

MOUNTING METHOD OF IC CHIP AND MANUFACTURING METHOD OF
HEAD SUSPENSION ASSEMBLY WITH THE IC CHIP

FIELD OF THE INVENTION

The present invention relates to a method of mounting an IC (integrated circuit) chip for a thin-film magnetic head element used for a magnetic disk device for example, and to a method of manufacturing a head suspension assembly (HSA) with the IC chip.

DESCRIPTION OF THE RELATED ART

In a magnetic disk device, a thin-film magnetic head element for writing magnetic information into and/or reading magnetic information from a magnetic disk is in general formed on a magnetic head slider flying in operation above the rotating magnetic disk. The slider is supported by a suspension made of a resilient thin metal plate extended from one end of each movable arm of the magnetic disk device.

Recently, recording frequency in the magnetic disk rapidly increases to satisfy the requirement for ever increasing data storage capacities and densities in today's magnetic disk devices. In order to realize higher frequency recording, proposed is a HSA structure with a suspension for supporting both a magnetic head slider and a drive IC chip of a driver circuit for the magnetic head element. According to

this structure, since the length of trace conductors from the driver circuit to the magnetic head element can be shortened, generation of unnecessary noises from the trace conductors can be effectively suppressed resulting high frequency recording characteristics to improve.

Such the IC chip may be however heated to a high temperature due to the writing current flowing through it during recording operations. In order to cool the heated IC chip by air flowing produced by the rotating magnetic disk, the IC chip will be mounted on a surface of the suspension, which counters the magnetic disk surface in operation.

The HSA with the IC chip will have a larger thickness increased by the mounting height of the IC chip. Generally, in the magnetic disk device, in order to increase the record capacity per magnetic disk, both sides of the disk are used for record, and in addition, a plurality of such the magnetic disks are axially mounted. Therefore, two HSAs for writing/reading magnetic information will exist between the two magnetic disks, and thus the whole thickness of the magnetic disk device equipped with the HSAs with IC chips becomes great. This large thickness of the magnetic disk device will become a big problem particularly when the magnetic disk device is mounted in a thin notebook type personal computer.

Therefore, it is required for such IC chip to fabricate

thinner than a general-purpose IC chip. Namely, the general-purpose IC chip has a thickness of about 0.3-0.4 mm, whereas the IC chip for the thin-film magnetic head has a thickness less than 0.25 mm, for example a thickness of about 0.12 mm.

The C4 (Controlled Collapse Chip Connection) process is a typical process for mounting such IC chip on a suspension. In the C4 process, first, flux for solder material is applied to bump balls of the IC chip and then the IC chip is bonded to connection pads by reflow heat bonding.

If the mounting of the IC chip is performed by the reflow soldering using flux, it is necessary to execute the cleaning process after bonding. Namely, in the C4 bonding process, flux is applied to the suspension at a position to which the IC chip is bonded, in order to promote melting of the solder and temporarily adhere the IC chip to the suspension during reflow soldering. Since the applied flux may have adverse effect of producing out gas for example, the cleaning has to be done after bonding.

This cleaning process will exert an influence upon the suspension. Namely, although high accuracy is required in a bending angle of the suspension, this bending angle may unintentionally change during the cleaning process. Thus, it is difficult to use the C4 process in the mounting of the IC chip on the suspension.

An ultrasonic bonding can be carried out without

executing the cleaning process. In the ultrasonic bonding process, no solder bump is used but gold (Au) bumps formed on the IC chip are used. Namely, bonding is executed by applying an appropriate pressure and ultrasonic vibration to the Au bumps that are contacting with the respective Au pads on the suspension so as to fuse the Au. Since no soldering flux is utilized in this ultrasonic bonding process, no cleaning process is necessary.

However, if a heavy load and great ultrasonic power are applied to the very thin and small IC chip for the thin-film magnetic head element in order to mount it in the ultrasonic bonding process, damages such as scratches or cracks may be produced on the IC chip surface.

