DESCRIPTION

HEAT SINK INCLUDING HEAT RECEIVING SURFACE WITH PROTRUDING PORTION

Field of the Invention

The present invention relates to a heat sink including a heat receiving surface having protruding portions. The heat sink of the present invention including the heat receiving surface having the protruding portions is not limited to a heat sink used for heat dissipating and cooling of a heat generating electronic component or the like mounted on electronic devices, but can be used for heat dissipating and cooling in various technical fields which require heat dissipation.

Background of the Invention

A semiconductor chip or the like used in various electronic devices such as a personal computer, a game console or an audio system, has been downsized. The density of integration thereof has become larger and the processing speed has been remarkably increased, accordingly. However, the heat generating density thereof has become higher.

A heat sink including a heat dissipating fin is widely used as the means for dissipating the heat generated by the electronic devices such as a personal computer, a game console or an audio system, on which the increased heat density semiconductor chip or the like are mounted. When the heat dissipating fin is applied, the heat sink can be light in weight, and in addition, the heat dissipating area thereof can be larger.

The heat dissipation is implemented in the heat sink including the heat dissipating fin, as follows: the heat generated from a heat source is transferred at first to a base portion having a heat receiving surface of the heat sink, and then, the thus transferred

heat is dissipated through the heat dissipating fin attached to the other end of the base portion of the heat sink (which is located remote from the heat source or which is the surface opposite to the surface to which the heat source is contacted. Thus, the heat is dissipated from the heat source.

Fig. 6 shows one example of a conventional heat sink. Fig. 7 shows the conventional heat sink which is arranged in such manner that a heat receiving surface of the heat sink is visible. In the drawings, reference numeral 31 designates a heat dissipating fin, the reference numeral 32 designates a heat receiving surface of a base portion, the reference numeral 33 designates a heat transfer rubber, the reference numeral 34 designates an IC (heat generating component), the reference numeral 35 designates a printed board for an electronic/electric circuit, and the reference numeral 36 designates a fixing screw. As shown in Fig. 6, the heat generating component 34 mounted on the printed board 35 is caused to contact with the flat heat receiving surface 32 as shown in Fig. 7 through the heat transfer rubber 33, thus dissipating the heat from the heat generating component 34 into the open air through the heat dissipating fin.

However, at first, a contact heat resistance occurs in the contact surface between the heat receiving surface of the heat sink and the heat transfer rubber, and accordingly, this contact heat resistance is required to be lowered. Furthermore, the heat generating component comprises an electronic device in general, and a plurality of electronic components are mounted on a printed board for an electronic/electric circuit. The size of the electronic components vary in fabrication thereof, and the manner to mount the electronic components on the printed board for an electronic/electric circuit vary. Accordingly, the electronic components mounted on the printed board have different heights from the surface of the printed board. The above-mentioned difference in heights of the electronic components are absorbed by the heat transfer rubber interposed between the base portion of the heat sink and the electronic components.

However, in order to absorb the above-mentioned difference in heights of the

electronic components mounted on the printed board, a heat transfer rubber having a high compressibility is required. In general, the compressibility of the heat transfer rubber is inversely proportional to the heat conductivity thereof. Accordingly, when a heat transfer rubber having a high compressibility is used, the heat conductivity thereof becomes low. Thus, there is raised such a problem that the overall heat performance of the heat sink is deteriorated.

Fig. 8 schematically shows a heat sink and a heat generating component which are compressed against each other between which a heat transfer rubber having a high compressibility is interposed. As shown in Fig. 8, a heat transfer rubber 33 is interposed between the heat sink 31 and the heat generating component 34 mounted on a printed board 35 for an electronic/electric circuit. A pressure is applied between the heat sink 31 and the heat generating component 34 mounted on the printed board 35 so as to compress the heat transfer rubber 33, and accordingly, as mentioned above, the difference (i.e., unevenness) in height of a plurality of heat generating components mounted on the printed board can be absorbed.

In this case, if the difference in height of a plurality of heat generating components mounted on the printed board is large, there occurs such a problem that extraordinary force is exerted to the heat generating components, and accordingly, the heat generating components and the portion of the printed board on which the heat generating components are mounted are damaged or crack.

