the protrusions of the spacers 31a and 31c are sandwiched between the spacers 31b and 31d. The spacer 31e is substantially circular in plan view. The spacer 31e is located about at the center in the area surrounded by the spacers 31a-31d (specifically, at the position corresponding to the dimple 19 of the load beam 12B). However, the arrangement of these spacers 31a-31e is not limited to the pattern shown in Fig. 3 and can be appropriately changed.

As shown in Figs. 3 and 4, a wide area extending from the upper surface of the spacers 31a-31e to the surface of the gimbal portion 12Aa through the side surfaces of the spacers 31a-31e is covered with a conductive pattern 32 which is selectively formed and has very low electrical resistance. The conductive pattern 32 is formed by stacking a thin film made of, for example, copper (Cu) and a thin film made of gold (Au). However, the conductive pattern 32 may have a structure in which other metals are used. The magnetic head slider 11 is placed on the spacers 31a-31e with the conductive pattern 32 in between. The magnetic head slider 11 is fixedly bonded to the gimbal portion 12Aa by adhesive 33 filled into a concave space surrounded by the spacers 31a-31e. In this state, the back surface 11c of the magnetic head slider 11 is closely bonded to the conductive pattern 32. Thus, the back surface 11c of the magnetic head slider 11 is electrically connected to the gimbal portion 12Aa through the conductive pattern 32. The conductive pattern 32 corresponds to "a conductive pattern" of the present invention.

As described above, the bonding pads 15a-15d on the magnetic head

slider 11 side are bonded to the bonding pads 17a-17d on the flexure 12A side, respectively, by the gold (Au) ball 21.

The base of the flexure 12A including the gimbal portion 12Aa is electrically connected to a housing 140 for the magnetic disk apparatus through the driving arm 131 and other components shown in Fig. 1. This housing 140 is kept at a ground potential. Thus, when static electricity is generated on the magnetic head slider 11 side, the static electricity flows from the back surface 11c of the magnetic head slider 11 toward the grounded housing 140 for the disk apparatus through the conductive pattern 32 and the flexure 12A.

Preferably, conductive adhesive is used as the adhesive 33. However, non-conductive adhesive may be used. The reason is that the back surface 11c of the magnetic head slider 11 is electrically connected to the gimbal portion 12Aa by the conductive pattern 32.

Preferably, isotropic conductive resin adhesive is used as the conductive adhesive. However, anisotropic conductive resin adhesive may be used. The isotropic conductive resin adhesive achieves its electrical conductivity due to the contact of conductive fillers in a sufficient quantity mixed into an adhesive layer. On the contrary to the isotropic conductive resin adhesive, the anisotropic conductive resin adhesive has a thin adhesive layer while the quantity of the conductive fillers in the adhesive layer is reduced as greatly as possible. The anisotropic conductive resin adhesive is in a conductive state because of the contact of the conductive fillers in the thickness direction normal to the adhesive layer, whereas this adhesive is in

a non-conductive state because of little contact of the conductive fillers in the direction parallel to the adhesive layer (horizontal direction).

Among the material of the adhesive layer of the isotropic conductive resin adhesive are ultraviolet-curing resin which cures by ultraviolet-light irradiation and thermosetting resin which sets by heat, e.g., epoxy resin. Examples of the conductive fillers include metallic particles such as silver (Ag) and metal coating plastic particles. Desirably, a particulate matter having an average particle diameter of about 0.5-2 μm or a flaky matter having an average particle diameter of about 5-10 μm is used as the particle of the conductive filler, in the case of silver, for example.