Even if few damages such as scratches or cracks arise on the IC chip surface, a silicon particle falling from this IC chip may occur. This is never allowed in the magnetic disk device. Namely, in the magnetic disk device, generally, since the magnetic head slider flies at extremely low height above the rotating disk for performing reading/writing operations, no dust is allowed to exist. Thus, it is very difficult to determine the conditions for mounting the IC chip using the ultrasonic bonding process.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to

provide a method of mounting an IC chip and a method of manufacturing a HSA with the IC chip, whereby no damage occurs on a body of the IC chip even if the IC chip is very thin and very small.

According to the present invention, a method of mounting an IC chip on a suspension is provided. The suspension has connection pads, and the IC chip has a circuit for a thin-film magnetic head element and connection terminals connected to the circuit. The mounting method includes a step of increasing a load applied to the IC chip so that metal bumps formed on the connection terminals press the connection pads formed on the suspension, respectively, and a step of starting application of ultrasonic vibration to the IC chip during the increasing of the load applied to the IC chip.

Also, according to the present invention, a method of manufacturing a HSA with a suspension and an IC chip is provided. The suspension has connection pads, and the IC chip has a circuit for a thin-film magnetic head element and connection terminals connected to the circuit. The manufacturing method includes a step of forming metal bumps on the connection terminals, a step of positioning the IC chip so that the metal bumps oppose to the connection pads formed on the suspension, respectively, a step of increasing a load applied to the IC chip so that the metal bumps press the connection pads formed on the suspension, and a step of

starting application of ultrasonic vibration to the IC chip during the increasing of the load applied to the IC chip to mount the IC chip on the suspension.

If the application of the ultrasonic vibration is started while the load applied to the IC chip is increasing, top ends of the metal bumps, which have a convex shape, are softened by the ultrasonic vibration, and pushed by the applied load against the connection pads of the suspension. Also, this load applied to the IC chip is increasing. Thus, the metal bumps are bonded with the connection pads with melting and crushing their top ends. As a result, although the IC chip for the thin-film magnetic head element is very thin and very small, sufficient mounting intensity can be obtained without applying unnecessary large load to the body of the IC chip.

In other words, according to the present invention, the ultrasonic bonding can be performed without generating damages on the surface of the IC chip. Even if the IC chip is very thin and small, since the mounting is possible under the lower ultrasonic power and load, the decrease of inspection items at the actual fabrication and the improvement in quality can be expected. Therefore, the productivity can be greatly improved.

It is preferred that the load is increased to a predetermined value, kept at the predetermined value for a predetermined period of time, and then decreased.

It is also preferred that the load is increased to a first predetermined value, kept at the first predetermined value for a first predetermined period of time, increased to a second predetermined value, kept at the second predetermined value for a second predetermined period of time, and then decreased.

It is preferred that the application of ultrasonic vibration to the IC chip is finished during the application of the load to the IC chip.

It is further preferred that the application of ultrasonic vibration to the IC chip is finished during the increasing of the load applied to the IC chip.

Preferably, the metal bumps are gold bumps or copper bumps. Also, preferably, the connection pads are made of gold or copper.

It is preferred that the suspension is fabricated by forming a trace conductor member and the connection pads connected to the trace conductor member on a resilient flexure, and by fixing the flexure to a resilient load beam.

Further objects and advantages of the present invention will be apparent from the following description of the preferred embodiments of the invention as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a plane view of a preferred embodiment of a HSA according to the present invention;

Figs. 2a to 2e show sectional views illustrating a part of manufacturing processes of the HSA according to the embodiment shown in Fig. 1;

Figs. 3 shows graphs illustrating ultrasonic bonding conditions according to the conventional technique;

Figs. 4 shows graphs illustrating ultrasonic bonding conditions according to the embodiment shown in Fig. 1; and

Figs. 5 shows graphs illustrating ultrasonic bonding conditions according to another embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 schematically illustrates a head suspension assembly (HSA) as a preferred embodiment of the present invention.