Furthermore, as shown in Fig. 8, since the heat receiving surface of the heat sink and the heat transfer rubber have respective flat surfaces which make contact with each other, air is likely to be entered into the interface therebetween. When the air is entered into the interface between the heat receiving surface of the heat sink and the heat transfer rubber, the so-called heat insulating layer is created, and accordingly, there would be raised such a problem that the heat resistance therebetween increases.

It has been desired to provide a heat sink which can overcome the

above-mentioned problems, that is, which can prevent extraordinary force from being exerted to any of electronic components mounted on a printed board, which has a low heat resistance between the heat receiving surface of the heat sink and the heat transfer rubber, and which is excellent in heat dissipation efficiency.

Accordingly, an object of the present invention is to provide a heat sink which can prevent extraordinary force from being exerted to an electronic component or the like mounted on a printed board, which has a low heat resistance between a heat receiving surface of the heat sink and a heat transfer rubber, and which is excellent in heat dissipation efficiency.

Summary of the invention

The inventors have been studying hard to solve the above-mentioned problems. As a result, the followings are found:

More specifically, when protruding portions comprising concave and convex surfaces are provided in the heat receiving surface of the base portion of a heat sink which contact with heat generating components through a heat transfer conductive rubber, and then a pressure is applied between the heat receiving surface of the heat sink and the heat generating components, the part of the heat transfer rubber interposed between the heat receiving surface of the heat sink and the heat generating components enters into the concave portions in the above-mentioned heat receiving surface so as to reduce the pressure thereof within the concave portions, thereby it is possible to totally reduce the pressure, that is, the averaged compressibility can be lowered.

Furthermore, when protruding portions comprising concave and convex surfaces are provided in the heat receiving surface of the base portion of a heat sink which contact with heat generating components through a heat transfer conductive rubber, the surface area of the heat receiving surface is increased to expand the contact area between the heat receiving surface and the heat transfer rubber.

In addition, when protruding portions comprising concave and convex surfaces are provided in the heat receiving surface of the base portion of a heat sink which contact with heat generating components through a heat transfer conductive rubber, it is possible to prevent air from entering into the interface between the heat receiving surface of the base portion of the heat sink and the heat transfer rubber.

More specifically, by lowering the averaged compressibility, it is possible to prevent extraordinary load from being exerted to electronic portions or the like, mounted on the printed board, and furthermore, by increasing the contact area between the heat receiving surface of the base portion of the heat sink and the heat transfer rubber, the heat resistance in the interface between the heat receiving surface of the heat sink and the heat transfer rubber can be decreased, and thereby it is possible to enhance the heat dissipation efficient.

The present invention is made on the basis of the above-mentioned findings.

The first embodiment of the heat sink of the present invention comprises a heat sink including a heat receiving surface having a plurality of protruding portions, said heat receiving surface being thermally connected to a heat generating component through a heat transfer rubber, to receive heat from said heat generating component and then dissipate said heat.

The second embodiment of the heat sink of the present invention comprises a heat sink, wherein said protruding portions are defined by a plurality of grooves formed in said heat receiving surface.

The third embodiment of the heat sink of the present invention comprises a heat sink, wherein said grooves comprise grooves extending in at least two directions crossing each other.

The fourth embodiment of the heat sink of the present invention comprises a heat sink, wherein each of said groove has a cross-sectional configuration comprising a bottom surface and side surfaces, at least one of which surfaces is curved.

The fifth embodiment of the heat sink of the present invention comprises a heat sink, wherein said protruding portions are projected from a surface of said heat receiving surface, and said protruding portions are separated from one another.

The sixth embodiment of the heat sink of the present invention comprises a heat sink, wherein said heat generating component is mounted on a printed board.

The seventh embodiment of the heat sink of the present invention comprises a heat sink, wherein a load is applied between said heat generating component and said heat receiving surface so as to be joined each other in such manner that said load is absorbed by said heat transfer rubber arranged therebetween.

The eighth embodiment of the heat sink of the present invention comprises a heat sink, wherein said grooves in said heat receiving surface are filled therein with said heat transfer rubber.

The ninth embodiment of the heat sink of the present invention comprises a heat sink, wherein a compressibility of said heat transfer rubber falls within a range of 10 to 60 %.

The tenth embodiment of the heat sink of the present invention comprises a heat sink, wherein a heat pipe is further included.