On the other hand, among the material of the adhesive layer of the anisotropic conductive resin adhesive is the thermosetting resin which sets by ultraviolet-light irradiation and heat, e.g., the epoxy resin. Examples of the conductive fillers include the metallic particles such as silver (Ag) and the metal coating plastic particles. Desirably, the particle of the conductive filler has an average particle diameter of about 3 μm and a maximum particle diameter of about 10 μm , in the case of silver, for instance. The anisotropic conductive resin adhesive containing acrylic resin and silver powders mixed therein can be prepared by mixing silver powders, urethane acrylate and acrylate, for example. This anisotropic conductive resin is set in the following process: while a load of, for example, 2.0 kg weight/cm² is applied to the resin, the resin is irradiated with the ultraviolet light having an accumulated quantity of light of, for example, 3000 mJ/cm²; then the resin is heated for 30 minutes at 120°C, for example. The adhesive in which the

content of silver powders in the acrylic resin is about 40-60% can be used as the anisotropic conductive resin adhesive.

Next, a function of the magnetic head assembly having the above-described configuration will now be described.

In the magnetic head assembly 10, recording and reproduction of information is performed in the following manner: in Fig. 5, when the magnetic disk 110 is not rotated, the magnetic head slider 11 pressed by the suspension 12 and the magnetic disk 110 are in contact with each other. When the magnetic disk 110 is rotated, an air flow is generated between the magnetic head slider 11 and the magnetic disk 110 and thus a lift is generated. Thus, the magnetic head slider 11 is separated and levitated from the surface of the magnetic disk 110, and the magnetic head slider 11 is moved relatively to the magnetic disk 110 while holding a slight distance by a balance between the lift and a pressing force applied by the suspension 12, whereby information is recorded on or reproduced from the magnetic disk 110. Such a recording and reproducing method is called a CSS (Contact-Start-Stop) method.

Even if static electricity is generated due to a slide of the air bearing surface of the magnetic head slider 11 on the surface of the magnetic disk 110, or a very short distance between the magnetic head slider 11 and the surface of the magnetic disk 110 rotating at high speed, and so on, static electricity flows from the back surface 11c of the magnetic head slider 11 to the gimbal portion 12Aa through the conductive pattern 32 (the conductive pattern 32 and the adhesive 33 when the adhesive 33 is conductive).

Furthermore, static electricity flows to the grounded housing 140 for the magnetic disk apparatus through the driving arm 131. It is therefore possible to prevent the magnetic head element 14 of the magnetic head slider 11 from being damaged by an influence of the static electricity. The conductive adhesive is more desirable for the adhesive 33 because this adhesive 33 also contributes to the function that static electricity flows from the back surface 11c of the magnetic head slider 11 to the gimbal portion 12Aa, as described above.

As described above, according to the magnetic head assembly of this embodiment, the magnetic head slider 11 is placed on and fixedly bonded to the insulating spacers 31a-31e with the conductive pattern 32 in between, which connects the upper surface of the spacers 31a-31e for placing the magnetic head slider 11 thereon and the surface of the gimbal portion 12Aa. This structure improves grounding properties of the magnetic head slider 11 and ensures that the magnetic head element 14 of the magnetic head slider 11 can be prevented from being damaged by the influence of the static electricity, compared to the case where the magnetic head slider 11 is connected to the gimbal portion 12Aa by the conductive adhesive alone. Moreover, there is no need for an additional process of forming a ground connection portion in an outer periphery of the magnetic head slider 11 after the bonding, because the magnetic head slider 11 is connected to the ground only by bonding the magnetic head slider 11 to the gimbal portion 12Aa.

Moreover, the presence of the conductive pattern 32 allows a sufficient ground effect to be obtained, even if the non-conductive adhesive

containing no conductive filler or the conductive adhesive having a low content of conductive filler and thus low conductivity (i.e., relatively high electrical resistance) is used as the adhesive 33. Therefore, there is no problem that durability is deteriorated due to the reduction of adhesion. In other words, the damage by static electricity can be effectively prevented while sufficient adhesive strength is ensured.

[Method of manufacturing the head assembly according to the embodiment of the invention]

Next, a method of manufacturing the head assembly according to this embodiment will be described. Since a method of manufacturing the head slider suspension according to this embodiment is embodied by the method of manufacturing the head assembly according to this embodiment, these methods will be described below together.