As shown in the figure, the HSA is assembled by fixing a slider 11 having a thin-film magnetic head element to a top end section of a suspension 10, and by mounting a drive IC chip 12 on a middle location of this suspension 10. The slider 11 and the drive IC chip 12 are fixed on a surface of the suspension 10, which will oppose to the magnetic disk surface in operation. This surface of the suspension is called hereinafter as a slider-attached surface.

The suspension 10 is substantially constituted by a resilient flexure 13 for carrying the slider 11 at its tongue located near its top end section and supports the drive IC chip 12 at its middle section, a resilient load beam 14 for supporting and fixing the flexure 13, and a base plate 15 formed at a base end section of the load beam 14.

The load beam 14 has elasticity for suppressing the slider 11 toward the direction of the magnetic disk in operation. The flexure 13 has the flexible tongue centered by a dimple formed on the load beam 14 and has elasticity for supporting the slider 11 flexibly by this tongue. As will be noted, in this embodiment, the suspension 10 has a three-pieces structure constituted by individual components of the flexure 13, the load beam 14 and the base plate 15. In such three-pieces structure, stiffness of the flexure 13 is set to be lower than that of the load beam 14.

In the drive IC chip 12, an integrated driver circuit constituting a head amplifier of the magnetic head element is formed. Although it is mere examples, the size of the IC chip 12 may be $1.0\text{ mm} \times 1.0\text{ mm} \times 0.15\text{ mm}$ or $1.5\text{ mm} \times 1.5\text{ mm} \times 0.25\text{ mm}$. The fixed position of the IC chip 12 on the suspension 10 is in this embodiment determined so as to improve heat radiation characteristics and electromagnetic characteristics and to make mounting of the IC chip easy.

The flexure 13 is made of in this embodiment a

stainless steel plate (for example SUS304TA) with a thickness of about 25 μm . This flexure 13 has a uniform width smaller than that of the load beam 14.

A trace conductor layer 16 of a thin-film pattern that constitutes necessary number of input/output signal lines is formed on the flexure 13 along its length. One end of the trace conductor 16 is connected to slider-connection pads for making electrical connection with the magnetic head slider 11 formed at the top end section of the flexure 13, and the other end of the trace conductor 16 is connected via the IC chip 12 to external connection pads 17 which will be connected to external circuits.

The load beam 14 is made of in this embodiment a resilient stainless steel plate with a thickness of about 60-65 μm and supports the flexure 13 along its whole length. This load beam 14 has a shape with a width that narrows with approaching to its top end. Fixing of the flexure 13 to the load beam 14 is achieved by means of a plurality of welded spots.

The base plate 15 is made of a stainless steel or iron and is fixed to the base end section of the load beam 14 by welding. The suspension 10 will be attached to each movable arm (not shown) by fixing an attachment part 18 of the base plate 15 to the movable arm.

In modification, the suspension may be formed in a two-

pieces structure with a base plate and a flexure-load beam instead of the three-pieces structure with the flexure 13, the load beam 14 and the base plate 15.

As aforementioned, the slider 11 with the magnetic head element is mounted on the tongue of the flexure 13 at the top end section of the suspension 10. The trace conductor layer 16 which includes the necessary number of the input/output signal lines passes both sides of the slider 11 and turns back at the top end section of the flexure 13 to the slider-connection pads so as to be electrically connected with input/output electrodes of the slider 11. The insulation material layer made of the resin covers the connected part.

The drive IC chip 12 is mounted on the slider-attached surface at the middle length location of the suspension 10. The IC chip 12 in this embodiment is formed by a bare chip and mounted, by the ultrasonic bonding, on and connected to chip-connection pads formed on the way of the trace conductor layer 16 that is formed on the flexure 13 of the suspension 10 via an insulation material layer.

An underfill is filled in a clearance between the bottom surface of the IC chip 12 and the trace conductor layer surface so as to improve heat radiation characteristics, to improve mechanical strength of this area, and to cover a part of the IC chip 12.