There is provided another embodiment of the heat sink of the present invention which comprises a heat sink including a heat receiving surface having a plurality of protruding portions, in which each of the above-mentioned plurality of grooves has a cross-sectional configuration comprising a bottom surface and straight side surfaces.

There is provided other embodiment of the heat sink of the present invention which comprises a heat sink including a heat receiving surface having a plurality of protruding portions, in which each of the above-mentioned protruding portions projected from the heat receiving surface and separated from one another has at least one curved surface.

There is provided other embodiment of the heat sink of the present invention

which comprises a heat sink including a heat receiving surface having a plurality of protruding portions, in which the above-mentioned pressure is applied by a fixing member for fixing the printed board and the heat sink each other.

There is provided other embodiment of the heat sink of the present invention which comprises a heat sink including a heat receiving surface having a plurality of protruding portions, in which the heat sink comprises a heat sink main body, and the heat receiving surface is included on the heat sink main body.

There is provided other embodiment of the heat sink of the present invention which comprises a heat sink including a heat receiving surface having a plurality of protruding portions, in which the heat sink comprises a heat sink main body and a heat dissipating fin, and the heat receiving surface is included in the heat sink main body.

Brief Description of the Drawings

Fig. 1 is a view illustrating an embodiment of a heat skink including a heat receiving surface having protruding portions, according to the present invention;

Fig. 2 is a sectional view along line A-A in Fig. 1, in which the base portion of the heat sink is shown in such manner that the bottom surface thereof is positioned to be upper side in order to illustrate details of the heat receiving surface;

Fig. 3 is another sectional view along line A-A in Fig. 1, in which the base portion of the heat sink is shown in such manner that the bottom surface thereof is positioned to be upper side in order to illustrate details of the heat receiving surface;

Fig. 4 is a schematic view illustrating the heat sink according to the present invention, in which a heat generating component and a heat transfer rubber having a high compressibility is compressed;

Fig. 5 is a view illustrating in detail protruding portions formed on the heat receiving surface in an example of the present invention;

Fig. 6 is a view illustrating a conventional heat sink.

Fig. 7 is a view illustrating a conventional heat sink which is arranged in a position so as to make the heat receiving surface visible; and

Fig. 8 is a schematic view illustrating a conventional heat sink, in which a heat generating component and a heat transfer rubber having a high compressibility is compressed.

Detailed Description of Preferred Embodiments of the Invention

A heat sink including a heat receiving surface having protruding portions of the present invention is described with reference to the drawings.

The heat sink of the present invention comprises a heat sink including a heat receiving surface having a plurality of protruding portions, in which the heat receiving surface is thermally connected to a heat generating component through a heat transfer rubber, to receive heat from the heat generating component and then dissipate the heat.

Fig. 1 is a view illustrating an embodiment of a heat skink including a heat receiving surface having protruding portions, according to the present invention. The heat sink comprises a base portion 3 and a heat dissipating fin 2, and the heat receiving surface 4 is formed in the base portion. The heat sink is fixed through a heat transfer rubber by a fixing member 5 (for example, screws) to a printed board for an electronic/electric circuit on which the heat generating component is mounted. Figs. 2 and 3 show in detail the heat receiving surface. Figs. 2 and 3 are sectional views along line A-A in Fig. 1 in which the bottom surface of the base portion is located on the upper side in order to clearly show in detail the heat receiving surface. As clearly shown in Figs. 2 and 3, the heat receiving surface includes a plurality of protruding portions.

In the heat sink including the heat receiving surface having the above mentioned plurality of protruding portions, the protruding portions are defined by a plurality of grooves formed in the heat receiving surface. Furthermore, the grooves may comprise grooves extending in at least two different directions which cross each other. More

specifically, the protruding portions may be formed by grooves extending in two directions, i.e., lengthwise and crosswise directions crossing each other. Furthermore, the grooves has a cross-sectional configuration comprising a bottom surface and side surfaces, at least one of which surfaces is curved. Furthermore, each of the grooves has a cross-sectional configuration comprising a bottom surface and straight side surfaces.

As shown in Fig. 2, the plurality of protruding portions 8 are formed by the plurality of grooves formed in the heat receiving surface 4, and each of the groove has a U-shaped cross-section, each being comprising a bottom surface 6 and straight side surfaces 7. For example, lengthwise four grooves and crosswise four grooves are orthogonal to one another so as to form the protruding portions having the above-mentioned configuration.

