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[Document Name] SPECIFICATION

[Title of the Invention] Semiconductor device and method of manufacturing the same, circuit board, and electronic instrument

[Claims]

[Claim 1]



A semiconductor device comprising:

a plurality of semiconductor chips having electrodes, and aligned in a horizontal direction for face-down bonding;

a substrate on which an interconnect pattern is formed, the interconnect pattern having bonding portions to which the electrodes of the semiconductor chip are connected, and lands to which the bonding portions are electrically connected; and

external electrodes provided on the lands.



[Claim 2]

The semiconductor device as defined in claim 1,

wherein the external electrodes are disposed within mounting regions of the semiconductor chips.

[Claim 3]

The semiconductor device as defined in claim 1,

wherein the external electrodes are disposed outside regions where the semiconductor chips are mounted.

[Claim 4]

The semiconductor device as defined in claim 3,

wherein the substrate is a flexible substrate and is formed to be larger than the regions where the semiconductor chips are mounted, and a flat support member is provided on a periphery of

the substrate.

[Claim 5]

The semiconductor device as defined in claim 1,

wherein the external electrodes are disposed within a region where any one of the semiconductor chips is mounted.

[Claim 6]

The semiconductor device as defined in claim 5,

wherein the substrate is a flexible substrate and part of the substrate is bent; and

wherein a surface of the one semiconductor chip, which is disposed at a region where the external electrodes are provided, opposite to a surface on which the electrodes are formed is adhered to a surface of at least one remaining semiconductor chip opposite to a surface on which the electrodes are formed.

[Claim 7]

The semiconductor device as defined in claim 6,

wherein the substrate has a hole formed along a region to be bent.

[Claim 8]

The semiconductor device as defined in claim 6 or 7,

wherein the semiconductor chips are adhered by an electrically conductive adhesive or a thermally conductive adhesive.

[Claim 9]

The semiconductor device as defined in any one of claims 5 to 8,

wherein a surface area of one of the semiconductor chips is

larger than a surface area of a remaining semiconductor chip; and

wherein the external electrodes are formed only in a region where the semiconductor chip having a larger surface area is provided.

[Claim 10]

The semiconductor device as defined in any one of claims 1 to 9,

wherein the electrodes of the semiconductor chips are connected to the bonding portions by an anisotropically conductive material including conductive particles dispersed in an adhesive.

[Claim 11]

A method of manufacturing a semiconductor device, comprising:

a step of providing a substrate on which an interconnect pattern is formed, the interconnect pattern having a plurality of bonding portions and a plurality of lands electrically connected to the bonding portions, and providing a plurality of semiconductor chips having electrodes;

a step of providing anisotropically conductive materials including conductive particles dispersed in an adhesive at least on the bonding portions;

a step of positioning the electrodes over the bonding portions on the anisotropically conductive materials, and mounting the semiconductor chips over the substrate;

a step of applying pressure to at least one of the semiconductor chips and the substrate so that the bonding portions and the electrodes are electrically connected by the conductive

particles; and

a step of forming external electrodes on the lands.

[Claim 12]

The method of manufacturing a semiconductor device as defined in claim 11,

wherein the substrate is a flexible substrate and is formed to be larger than the regions where the semiconductor chips are mounted; and

wherein a flat support member is provided on a periphery of the substrate.

[Claim 13]

The method of manufacturing a semiconductor device as defined in claim 11 or 12,

the method further comprising a step of bending a part of the substrate, after the step of mounting the semiconductor chips on the substrate, so that a surface of one of the semiconductor chips opposite to a surface where the electrodes are provided is adhered to a surface of another of the semiconductor chips opposite to a surface on which the electrodes are formed.

[Claim 14]

The method of manufacturing a semiconductor device as defined in claim 13,

wherein the substrate has a hole formed along a region to be bent.

[Claim 15]

A circuit board on which the semiconductor device as defined in any one of claims 1 to 10 is mounted.

[Claim 16]

An electronic instrument on which the circuit board as defined in claim 15 is mounted.

[Detailed Description of the Invention]

[0001]

[Field of Industrial Application]

The present invention relates to a semiconductor device and method of manufacturing the same, to a circuit board and to an electronic instrument.

[0002]

[Background of the Invention]

In recent years, with the increasing compactness of electronic instruments, the development of multichip modules incorporating a plurality of semiconductor chips at high density is proceeding. With a multichip module, since an existing plurality of semiconductor chips can be used, the cost can be reduced compared with the design of a new integrated circuit.