Hereinafter, a mounting process of the IC chip 12 to

the suspension according to this embodiment will be described with reference to Figs. 2a to 2e.

As shown in Fig. 2a, on the flexure 13 that is made of stainless steel plate, the thin-film conductive pattern is formed by a well-known method similar to the patterning method of forming a printed circuit board on a thin metal plate such as a flexible printed circuit (FPC).

For example, the conductive pattern is formed by sequentially depositing a first insulation material layer 20 made of a resin such as polyimide with a thickness of about 5 μm , a patterned Cu (copper) layer (conductive layer) 21 with a thickness of about 4 μm , and a second insulation material layer 22 made of a resin such as polyimide with a thickness of about 5 μm on the flexure 13 in this order. Within the regions of the slider-connection pads to the magnetic head slider, external-connection pads to the external circuit and chip-connection pads 23 to the IC chip 12, only an Au layer 24 is deposited on the Cu layer 21 and there is no second insulation material layer on the Au layer 24.

As shown in Fig. 2b, bumps 25 of Au balls are preliminarily made on connection terminals (not shown) formed on the bottom face of the IC chip 12. This IC chip 12 is picked up by a ultrasonic bonding head or nozzle 26 that is in contact with the top face of the IC chip by the bonding head as shown in Fig. 2b, and aligned with the chip-connection pads

23 of the thin-film conductive pattern.

Then, the nozzle 26 moves down until the Au ball bumps 25 of the IC chip 12 come in contact with the respective chip-connection pads 23 of the thin-film conductive pattern, and presses the IC chip 12 toward a direction of an arrow 27, as shown in Fig. 2c, so as to apply a load onto the IC chip 12. This load applied is gradually increased.

During the increasing of the load, ultrasonic vibration along directions of an arrow 28 (lateral directions) is applied from the ultrasonic head 26, as shown in Fig. 2c.

The depression due to the load and the application of ultrasonic vibration result fused bonding of the Au ball bumps 25 of the IC chip 12 with the Au layer 24 of the chip-connection pads 23.

Thus, as shown in Fig. 2d, electrical connection between the connection terminals of the IC chip 12 and the chip-connection pads 23 is achieved.

Then, as shown in Fig. 2e, an underfill 29 in liquid state for improving heat radiation characteristics, improving mechanical strength of this area, and covering a part of the IC chip 12 is injected into a clearance between the bottom face of the IC chip 12 and the surface of the thin-film conductive pattern. The underfill 29 is good heat conductivity material made of for example mixture of a resin such as epoxy resin and insulation material with good heat

conductivity. The underfill 29 will be cured during a heat and dry process executed later.

The underfill resin with good heat conductivity composing the underfill layer 29 may be for example a resin such as epoxy resin containing fused silica (heat conductivity ratio of about $50.4 \times 10^{-6} \text{ W/m}\cdot^{\circ}\text{C}$), a resin containing alumina (heat conductivity ratio of about $168 \times 10^{-6} \text{ W/m}\cdot^{\circ}\text{C}$), a resin containing crystal silica (heat conductivity ratio of about $147 \times 10^{-6} \text{ W/m}\cdot^{\circ}\text{C}$), or a resin containing aluminum nitride (heat conductivity ratio of about $168 \times 10^{-6} \text{ W/m}\cdot^{\circ}\text{C}$).

According to the embodiment, since the Au ball bumps 25 of the IC chip 12 are electrically and mechanically bonded with the Au layer 24 of the chip-connection pads 23 by the ultrasonic fused bonding, no temporal fixing of the IC chip nor reflow soldering is required.

The ultrasonic bonding process according to this embodiment will be now described in detail in comparison with the conventional ultrasonic bonding process.

Figs. 3 illustrates ultrasonic bonding conditions in the conventional ultrasonic bonding process. In the figure, (A) denotes characteristics of a relative height or position of the ultrasonic bonding head from the chip-connection pads with respect to time, (B) characteristics of a load applied to the IC chip with respect to time, and (C) characteristics of an ultrasonic power applied to the IC chip with respect to

time.