As shown in Fig. 3, a plurality of protruding portions 10 are formed by the grooves formed in the heat receiving surface 4, and the grooves have such a sectional configuration that it has a bottom surface 9 and curved side surfaces 10.

Furthermore, in the heat sink of the present invention including the heat receiving surface having the plurality of protruding portions, the protruding portions may be those which are projected from the heat receiving surface and which are separated from each other. More specifically, the above-mentioned protruding portions are not formed by grooves or the like cut in the heat receiving surface, but they may be formed by the manner in which each of the protruding portions having a prescribed shape is projected from the heat receiving surface 4 (for example, a convex shape including straight side surfaces or curved side surface, as already mentioned above). Furthermore, the protruding portions may have at least one curved surface.

Fig. 4 schematically shows such a condition that the heat transfer rubber having a high compressibility used between the heat sink of the invention and the heat generating component is compressed. As shown in Fig. 4, the heat transfer rubber 11 is interposed between the heat generating component 12 mounted on the printed board 13 and the heat

sink 1. The protruding portions are defined by the grooves formed in the heat receiving surface 4 of the heat sink 1, and the cross-sectional configuration of the grooves is such that it has a bottom surface 9 and the curved side surfaces 10.

When a pressure is applied between the heat sink 1 and the heat generating component 12 mounted on the printed board 13, the heat transfer rubber 11 is compressed, and is filled in the grooves each comprising the bottom surface 9 and the curved side surfaces 10. At this stage, if the ends of the grooves are opened, air existing in the gap between the heat sink and the heat transfer rubber is compelled through the opened end portions of the grooves, thereby it is possible to prevent the air being trapped so as to create a heat insulating layer.

The heat transfer rubber 11 is filled in the grooves each of which comprises the bottom surface 9 and partly curved or entirely curved side surfaces 10 to enlarge the contact area between the heat receiving surface of the base portion of the heat sink and the heat transfer rubber, thus improving the heat dissipation efficiency. Furthermore, since the heat transfer rubber 11 is filled in the grooves each of which comprises the bottom surface 10 and the curved side surfaces 10, the average compressibility is lowed so as to prevent extraordinary force from being exerted to an electronic component or the like mounted on the printed board, thereby it is possible to prevent the electronic component or the like from being damaged.

As described above, in the heat sink of the present invention including the heat receiving surface having the protruding portions, a pressure is applied to the generating component and the heat receiving surface with the heat transfer rubber interposed therebetween so as to be joined together. Furthermore, the pressure is applied by the screws for fixing the heat sink to the printed board.

In the present invention, the scope of the compressibility of the heat transfer rubber falls within a range of 10 to 60 %. More specifically, with the compressibility of the heat transfer rubber below 10 %, extraordinary force is applied to a plurality of heat

generating components mounted on the printed board, in such a case that the difference in size in the height direction of the heat generating components is large, thus damaging or cracking the heat generating components mounted on the printed board. On the other hand, with the compressibility of the heat transfer rubber over 60 %, the heat resistance of the heat transfer rubber becomes higher, thus the heat dissipation efficiency is lowered. In addition, it is preferable that the compressibility of the heat transfer rubber falls within a range of 20 to 30 %.

The heat sink of the present invention including the heat receiving surface having the protruding portions comprises a heat sink main body as shown in Fig. 1, and the heat receiving surface may be included in the heat sink main body. Furthermore, the heat sink of the present invention including the heat receiving surface having the protruding portions may comprise a heat sink main body and a heat dissipating fin, and the heat receiving surface may be included in the heat sink main body. Furthermore, the heat sink main body may be positioned to be spaced each other from the heat dissipating fin by a prescribed distance.

Further, the heat sink of the present invention including the heat receiving surface having the protruding portions may include a heat pipe. For example, the heat receiving surface and the heat dissipating fines are spaced from each other by a predetermined distance, and the heat pipe may be arranged so as to connect the heat receiving surface to the heat dissipating fins.

The heat sink of the present invention including the heat receiving surface having the protruding portions is described in detail by an example.

Example

The heat sink of the present invention including the heat receiving surface having a plurality of protruding portions was pressed through a heat transfer rubber having a heat transfer rate of 2.5 $W/m^2 \cdot K$ and a thickness of 1.3 mm to closely contact with a heat

generating component (i.e., IC chip) having a length of 40 mm and a width of 40 mm mounted on a printed board for an electronic/electric circuit. In this arrangement, the compressibility of the heat transfer rubber was 23 %, and a load of 5 Kg/cm^2 was applied to the arrangement so that the thickness of the heat transfer rubber was 1.0 mm.