[0003]

However, conventional multichip modules have used wire bonding to connect interconnect pattern of a substrate to the electrodes of the semiconductor chip. As a result, the interconnect pattern requires bonding pads for the wires, and therefore the area of the substrate is increased, preventing the required compactness of the package from being fully achieved.

[0004]

The present invention solves this problems, and has as its

object the provision of a compact semiconductor device incorporating a plurality of semiconductor chips at high density and a method of manufacturing the same, of a circuit board and of an electronic instrument.

[0005]

[Means for Solving the Problems]

(1) A semiconductor device of the present invention comprises:

a plurality of semiconductor chips having electrodes, and aligned in a horizontal direction for face-down bonding;

a substrate on which an interconnect pattern is formed, the interconnect pattern having bonding portions to which the electrodes of the semiconductor chip are connected, and lands to which the bonding portions are electrically connected; and

external electrodes provided on the lands.

[0006]

According to this aspect of the present invention, a plurality of semiconductor chips is aligned in a horizontal direction and mounted on a substrate. Each semiconductor chip is subjected to face-down bonding. Since the bonding is carried out within the region where the semiconductor chip is mounted, the area of the substrate can be kept to the minimum required. As a result, the semiconductor device can be made more compact.

[0007]

(2) In the semiconductor device:

the external electrodes may be disposed within mounting regions of the semiconductor chips.

[0008]

By means of this, external electrodes can be provided corresponding to the electrodes of the semiconductor chip, within the region where each semiconductor chip is mounted.

[0009]

(3) In the semiconductor device:

the external electrodes may be disposed outside regions where the semiconductor chips are mounted.

[0010]

By means of this, the external electrodes can be aligned on the periphery of the substrate.

[0011]

(4) In the semiconductor device:

the substrate may be a flexible substrate and is formed to be larger than the regions where the semiconductor chips are mounted, and a flat support member may be provided on a periphery of the substrate.

[0012]

By means of this, even if a flexible substrate is used, the uniform height (coplanarity) of the external electrodes can be assured by means of the flat support member.

[0013]

(5) In the semiconductor device:

the external electrodes may be disposed within a region where any one of the semiconductor chips is mounted.

[0014]

By means of this, all of the external electrodes can be provided within the region where any one of the semiconductor chips

is mounted, and no external electrodes can be provided within the region where any other semiconductor chip is mounted.

[0015]

(6) In the semiconductor device:

the substrate may be a flexible substrate and part of the substrate is bent; and

a surface of the one semiconductor chip, which is disposed at a region where the external electrodes are provided, opposite to a surface on which the electrodes are formed may be adhered to a surface of at least one remaining semiconductor chip opposite to a surface on which the electrodes are formed.

[0016]

Since on the semiconductor chip another semiconductor chip is adhered, the size of the semiconductor device in the horizontal direction can be reduced.

[0017]

(7) In the semiconductor device:

the substrate may have a hole formed along a region to be bent.

[0018]

By forming the hole in the substrate, the resilience of the substrate can be reduced, and the bent state can be more easily maintained.

[0019]

(8) In the semiconductor device:

the semiconductor chips may be adhered by an electrically conductive adhesive or a thermally conductive adhesive.

[0020]

When an electrically conductive adhesive is used, the electrical potential of the adhering surfaces of the semiconductor chips can be made the same. When a thermally conductive adhesive is used, cooling can be achieved by passing heat from the semiconductor chip which emits more heat to the semiconductor chip which emits less heat.

[0021]

(9) In the semiconductor device:

a surface area of one of the semiconductor chips may be larger than a surface area of a remaining semiconductor chip; and

the external electrodes may be formed only in a region where the semiconductor chip having a larger surface area is provided.

[0022]

By means of this, the largest possible region for providing the external electrodes can be assured, without going outside the surface area of the semiconductor chip.

[0023]

(10) In the semiconductor device:

the electrodes of the semiconductor chips may be connected to the bonding portions by an anisotropically conductive material including conductive particles dispersed in an adhesive.

[0024]

Since the bonding portions and electrodes are electrically connected by the anisotropically conductive material, a semiconductor device can be manufactured by a method of outstanding reliability and productivity.

[0025]

(11) A method of manufacturing a semiconductor device of the present invention comprises:

a step of providing a substrate on which an interconnect pattern is formed, the interconnect pattern having a plurality of bonding portions and a plurality of lands electrically connected to the bonding portions, and providing a plurality of semiconductor chips having electrodes;

a step of providing anisotropically conductive materials including conductive particles dispersed in an adhesive at least on the bonding portions;

a step of positioning the electrodes over the bonding portions on the anisotropically conductive materials, and mounting the semiconductor chips over the substrate;

a step of applying pressure to at least one of the semiconductor chips and the substrate so that the bonding portions and the electrodes are electrically connected by the conductive particles; and

a step of forming external electrodes on the lands.