The ultrasonic bonding head moves down and thus the bumps of the IC chip come in contact with the chip-connection pads at V_{a1} shown in Fig. 3 (A). As shown in Fig. 3 (B), a load at this point is represented as a contact load P_c . The load is increased from this contact load P_c for a time period T_2' . When the load reaches a predetermined load P_{b2}' (equal to about 13.72 N), this load is kept at that value for a predetermined time period T_3' .

As shown in Fig. 3 (C), when the load becomes at the contact load P_c , a timer starts. Then, when the timer exceeds a time period T_7' , application of the ultrasonic vibration starts with an ultrasonic power of $P_u' = 1.4$ W for the ultrasonic bonding. This starting point of the ultrasonic vibration application is set within a period where the load is kept at the load P_{b2}' . The application of ultrasonic vibration is continued for T_8' and then finished.

After the predetermined time T_5' elapsed, the load is reduced to the contact load P_c for a time period T_6' and then the ultrasonic bonding head moves upward to end the bonding process.

Figs. 4 illustrates ultrasonic bonding conditions in the aforementioned embodiment. In the figure, (A) denotes characteristics of a relative height or position of the ultrasonic bonding head 26 from the chip-connection pads 23

with respect to time, (B) characteristics of a load applied to the IC chip 12 with respect to time, and (C) characteristics of an ultrasonic power applied to the IC chip 12 with respect to time.

The ultrasonic bonding head 26 moves down and thus the bumps 25 of the IC chip 12 come in contact with the chip-connection pads 23 at V_{a1} shown in Fig. 4 (A). As shown in Fig. 4 (B), a load at this point is represented as a contact load P_c . The load is increased from this contact load P_c for a time period T_2 . When the load reaches a first predetermined load P_{b1} (equal to about 1.96 N), this load P_{b1} is kept at that value for a first predetermined time period T_3 . After the first predetermined time T_3 elapsed, the load is increased from the value P_{b1} for a time period T_4 . When then the load reaches a second predetermined load P_{b2} (equal to about 4.9 N), this load P_{b2} is kept at that value for a second predetermined time period T_5 .

As shown in Fig. 4 (C), when the load becomes at the contact load P_c , a timer starts. Then, when the timer exceeds a time period T_1 , application of the ultrasonic vibration starts with a low ultrasonic power of $P_w' = 0.2$ W for the ultrasonic bonding. This starting point of the ultrasonic vibration application is set within a period where the load is increasing from the first predetermined load P_{b1} to the second predetermined load P_{b2} , that is, during the time period T_4 .

The application of ultrasonic vibration is continued for T_3 and then finished. In the embodiment, the finishing point of the ultrasonic vibration application is set also within this period where the load is increasing from the first predetermined load P_{b1} to the second predetermined load P_{b2} , that is, during the time period T_1 .

After the predetermined time T_3 elapsed, the load is reduced to the contact load P_c for a time period T_4 and then the ultrasonic bonding head 26 moves upward to end the bonding process.

As described in detail, according to the conventional ultrasonic bonding method, the application of the ultrasonic vibration starts when the load is reached and kept at the value P_{b2}' . As for a large and thick general-purpose IC chip, since it has a sufficient power apply area and can bear a great load applied thereto, there will occur no problem for such conventional ultrasonic bonding conditions. However, since the IC chip for the thin-film magnetic head is very thin and small, if the conventional ultrasonic bonding conditions are adopted, serious damages such as scratches or cracks may be produced on the IC chip surface.

Whereas according to the ultrasonic bonding method of this embodiment, the ultrasonic vibration application starts within a period where the load is increasing from the first predetermined load P_{b1} to the second predetermined load P_{b2} .