A total of six slits 15, 16 each having a width of 0.2 mm and a depth of 0.3 mm were formed in the heat receiving surface, each of which is arranged at pitches of 10 mm, and is orthogonal to one another, as shown in Fig. 5(A). Thus, sixteen rectangular protruding portions 14 each having a flat top surface were formed. As shown in Fig. 5(B), the cross-sectional configuration thereof is such that the rectangular protruding portions 14 each having a flat top surface are formed among U-shaped grooves 16.

The heat transfer rubber was filled in the grooves forming the protruding portions, under application of a load.

For the purpose of comparison, a heat sink having a flat heat receiving surface with no protruding portions, was pressed through a heat transfer rubber having a heat conductivity of 2.5 W/m^2 and a thickness of 1.3 mm to closely contact with a heat generating component (i.e., IC chip) having a length of 40 mm and a width of 40 mm mounted on a printed board.

Thermal resistance and the load exerted to the IC chips were investigated in the thus prepared heat sink of the present invention and the heat sink for comparison. As a result, the heat resistance (including the contact resistance) of the heat transfer rubber in the arrangement of the present invention was 0.4 degree centigrade /W while the heat resistance (including the contact resistance) of the heat transfer rubber in the arrangement for comparison was 0.5 degree centigrade/W.

Furthermore, the load applied to the IC chip in the arrangement of the present invention was 60 Kg while the load applied to the IC chip in the arrangement for comparison was 80 Kg.

As is clear from the foregoing, according to the heat sink of the present invention

including the heat receiving surface having the protruding portions, the heat resistance of the heat transfer rubber can be remarkably lowered, and the load exerted to the IC chip can be greatly lowered.

Thus, according to the present invention, there can be provided a heat sink which has a small heat resistance between the heat receiving surface of the heat sink and a heat transfer rubber so as to be excellent in heat dissipation efficiency without exerting extraordinary force to electronic components or the like mounted on a printed board for an electronic/electric circuit.

CLAIMS

1. A heat sink including a heat receiving surface having a plurality of protruding portions, said heat receiving surface being thermally connected to a heat generating component through a heat transfer rubber, to receive heat from said heat generating component and then dissipate said heat.

2. The heat sink as claimed in claim 1, wherein said protruding portions are defined by a plurality of grooves formed in said heat receiving surface.

3. The heat sink as claimed in claim 2, wherein said grooves comprise grooves extending in at least two directions crossing each other.

4. The heat sink as claimed in claim 2 or 3, wherein each of said groove has a cross-sectional configuration comprising a bottom surface and side surfaces, at least one of which surfaces is curved.

5. The heat sink as claimed in claim 1, wherein said protruding portions are projected from a surface of said heat receiving surface, and said protruding portions are separated from one another.

6. The heat sink as claimed in claim 1, wherein said heat generating component is mounted on a printed board.

7. The heat sink as claimed in any one of claims 1 to 6, wherein a load is applied between said heat generating component and said heat receiving surface so as to be joined each other in such manner that said load is absorbed by said heat transfer rubber arranged

therebetween.

8. The heat sink as claimed in claim 7, wherein said grooves in said heat receiving surface are filled therein with said heat transfer rubber.

9. The heat sink as claimed in claim 1, wherein a compressibility of said heat transfer rubber falls within a range of 10 to 60 %.

10. The heat sink as claimed in claim 1, wherein a heat pipe is further included.

11. The heat sink as claimed in 2, wherein said grooves have a cross-sectional configuration comprising a bottom surface and straight side surfaces.

12. The heat sink as claimed in 1, wherein said protruding portions projected from the heat receiving surface and separated from one another have at least one curved surface.

13. The heat sink as claimed in 7, wherein said load is applied by a fixing member for fixing said printed board to said heat sink.

14. The heat sink as claimed in claim 1, wherein said heat sink comprises a heat sink main body, and said heat receiving surface is included on said heat sink main body.

15. The heat sink as claimed in claim 1, wherein said heat sink comprises a heat sink main body and a heat dissipating fin, and said heat receiving surface is included in said heat sink main body.