In the method of manufacturing the magnetic head assembly according to this embodiment, firstly, the magnetic head element 14 including the inductive magnetic transducer for writing and the magneto resistive element for reading-out is formed on the substrate made of altic ($\text{Al}_2\text{O}_3\cdot\text{TiC}$) by the process of forming a thin film by using a photolithography technique. Then, the magnetic head slider 11 is formed through the process of polishing the air bearing surface, the process of dividing the element by machining, and so on. DLL may be formed as a protective film on the air bearing surface 11b.

Next, the insulating pattern 31f and the spacers 31a-31e made of polyimide or the like are simultaneously formed on the disk-facing surface of

the flexure 12A of the suspension 12 by printing, sheet lamination or the like, for example. The thickness of the spacers 31a-31e and the insulating pattern 31f is set to, for example, about 10-20 μm , as described above.

Next, the lead patterns 16a-16d and the bonding pads 17a-17d are selectively formed on the insulating pattern 31f by sputtering, vapor-phase epitaxy such as vapor deposition or liquid-phase epitaxy such as electroplating, for example. At the same time, the conductive pattern 32 is selectively formed across a predetermined area covering the upper and side surfaces of the spacers 31a-31e and the surface of the gimbal portion 12Aa. The conductive pattern 32 is formed from the same material and in the same process as the material and process of the lead patterns 16a-16d and the bonding pads 17a-17d. The conductive pattern 32 has, for example, a two-layer structure of copper and gold as described above. The thickness of the conductive pattern 32 is set to 2-3 μm , for instance.

Next, the area surrounded by the spacers 31a-31e on the gimbal portion 12Aa is selectively coated with the ultraviolet-curing isotropic conductive resin adhesive, for example, by a microdispenser, printing or the like, for example. However, the isotropic non-conductive resin adhesive may be used as mentioned above. The adhesive 33 may be applied to the magnetic head slider 11 or to both of the magnetic head slider 11 and the gimbal portion 12Aa.

Next, the magnetic head slider 11 is positioned and placed on the gimbal portion 12Aa of the flexure 12A. Subsequently, while a predetermined load (e.g., about 2.0 kg f/cm²) is applied to the magnetic head

slider 11, the adhesive 33 is irradiated with the ultraviolet light and heated at a predetermined temperature, whereby the adhesive 33 is cured. Thus, the magnetic head slider 11 is fixed to the gimbal portion 12Aa and the back surface 11c of the magnetic head slider 11 is surely electrically connected to the gimbal portion 12Aa.

Next, the bonding pads 15a-15d on the magnetic head slider 11 side are bonded to the bonding pads 17a-17d on the flexure 12A side, respectively, by using the gold ball 21.

Then, the ultraviolet-curing resin (UV resin) may be applied and cured by ultraviolet-light irradiation and heating in order to protect the ball bonding portion, as needed.

As described above, according to the method of manufacturing the magnetic head assembly of this embodiment, the magnetic head slider 11 is bonded and fixed to the gimbal portion 12Aa of the flexure 12A by the adhesive 33 after forming the conductive pattern 32 connecting the upper surface of the spacers 31a-31e with the surface of the gimbal portion 12Aa. Thus, the back surface 11c of the magnetic head slider 11 can be surely connected to the ground through the conductive pattern 32 and the flexure 12A, regardless of whether or not the adhesive 33 is conductive. It is therefore possible to effectively prevent the magnetic head element 14 from being damaged by static electricity when the magnetic head assembly is used.

Moreover, according to this embodiment, the presence of the conductive pattern 32 permits the sufficient ground effect to be obtained,

even if the non-conductive adhesive containing no conductive filler or the conductive adhesive having a low content of conductive filler and thus low conductivity (i.e., relatively high electrical resistance) is used as the adhesive 33. As a result, the adhesive which is not so viscous and thus has excellent coating properties can be used. That is, the damage by static electricity can be effectively prevented while good workability is maintained.