Therefore, the Au bumps 25 of the IC chip 12 in the softened state due to the received ultrasonic vibration come in contact with the Au layer 24 of the chip-connection pads 23 and are pushed against the chip-connection pads 23. Namely, the Au bumps 25 are bonded with the Au layer 24, in melting. Since the IC chip for the thin-film magnetic head element is very thin and small, and furthermore, there are few bumps on the IC chip, bonding can be performed by only applying very low ultrasonic power if the bumps are bonded, melting. Thanks for a minimal ultrasonic amplitude, precise positioning of the IC chip at mounting can be expected. Also, damages on the surface of the IC chip can be prevented from occurring because of the lower ultrasonic power and load applied to the IC chip. As a result, a silicon particle falling from the IC chip due to the damages on its surface, which is never allowed in the magnetic disk device, can be certainly prevented.

Figs. 5 illustrates ultrasonic bonding conditions according to another embodiment of the present invention. Configurations, operations and advantages in this embodiment are the same as these of the embodiment shown in Fig. 1 except for the ultrasonic bonding conditions. Thus, in this embodiment, the same reference numerals as these in the embodiment of Fig. 1 are used.

In Fig. 5, (A) denotes characteristics of a relative height or position of the ultrasonic bonding head 26 from the

chip-connection pads 23 with respect to time, (B) characteristics of a load applied to the IC chip 12 with respect to time, and (C) characteristics of an ultrasonic power applied to the IC chip 12 with respect to time.

The ultrasonic bonding head 26 moves down and thus the bumps 25 of the IC chip 12 come in contact with the chip-connection pads 23 at V_{a1} shown in Fig. 5 (A). As shown in Fig. 5 (B), a load at this point is represented as a contact load P_c . The load is increased from this contact load P_c for a time period T_2 plus T_4' . When the load reaches a predetermined load P_{b2} (equal to about 4.9 N), this load P_{b2} is kept at that value for a predetermined time period T_5 .

As shown in Fig. 5 (C), when the load becomes at the contact load P_c , a timer starts. Then, when the timer exceeds a time period T_7 , application of the ultrasonic vibration starts with a low ultrasonic power of $P_v' = 0.2$ W for the ultrasonic bonding. This starting point of the ultrasonic vibration application is set within a period where the load is increasing from the contact load P_c to the predetermined load P_{b2} , that is, during the time period T_2 plus T_4' . The application of ultrasonic vibration is continued for T_8 and then finished. In the embodiment, the finishing point of the ultrasonic vibration application is set also within this period where the load is increasing from the contact load P_c to the predetermined load P_{b2} , that is, during the time period

T_2 plus T_4' .

After the predetermined time T_5 elapsed, the load is reduced to the contact load P_c for a time period T_6 and then the ultrasonic bonding head 26 moves upward to end the bonding process.

According to the ultrasonic bonding method of this embodiment, the ultrasonic vibration application starts within a period where the load is increasing from the contact load P_c to the predetermined load P_{b2} . Therefore, the Au bumps 25 of the IC chip 12 in the softened state due to the received ultrasonic vibration come in contact with the Au layer 24 of the chip-connection pads 23 and are pushed against the chip-connection pads 23. Namely, the Au bumps 25 are bonded with the Au layer 24, in melting. Since the IC chip for the thin-film magnetic head element is very thin and small, and furthermore, there are few bumps on the IC chip, bonding can be performed by very low ultrasonic power if the bumps are bonded, melting. Thanks for a minimal ultrasonic amplitude, precise positioning of the IC chip at mounting can be expected. Also, damages on the surface of the IC chip can be prevented from occurring because of the lower ultrasonic power and load applied to the IC chip. As a result, a silicon particle falling from the IC chip due to the damages on its surface, which is never allowed in the magnetic disk device, can be certainly prevented.

In the aforementioned embodiments, the finishing point of the ultrasonic vibration application is set within the period where the load is increasing. However, this finishing point can be set at any time after the bonding is actually performed.

In the aforementioned embodiments, also, the Au ball bumps 25 of the IC chip 12 and the Au layer 24 of the chip-connection pads 23 are bonded by ultrasonic bonding. However, the present invention can be achieved by ultrasonic bonding using Cu balls and a Cu layer or using another metal balls and another metal layer instead of the Au balls and the Au layer. In modifications, the bumps may be formed on the chip-connection pads of the thin-film conductive pattern.