[0026]

According to this aspect of the present invention, a plurality of semiconductor chips is mounted on the substrate, and the electrodes of the semiconductor chips and bonding portions are subjected to face-down bonding. Therefore, since the bonding is carried out within the region where the semiconductor chip is mounted, the area of the substrate can be kept to the minimum required. As a result, the semiconductor device can be made more

compact.

[0027]

Since the bonding portions and electrodes are electrically connected by the anisotropically conductive material, a semiconductor device can be manufactured by a method of outstanding reliability and productivity.

[0028]

(12) In this method,

the substrate may be a flexible substrate and formed to be larger than the regions where the semiconductor chips are mounted; and

a flat support member may be provided on a periphery of the substrate.

[0029]

By means of this, even if a flexible substrate is used, the uniform height (coplanarity) of the external electrodes can be assured. In the case where all of the external electrodes are provided outside the region where all of the semiconductor chips are mounted, the external electrodes can be provided on the region to which the flat support member is attached.

[0030]

(13) The method may further comprise a step of bending a part of the substrate, after the step of mounting the semiconductor chips on the substrate, so that a surface of one of the semiconductor chips opposite to a surface where the electrodes are provided is adhered to a surface of another of the semiconductor chips opposite to a surface on which the electrodes are formed.

[0031]

Since on the semiconductor chip another semiconductor chip is adhered, the size of the semiconductor device in the horizontal direction can be reduced.

[0032]

(14) In this method,

the substrate may have a hole formed along a region to be bent.

[0033]

In this way, by forming a hole in the substrate, the resilience of the substrate can be reduced, and the substrate can be made easier to bend.

[0034]

(15) The circuit board of the present invention has the above described semiconductor device mounted.

[0035]

(16) The electronic instrument of the present invention has the above described circuit board.

[0036]

[Embodiments]

The present invention is now described in terms of a number of preferred embodiments, with reference to the drawings.

[0037]

(First Embodiment)

Figs. 1(A) to 1(C) show a first embodiment of the semiconductor device to which the present invention is applied. It should be noted that Fig. 1(A) is a plan view of the semiconductor

device, Fig. 1(B) is a cross-sectional view along the line IB-IB in Fig. 1(A), and Fig. 1(C) is a bottom view of the semiconductor device. A semiconductor device 1 comprises a substrate 10 a plurality (for example two) of semiconductor chips 20 and 30, and a plurality of external electrodes 40.

[0038]

The substrate 10 may be formed of either of an organic or inorganic material, or may be a compound construction thereof. As a substrate 10 formed of an organic material may be cited, for example, a flexible substrate formed of a polyimide resin. As a substrate 10 formed of an inorganic material may be cited, for example, a ceramic substrate or glass substrate. As a compound construction of organic and inorganic materials may be cited, for example, a glass epoxy substrate.

[0039]

On the substrate 10, is formed an interconnect pattern 12. The interconnect pattern 12 is formed on one surface of the substrate 10. It should be noted that in addition to the interconnect pattern 12 formed on the one surface of the substrate 10, an interconnect pattern may also be formed on the other surface.

[0040]

The interconnect pattern 12 can be formed by covering the substrate 10 with copper or the like by sputtering or the like to form a conductive film, and etching the same. In this case, the interconnect pattern 12 is formed directly on the substrate 10, and forms a two-layer substrate without an intervening adhesive. Alternatively, a three-layer substrate may be used with an adhesive

interposed between the substrate 10 and the interconnect pattern 12. Alternatively, a built-up substrate of multi-layer construction may be used, with an insulating resin and interconnect pattern laminated on the substrate, or a multi-layer substrate with a plurality of substrates laminated may be used.

[0041]

The interconnect pattern 12 includes a plurality of bonding portions 14 and a plurality of lands 16. Each of the bonding portions 14 is electrically connected to at least one of the lands 16. The bonding portions 14 and lands 16 are formed to be larger in area than the interconnect portions. It should be noted that bumps may be formed on the bonding portions 14.