Moreover, in this embodiment, the insulating spacers 31a-31e on which the magnetic head slider 11 is to be placed are formed in the same process and from the same material as the process and material of the insulating pattern 31f. Thus, a manufacturing process is simplified.

Furthermore, in this embodiment, the conductive pattern 32 is formed in the same process and from the same material as the process and material of the lead patterns 16a-16d and the bonding pads 17a-17d. The manufacturing process is also simplified in this respect.

Moreover, in this embodiment, the magnetic head slider 11 is fixedly bonded to the gimbal portion 12Aa by the adhesive. Therefore, only one bonding process is necessary, as described above. In contrast, in a case with a sheet previously formed into a film, such as an anisotropic conductive sheet of the related art, two bonding processes, i.e., temporary bonding and final bonding are required. In this embodiment, a lead time can be therefore reduced compared to the case in which the anisotropic conductive sheet is used. Additionally, unlike the related art, this embodiment can ensure the bonding and conductivity between the head slider and the suspension in only one process.

Although the present invention has been described above as related to the embodiment, the present invention is not limited to the above embodiment and the invention can be variously modified. For example, in the above embodiment, the insulating spacers for supporting the magnetic head slider 11 which is placed thereon are not limited to the spacers 31a-31e having the pattern of a plan shape as shown in Fig. 3 but may have any other pattern of a plan shape.

In Fig. 3, the conductive pattern 32 is formed into one piece having no notch (opening) over the whole thereof so that the adhesive 33 is in contact with only the conductive pattern 32 close-formed on the surface of the gimbal portion 12Aa. However, the present invention is not limited to this example. For example, one or more opening patterns may be formed on the conductive pattern 32 so that the adhesive 33 is in direct contact with the surface of the gimbal portion 12Aa through this opening pattern. In this case, the fixed bonding between the magnetic head slider 11 and the gimbal portion 12Aa can be ensured even if the contact between the surface of the gimbal portion 12Aa and the conductive pattern 32 is not very firm. The conductive pattern 32 may be divided into a plurality of portions.

Moreover, although the suspension 12 has the structure including the flexure 12A having the gimbal portion 12Aa and the load beam 12B in this embodiment, the present invention is not limited to this embodiment and is applicable to the suspension having any other structure.

Moreover, although the magnetic head assembly has been described in this embodiment, the present invention can be applied to any other

recording and reproducing apparatus, e.g., a magneto-optical head assembly and an optical head assembly.

As described above, according to the head slider suspension, the head assembly, the method of manufacturing the head slider suspension or the method of manufacturing the head assembly of the present invention, the conductive pattern for maintaining the head slider at the ground potential is formed on the slider suspension member as a base for supporting the head slider. Thus, the head slider is automatically connected to the ground when the head slider is fixedly bonded to the slider suspension member. Accordingly, no grounding work is necessary aside from the work of mounting the head slider on the head slider suspension. Therefore, the head slider can be connected to the ground while the manufacturing is simplified.

In the head slider suspension, the head assembly, the method of manufacturing the head slider suspension or the method of manufacturing the head assembly according to an aspect of the present invention, the insulating spacer is formed on the surface of the slider suspension member, and the conductive pattern is formed so that at least the surface of the slider suspension member is maintained at the ground potential and that the conductive pattern spreads across an area extending from an upper surface of the spacer to the surface of the slider suspension member. Thus, a sufficient space to be filled with the adhesive is created by the spacer. In addition, although the head slider is placed on and fixed to the spacer, the surface of the slider suspension member is electrically connected to the head

slider by the conductive pattern. That is, the head slider can be connected to the ground, regardless of whether or not the adhesive filled into the space to be filled with the adhesive is conductive.

In the head slider suspension, the head assembly, the method of manufacturing the head slider suspension or the method of manufacturing the head assembly according to another aspect of the present invention, the conductive pattern is formed from the same material and in the same process as the material and process of wiring patterns for transmitting the signal inputted to or outputted from the head element. Therefore, the manufacturing process is simplified.