Furthermore, according to the embodiments, since the ultrasonic bonding is used, no transfer process of solder flux and also no reflow soldering process are needed, and therefore no cleaning process is needed. Still further, since the application of the ultrasonic vibration is started during increasing of the load, no damage is occurred on the surface of the silicon body of the IC chip during its mounting process resulting that a silicon particle falling from the IC chip due to the damage can be effectively prevented.

It is apparent that the characteristics of the load and the ultrasonic power applied to the IC chip with respect to time in the ultrasonic bonding conditions according to the

present invention are not limited to that in the
aforementioned embodiments. Any load and ultrasonic power
characteristics can be adopted if the application of the
ultrasonic vibration is started during increasing of the load
so as to perform the bonding by applying a lower load and a
lower ultrasonic power.

Many widely different embodiments of the present
invention may be constructed without departing from the spirit
and scope of the present invention. It should be understood
that the present invention is not limited to the specific
embodiments described in the specification, except as defined
in the appended claims.



WHAT IS CLAIMED IS:

1. A method of mounting an IC chip on a suspension having connection pads, said IC chip having a circuit for a thin-film magnetic head element and connection terminals connected to said circuit, said method comprising the steps of:

increasing a load applied to said IC chip so that metal bumps formed on said connection terminals press said connection pads formed on said suspension, respectively; and

starting application of ultrasonic vibration to said IC chip during the increasing of the load applied to said IC chip.

2. The method as claimed in claim 1, wherein said load is increased to a predetermined value, kept at the predetermined value for a predetermined period of time, and then decreased.

3. The method as claimed in claim 1, wherein said load is increased to a first predetermined value, kept at the first predetermined value for a first predetermined period of time, increased to a second predetermined value, kept at the second predetermined value for a second predetermined period of time, and then decreased.

4. The method as claimed in claim 1, wherein said application of ultrasonic vibration to said IC chip is finished during the application of the load to said IC chip.



5. The method as claimed in claim 1, wherein said application of ultrasonic vibration to said IC chip is finished during the increasing of the load applied to said IC chip.

6. The method as claimed in claim 1, wherein said metal bumps are gold bumps or copper bumps.

7. The method as claimed in claim 1, wherein said connection pads are made of gold or copper.

8. A method of manufacturing a head suspension assembly with a suspension having connection pads, and an IC chip having a circuit for a thin-film magnetic head element and connection terminals connected to said circuit, said method comprising the steps of:

forming metal bumps on said connection terminals;

positioning said IC chip so that said metal bumps oppose to said connection pads formed on said suspension, respectively;

increasing a load applied to said IC chip so that said metal bumps press said connection pads formed on said suspension; and

starting application of ultrasonic vibration to said IC



chip during the increasing of the load applied to said IC chip to mount said IC chip on said suspension.

9. The method as claimed in claim 8, wherein said load is increased to a predetermined value, kept at the predetermined value for a predetermined period of time, and then decreased.

10. The method as claimed in claim 8, wherein said load is increased to a first predetermined value, kept at the first predetermined value for a first predetermined period of time, increased to a second predetermined value, kept at the second predetermined value for a second predetermined period of time, and then decreased.

11. The method as claimed in claim 8, wherein said application of ultrasonic vibration to said IC chip is finished during the application of the load to said IC chip.

12. The method as claimed in claim 8, wherein said application of ultrasonic vibration to said IC chip is finished during the increasing of the load applied to said IC chip.

13. The method as claimed in claim 8, wherein said metal bumps are gold bumps or copper bumps.



14. The method as claimed in claim 8, wherein said suspension is fabricated by forming a trace conductor member and said connection pads connected to said trace conductor member on a resilient flexure, and by fixing said flexure to a resilient load beam.

15. The method as claimed in claim 8, wherein said connection pads are made of gold or copper.