[0042]

The bonding portions 14 and lands 16 are formed within the mounting region of each of the semiconductor chips 30 and 40 on the substrate 10, and are not formed outside these regions. The bonding portions 14 positioned within the mounting regions of each of the semiconductor chips 30 and 40 are connected to the lands 16 positioned within the respective mounting region. Alternatively, bonding portions 14 positioned within the mounting region of either one of the semiconductor chips 30 and 40 may be connected to lands 16 positioned within the mounting region of the other of the semiconductor chips 30 and 40. To simplify trimming die, the substrate 10 may be formed to be oblong as shown in the drawing, and where even more extreme compactness is required, may be formed along the outline of the semiconductor chip.

[0043]

In the substrate 10 are formed through holes 18. On the through holes 18 are positioned the lands 16. That is to say, the lands 16 are able to be connected to the surface opposite to the surface of formation of the interconnect pattern 12 through the through holes 18. In this way, on the surface of the substrate 10 opposite to the surface where the interconnect pattern 12 is formed, a plurality of external electrodes 40 (see Fig. 1(C)) electrically connected to the interconnect pattern 12 can be formed.

[0044]

The plurality of semiconductor chips 20 and 30 are, for example, flash memory and SRAM, both SRAMs, both DRAMs, memory and ASIC, or an MPU and memory, and have respective pluralities of electrodes 22 and 32. The electrodes 22 and 32 are positioned over some of the bonding portions 14, and are electrically connected through an anisotropically conductive material 50. That is to say, the semiconductor chips 20 and 30 are subjected to face-down bonding to the interconnect pattern 12 of the substrate 10 by facing down the surfaces on which the electrodes 22 and 32 are formed. It should be noted that the semiconductor chips 20 and 30 shown in the drawings have different sizes and shapes, but they may equally be of the same size and shape. The electrodes 22 and 32 are commonly gold formed by plating or as wire, but may equally be nickel, solder or suchlike material.

[0045]

The anisotropically conductive material 50 comprises an adhesive (binder) in which conductive particles (conductive filler) is dispersed, and may also include a dispersant. The

anisotropically conductive material 50 may be preformed into a sheet, then adhered to the substrate 10, or may be disposed in liquid form on the substrate 10. A thermosetting adhesive is commonly used as the adhesive of the anisotropically conductive material 50. The anisotropically conductive material 50 is provided at least on the bonding portions 14. Alternatively, when the anisotropically conductive material 50 is provided to cover the whole of the substrate 10, this step can be carried out simply. When the anisotropically conductive material 50 is provided to exclude the periphery of the substrate 10, the anisotropically conductive material 50 will not be attached to the peripheral surface of the substrate 10, which is convenient for the later handling of the substrate 10.

[0046]

The anisotropically conductive material 50 is squeezed between the electrodes 22 and 32 and the bonding portions 14, and the conductive particles are arranged to provide electrical conduction therebetween. In this embodiment, the semiconductor chips 20 and 30 are subject to face-down bonding. When the face-down bonding is performed, instead of using the anisotropically conductive material 50, any of at least one of light, heat, pressure, and vibration may be used to bond the electrodes 22 and 32 to the bonding portions 14. In this case, the reliability is highest with metal-to-metal bonding. In this case, between the semiconductor chips 20 and 30 and the substrate 10 is commonly filled with an underfill resin.

[0047]

The external electrodes 40 are provided on lands 16 of the interconnect pattern 12. In more detail, the external electrodes 40 are provided on the surface opposite to the surface where the interconnect pattern 12 is formed on the substrate 10, and are electrically connected to the lands 16 through the through holes 18. The electrical connection of the external electrodes 40 to the lands 16 is commonly achieved by providing solder balls together with flux on the through holes on the surface of the substrate opposite to that on which the semiconductor chips are mounted, and formed by a reflow process, but may equally be achieved by providing a conductive material such as gold or copper plated on the inner surface of the through holes 18. Alternatively, when solder balls are used as the external electrodes 40, the through holes 18 may be filled with the solder which is the material of the solder balls, and a conductive material formed integrally with the solder balls within the through holes 18.

[0048]

Further, on the surface opposite to the semiconductor chip mounting surface, may be formed lands for external electrodes connected by via holes or through holes to the interconnect pattern 12, and external electrodes may be formed thereon. The external electrodes may equally be formed of a metal other than the solder described above, or of a conductive resin, or the like.

[0049]

As described above, when all of the lands 16 are positioned within the mounting region of the semiconductor chips 20 and 30, the external electrodes 40 are also positioned within the mounting

region of the semiconductor chips 20 and 30 (FAN-IN structure). When bonding portions 14 provided within the mounting region of some of the semiconductor chips 20 and 30 are connected to lands 16 provided within the mounting region, the external electrodes 40 are also electrically connected to electrodes 22 and 32 of semiconductor chips 20 and 30 corresponding to the mounting region in which the external electrodes 40 are provided.