In the head slider suspension, the head assembly, the method of manufacturing the head slider suspension or the method of manufacturing the head assembly according to still another aspect of the present invention, the spacer is formed from the same material and in the same process as the material and process of the insulating pattern formed for insulating wiring patterns from the slider suspension member. Therefore, the manufacturing process is further simplified.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.



What is claimed is:

1. A head slider suspension comprising:
a slider suspension member as a base for supporting a head slider having a head element for at least either recording or reproducing information on/from a predetermined recording medium; and
a conductive pattern formed so as to spread over at least the slider suspension member, for maintaining the head slider at a ground potential when the head slider is mounted on the slider suspension member.
2. A head slider suspension according to claim 1, further comprising a wiring pattern for transmitting a signal inputted to or outputted from the head element, wherein the conductive pattern is formed from the same material and in the same process as the material and process of the wiring pattern.
3. A head slider suspension according to claim 1, wherein the conductive pattern includes a conductive thin film having at least one layer.
4. A head slider suspension according to claim 3, wherein the conductive thin film is made of metal.
5. A head slider suspension according to claim 4, wherein the metal contains at least either copper or gold.



6. A head slider suspension according to claim 1, further comprising:
at least one insulating spacer selectively formed on a surface of the slider suspension member, for creating a space to be filled with adhesive between the head slider and the slider suspension member when the head slider is mounted on the slider suspension member.
7. A head slider suspension according to claim 6, wherein at least the surface of the slider suspension member is maintained at the ground potential.
8. A head slider suspension according to claim 7, wherein the conductive pattern is formed so as to spread across an area extending from an upper surface of the spacer to the surface of the slider suspension member.
9. A head slider suspension according to claim 6, further comprising a wiring pattern for transmitting a signal inputted to or outputted from the head element, wherein the conductive pattern is formed from the same material and in the same process as the material and process of the wiring pattern.
10. A head slider suspension according to claim 6, wherein the



conductive pattern includes a conductive thin film having at least one layer.

11. A head slider suspension according to claim 10, wherein the conductive thin film is made of metal.

12. A head slider suspension according to claim 11, wherein the metal contains at least either copper or gold.

13. A head slider suspension according to claim 6, further comprising a wiring pattern for transmitting a signal inputted to or outputted from the head element and an insulating pattern provided for insulating the wiring pattern from the slider suspension member, wherein the spacer is formed from the same material and in the same process as the material and process of the insulating pattern.

14. A head slider suspension according to claim 6, wherein the spacer is formed as the pattern which is divided into a plurality of portions.

15. A head slider suspension according to claim 6, wherein the spacer is made of insulating resin.

16. A head slider suspension according to claim 15, wherein the insulating resin is polyimide.



17. A head assembly comprising:
a head slider having a head element for at least either recording or reproducing information on/from a predetermined recording medium;
a slider suspension member as a base for supporting the head slider;
and
a conductive pattern formed so as to spread over at least the slider suspension member, for maintaining the head slider at a ground potential.

18. A head assembly according to claim 17, further comprising a wiring pattern for transmitting a signal inputted to or outputted from the head element, wherein the conductive pattern is formed from the same material and in the same process as the material and process of the wiring pattern.

19. A head assembly according to claim 17, wherein the conductive pattern includes a conductive thin film having at least one layer.

20. A head assembly according to claim 19, wherein the conductive thin film is made of metal.

21. A head assembly according to claim 20, wherein the metal contains at least either copper or gold.

22. A head assembly according to claim 17, further comprising:



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at least one insulating spacer selectively formed on the surface of the slider suspension member, for creating a space to be filled with adhesive between the head slider and the slider suspension member.

23. A head assembly according to claim 22, wherein at least the surface of the slider suspension member is maintained at the ground potential.

24. A head assembly according to claim 23, wherein the conductive pattern is formed so as to spread across an area extending from the upper surface of the spacer to the surface of the slider suspension member is continuously covered with the conductive pattern.