[0050]

According to this embodiment, the plurality of semiconductor chips 20 and 30 are aligned in the horizontal direction and mounted on the substrate 10, and the electrodes 22 and 32 of the semiconductor chips 20 and 30 are subjected to face-down bonding to the bonding portions 14. Therefore, since bonding is carried out within the region of the semiconductor chips 20 and 30, the area of the substrate 10 can be kept to the minimum required. As a result, the semiconductor device 1 can be made compact.

[0051]

This embodiment has the above described construction, and one example of a method of manufacturing the same is now described. First, the substrate 10 having formed thereon the interconnect pattern 12 which has a plurality of bonding portions 14 and a plurality of lands 16 connected to the bonding portions 14 is provided in advance. Then on the surface of the substrate 10 on which the interconnect pattern 12 is formed, the anisotropically conductive material 50 is provided. In more detail, the anisotropically conductive material 50 is provided on at least the bonding portions 14.

[0052]

The plurality of the semiconductor chips 20 and 30 having a plurality of electrodes 22 and 32 is provided in advance. The electrodes 22 and 32 are positioned over the bonding portions 14 of the anisotropically conductive material 50, and the semiconductor chips 20 and 30 are mounted on the substrate 10.

[0053]

Next, at least one of the semiconductor chips 20 and 30 and the substrate 10 is pressed, and the bonding portions 14 and the electrodes 22 and 32 are electrically connected through the conductive particles of the anisotropically conductive material 50.

[0054]

Then from the surface of the substrate 10 opposite to that on which the interconnect pattern 12 is formed, with through holes 18 interposed, the external electrodes 40 are formed on the lands 16.

[0055]

By the above process, the semiconductor device 1 is obtained. According to this embodiment, since the bonding portions 14 and electrodes 22 and 32 are electrically connected by the anisotropically conductive material 50, a semiconductor device 1 can be manufactured by a method of outstanding reliability and manufacturing characteristics.

[0056]

(Second Embodiment)

Figs. 2(A) to 2(C) shows a second embodiment of the

semiconductor device to which the present invention is applied. It should be noted that Fig. 2(A) is a plan view of the semiconductor device, Fig. 2(B) is a cross-sectional view along the line IIB-IIB in Fig. 2(A), and Fig. 2(C) is a bottom view of the semiconductor device. A semiconductor device 2 includes a substrate 110, external electrodes 140, and the plurality (for example, two) of semiconductor chips 20 and 30 used in the first embodiment.

[0057]

On the substrate 110 is formed an interconnect pattern 112. The interconnect pattern 112 includes bonding portions 114 and lands 116. The bonding portions 114 are provided in positions corresponding to the electrodes 22 and 32 of the semiconductor chips 20 and 30. On the other hand, the lands 116 are formed only within the mounting region of one of the semiconductor chips 20 and 30. Therefore, the lands 116 within this one of the mounting regions are electrically connected to the bonding portions 114 within the other of the mounting regions through interconnects 115.

[0058]

Since the lands 116 are formed in this way, the external electrodes 140 are also formed only within the mounting region of one of the semiconductor chips 20 and 30. It should be noted that in Fig. 2(C), for simplification a reduced number of the external electrodes 140 are shown, and a larger number of the external electrodes 140 can actually be provided.

[0059]

Other than this, the structure and method of manufacture is the same as in the first embodiment described above. Depending on

the interconnect pattern of the mounting substrate or motherboard, it may be beneficial for all of the external electrodes 140 to be concentrated in a single location as in the second embodiment of the semiconductor device 2.

[0060]

To prevent inclination of the semiconductor device due to a weight imbalance during mounting on the motherboard, a projection of the same size, height, and form as the external electrodes 140 may be formed on the surface of the substrate 110 opposite to that on which the semiconductor chip 20 is mounted. This projection may be formed of resin or tape or the like.

[0061]

(Third Embodiment)

Figs. 3(A) to 3(C) show a third embodiment of the semiconductor device to which the present invention is applied. It should be noted that Fig. 3(A) is a plan view of the semiconductor device, Fig. 3(B) is a cross-sectional view along the line IIIB-IIIB in Fig. 3(A), and Fig. 3(C) is a bottom view of the semiconductor device. A semiconductor device 3 includes a substrate 210, external electrodes 240, and the plurality (for example, two) of semiconductor chips 20 and 30 used in the first embodiment.

[0062]

On the substrate 210 is formed an interconnect pattern 212. The interconnect pattern 212 includes bonding portions 214 and lands 216. The bonding portions 214 are provided in positions corresponding to the electrodes 22 and 32 of the semiconductor chips 20 and 30. On the other hand, the lands 216 are formed on the outside

of the mounting region of the semiconductor chips 20 and 30. Therefore, the bonding portions 214 within the mounting region of the semiconductor chips 20 and 30 and the lands 216 positioned outside this mounting region are electrically connected through interconnects 215. The substrate 210 is formed to be larger than the mounting region of the semiconductor chips 20 and 30.

[0063]

Since the lands 216 are formed in this way, the external electrodes 240 are also formed outside the mounting region of the semiconductor chips 20 and 30 (FAN-OUT structure). It should be noted that in Fig. 3(C), for simplification a reduced number of the external electrodes 240 are shown, and in practice a larger number of the external electrodes 240 can be provided.

[0064]

On the substrate 210 is provided a flat support member 200 which is rigid, for example of metal. The flat support member 200 serves to reinforce the substrate 210 and maintain flatness, so that as long as it is rigid there are no restrictions on the material. For example, a metal such as stainless steel or a copper alloy is commonly used, but this may also be formed of plastic, ceramic, or another insulating material. In this embodiment, the anisotropically conductive material 50 is provided on the interconnect pattern 212, and when there is no conduction from the conductive particles of the anisotropically conductive material 50, even if a metal flat support member 200 is used, electrical conduction between the interconnect pattern 212 and the flat support member 200 can be prevented. Alternatively, when the flat

support member 200 is formed of an insulating material, there may be an electrical connection from the conductive particles of the anisotropically conductive material 50. By forming an insulation layer at least on the contact surface with the anisotropically conductive material 50 on the flat support member 200, electrical conduction between the interconnect pattern 212 and the flat support member 200 can be prevented even if the flat support member 200 is of metal. The flat support member 200 may be adhered to the substrate 210 with a general insulating adhesive other than the anisotropically conductive material.

[0065]

The flat support member 200 is adhered outside the mounting region of the semiconductor chips 20 and 30 or the on the periphery of the substrate 210 by the anisotropically conductive material 50. Therefore, even if the substrate 210 is a flexible substrate, the flatness of the portion outside the semiconductor chips 20 and 30 and the periphery of the substrate 210 can be assured. In this embodiment, the flatness of the region of the substrate 210 in which the external electrodes 240 are provided is assured by the flat support member 200, as a result of which the uniform height (coplanarity) of the external electrodes 240 can be assured. Other than this, the structure and method of manufacture is the same as in the first embodiment described above, and description is omitted.

[0066]

It should be noted that in this embodiment, in the mounting region of the semiconductor chips 20 and 30 on the substrate 210,

no external electrodes 240 are provided, but in this region also, external electrodes may be provided (FAN-IN/OUT structure). In addition, or as an alternative, external electrodes may be provided in the region between the semiconductor chip 20 and the semiconductor chip 30. The semiconductor device 4 shown in Fig. 4 is an example showing the external electrodes 240 provided inside and outside of the mounting region of the semiconductor chips 20 and 30 and between the semiconductor chips 20 and 30 on the substrate 210.

[0067]

It should be noted that in the third embodiment, when the substrate 210 itself has flatness retaining properties (for example when the substrate 210 is of ceramic or glass epoxy), then the flat support member 200 is not necessarily required.

[0068]

(Fourth Embodiment)

Fig. 5 shows a fourth embodiment of the semiconductor device to which the present invention is applied, and Figs. 6(A) to 6(C) show a development of the substrate of the semiconductor device shown in Fig. 5. It should be noted that Fig. 6(A) is a plan view, Fig. 6(B) is a cross-sectional view along the line VB-VB in Fig. 6(A), and Fig. 6(C) is a bottom view. A semiconductor device 5 includes a substrate 310, semiconductor chips 320 and 330, and external electrodes 340.

[0069]

The substrate 310, is as shown in Fig. 5 formed of a material which can be bent, and in particular in the case of a two-layer

flexible substrate or in the case that the interconnect density is required to be further increased, a built-up type of flexible substrate is preferable. The substrate 310 forms an oblong shape, longer in one direction. At both ends of this substrate 310, the semiconductor chips 320 and 330 are mounted. It should be noted that in this embodiment the semiconductor chips 320 and 330 are of the same size and the same shape, but may equally be of a different size or different shape.