25. A head assembly according to claim 22, further comprising a wiring pattern for transmitting a signal inputted to or outputted from the head element, wherein the conductive pattern is formed from the same material and in the same process as the material and process of the wiring pattern.

26. A head assembly according to claim 22, wherein the conductive pattern includes a conductive thin film having at least one layer.

27. A head assembly according to claim 26, wherein the conductive thin film is made of metal.



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28. A head assembly according to claim 27, wherein the metal contains at least either copper or gold.

29. A head assembly according to claim 22, wherein the head slider is fixedly bonded to the slider suspension member by the adhesive filled into the space to be filled with the adhesive.

30. A head assembly according to claim 29, wherein the adhesive is conductive.

31. A head assembly according to claim 30, wherein the adhesive is made of resin containing at least silver.

32. A head assembly according to claim 22, further comprising a wiring pattern for transmitting a signal inputted to or outputted from the head element and an insulating pattern provided for insulating the wiring pattern from the slider suspension member, wherein the spacer is formed from the same material and in the same process as the material and process of the insulating pattern.

33. A head assembly according to claim 22, wherein the spacer is formed as the pattern which is divided into a plurality of portions.



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34. A head assembly according to claim 22, wherein the spacer is made of insulating resin.

35. A head assembly according to claim 34, wherein the insulating resin is polyimide.

36. A method of manufacturing a head slider suspension comprising the steps of:

forming a slider suspension member as a base for supporting a head slider having a head element for at least either recording or reproducing information on/from a predetermined recording medium; and

forming a conductive pattern on at least the slider suspension member, for maintaining the head slider at a ground potential when the head slider is mounted on the slider suspension member.

37. A method of manufacturing a head slider suspension according to claim 36, further including the step of:

selectively forming at least one insulating spacer on the surface of the slider suspension member, for creating a space to be filled with adhesive between the head slider and the slider suspension member when the head slider is mounted on the slider suspension member,

wherein the slider suspension member is formed so as to maintain at least the surface of the slider suspension member at the ground potential, and



the conductive pattern is formed so as to spread across an area extending from the upper surface of the spacers to the surface of the slider suspension member.

38. A method of manufacturing a head slider suspension according to claim 37, wherein the spacer is formed from the same material and in the same process as the material and process of an insulating pattern formed for insulating wiring patterns for transmitting a signal inputted to or outputted from the head element, from the slider suspension member.

39. A method of manufacturing a head slider suspension according to claim 36, wherein the conductive pattern is formed from the same material and in the same process as the material and process of the wiring patterns for transmitting a signal inputted to or outputted from the head element.

40. A method of manufacturing a head assembly comprising the steps of:

manufacturing a head slider having a head element for at least either recording or reproducing information on/from a predetermined recording medium;

manufacturing a slider suspension member as a base for supporting the head slider; and

forming a conductive pattern on at least the slider suspension



member, for maintaining the head slider at a ground potential.

41. A method of manufacturing a head assembly according to claim 40, further including the steps of:

selectively forming at least one insulating spacer on the surface of the slider suspension member, for creating a space to be filled with adhesive between the head slider and the slider suspension member; and

fixedly bonding the head slider to the slider suspension member by the adhesive filled into the space to be filled with the adhesive,

wherein the slider suspension member is formed so as to maintain at least the surface of the slider suspension member at the ground potential, and

the conductive pattern is formed so as to spread across an area extending from the upper surface of the spacers to the surface of the slider suspension member.

42. A method of manufacturing a head assembly according to claim 41, wherein the spacer is formed from the same material and in the same process as the material and process of an insulating pattern formed for insulating wiring patterns for transmitting a signal inputted to or outputted from the head element, from the slider suspension member.

43. A method of manufacturing a head assembly according to claim 40, wherein the conductive pattern is formed from the same material

and in the same process as the material and process of wiring patterns for transmitting a signal inputted to or outputted from the head element.