[0070]

An interconnect pattern 312 is formed on the substrate 310. The interconnect pattern 312 includes bonding portions 314 and lands 316. The bonding portions 314 are provided in positions corresponding to electrodes 322 and 332 of the semiconductor chips 320 and 330, and are electrically connected through an anisotropically conductive material 350. On the other hand, the lands 316 are formed only within the mounting region of one of the semiconductor chips 320 and 330. For this reason, the lands 316 within this one mounting region and the bonding portions 314 within the other mounting region are electrically connected through interconnects 315. The interconnects 315 are formed between the semiconductor chips 320 and 330, and are not covered thereby, and are protected by being covered by a protective layer 302 of resist or the like.

[0071]

Since the lands 316 are formed in this way, the external electrodes 340 are also formed only within the mounting region of one of the semiconductor chips 320 and 330. It should be noted that

in the drawing, for simplification a reduced number of the external electrodes 340 are shown, and in practice a larger number of the external electrodes 340 can be provided. With regard to the disposition of the external electrodes 340, as described in the third embodiment, they may equally be disposed using a flat support member on the outside of the semiconductor chip.

[0072]

In this embodiment, the region of the substrate 310 between the semiconductor chips 320 and 330 is bent so that the surface of the substrate 310 on which the semiconductor chips 320 and 330 are mounted forms a V-shape. It should be noted that in the drawing, the substrate 310 is bent gradually without forming a crease, but equally the substrate 310 may form a crease. In the substrate 310, as shown in Figs. 6(A) and 6(C), in the bending region at least one, or a plurality of holes 300 may be formed. By this means, the resilience of the substrate 310 is reduced, and it can be more easily bent, and becomes easier to hold the bent form. It should be noted that the interconnects 315 are preferably formed so as to avoid the holes 300, but the interconnects 315 may be formed over the holes 300.

[0073]

The substrate 310 is bent, and the surface of the semiconductor chip 320 opposite to the surface on which the electrodes 322 are formed, and the surface of the semiconductor chip 330 opposite to the surface on which the electrodes 332 are formed are adhered by an adhesive 304. The bent form of the substrate 310 is maintained by the adhesive force of the adhesive 304. Since

the surfaces of the semiconductor chips 320 and 330 are flat, the adhesion is easy to achieve. When the adhesive 304 is an electrically conductive adhesive, the potential of the adhered surfaces of the semiconductor chips 320 and 330 can be made the same. When the adhesive 304 is a thermally conductive adhesive, heat can be transferred between the semiconductor chips 320 and 330. For example, when one of the semiconductor chips 320 and 330 emits more heat and the other emits less heat, then cooling can be achieved by passing heat from the one to the other. The adhesive 304 may equally be a pressure-sensitive adhesive. The adhesive 304 in sheet form or liquid form is applied to the back surfaces of the semiconductor chips 320 and 330 in the state shown in Figs. 6A to 6C, and thereafter the back surfaces of the both semiconductor chips are adhered together. Alternatively, back surfaces of the semiconductor chip may be positioned together and then the gap filled with the adhesive 304 in liquid form.

[0074]

Except for the above described points, the construction is the same as in the first embodiment described above, and description is omitted. It should be noted that semiconductor chips of different sizes may be used, but in this case when the larger semiconductor chip is disposed on the side of formation of the external electrodes 340, this will give greater geometrical stability, and is preferable.

[0075]

In this embodiment, two semiconductor chips 320 and 330 are used, but a plurality of more than two semiconductor chips may also

be used. In such a case, the surface of one semiconductor chip opposite to the surface on which the electrodes are formed may be adhered to the surface of one or more of the remaining plurality of semiconductor chips opposite to the surface on which the electrodes are formed. By means of such a formation, a plurality, and in particular a large number of semiconductor chips can be superimposed within a small area.

[0076]

In this embodiment of the semiconductor device 5, a plurality of the semiconductor chips 320 and 330 are superimposed, and therefore even more compactness can be achieved than in the previous embodiments. It should be noted that for the method of manufacturing the semiconductor device 5, the same method can be applied as that described in the first embodiment, except for the bending of the substrate 310.

[0077]

In Fig. 7 shows a circuit board 1000 on which the first embodiment of the semiconductor device 1 is mounted. For the circuit board 1000, an organic substrate such as a glass epoxy substrate or the like is generally used. On the circuit board 1000, an interconnect pattern of for example copper is formed to constitute a desired circuit. Then by mechanical connection of corresponding parts of the interconnect pattern and external electrodes 40 (see Fig. 1B) of the semiconductor device 1, electrical connection thereof is achieved.

[0078]

It should be noted that the semiconductor device 1 has a

mounting area which can be made as small as the area for mounting a bare chip, and therefore by using this circuit board 1000 for an electronic instrument, the electronic instrument itself can be made more compact. Within the same area, a larger mounting space can be obtained, and therefore higher functionality is possible.

[0079]

Then as an electronic instrument equipped with this circuit board 1000, Fig. 8 shows a notebook personal computer 1100.

[0080]

It should be noted that the above embodiments are examples of the present invention applied to a semiconductor device, but the present invention can be applied to any surface-mounted electronic component requiring a large number of external electrodes as in the case of a semiconductor device, whether an active component or passive component. As electronic components, for example, may be cited resistors, capacitors, coils, oscillators, filters, temperature sensors, thermistors, varistors, variable resistors, and fuses.

[0081]

[Brief Description of the Drawings]

[Fig.1]

Figs. 1(A) to 1(C) show a first embodiment of the semiconductor device to which the present invention is applied;

[Fig.2]

Figs. 2(A) to 2(C) show a second embodiment of the semiconductor device to which the present invention is applied;

[Fig.3]

Figs. 3(A) to 3(C) show a third embodiment of the semiconductor device to which the present invention is applied;

[Fig.4]

Fig. 4 shows a modification of the third embodiment to which the present invention is applied;

[Fig.5]

Fig. 5 shows a fourth embodiment of the semiconductor device to which the present invention is applied;

[Fig.6]

Figs. 6(A) to 6(C) show a development of a fourth embodiment of the semiconductor device to which the present invention is applied;

[Fig.7]

Fig. 7 shows a circuit board on which the semiconductor device of this embodiment is mounted;

[Fig.8]

Fig. 8 shows an electronic instrument having a circuit board on which the semiconductor device of this embodiment is mounte.

[Explanation of Reference Numerals]

1 semiconductor device
10 substrate
12 interconnect pattern
14 bonding portion
16 land
20 semiconductor chip
22 electrode
30 semiconductor chip

32 electrode

40 external electrodes

50 anisotropically conductive material

CLAIMS:

1. A semiconductor device comprising:

a plurality of semiconductor chips having electrodes, and aligned in a horizontal direction for face-down bonding;

a substrate on which an interconnect pattern is formed, the interconnect pattern having bonding portions to which the electrodes of the semiconductor chip are connected, and lands to which the bonding portions are electrically connected;

wherein all the external electrodes of the semiconductor device are electrically connected to the lands, are disposed only within a region where one of the semiconductor chips is mounted.

2. The semiconductor device as defined in claim 1, wherein the substrate is flexible substrate and part of the substrate is bent; and

wherein a surface of the one semiconductor chip, which is disposed at a region where the external electrodes are provided, opposite to a surface on which the electrodes are formed is adhered to a surface of at least one remaining semiconductor chip opposite to a surface on which the electrodes are formed.

3. The semiconductor device as defined in claim 2, wherein the substrate has at least one hole formed along a region to be bent.

4. The semiconductor device as defined in claim 3,

wherein the hole is a slot extending along a bending line;

wherein the interconnect pattern is formed to pass over the hole; and

wherein an edge of the slot extending along the bending line forms a part of an outer edge.

5. The semiconductor device as defined in claim 3,

wherein a plurality of the holes are formed;

wherein the interconnect pattern is formed to pass over the plurality of holes; and

wherein the holes are slots extending along a bending line, and are aligned.

6. The semiconductor device as defined in claim 2,

wherein the substrate has a slit formed along a region to be bent, and

wherein the substrate is divided by the slit, and a gap is opened up between opposing divided edges.

7. The semiconductor device as defined in claim 6,

wherein a joining member is provided spanning the slit.

8. The semiconductor device as defined in claim 4,

wherein a flexible resin is provided on the interconnect pattern in the hole; and

wherein the resin is bent together with the substrate.

9. The semiconductor device as defined in claim 2,

wherein the semiconductor chips are adhered by an electrically conductive adhesive or a thermally conductive adhesive.

10. The semiconductor device as defined in claim 1,

wherein a surface area of one of the semiconductor chips is larger than a surface area of a remaining semiconductor chip; and

wherein the external electrodes are formed only in a region where the semiconductor chip having a larger surface area is provided.

11. The semiconductor device as defined in claim 1,

wherein the electrodes of the semiconductor chips are connected to the bonding portions by an anisotropically conductive material including conductive particles dispersed in an adhesive.

12. A semiconductor device comprising:

a plurality of semiconductor chips having electrodes;

a substrate on which an interconnect pattern is formed, the interconnect pattern having bonding portions to which the electrodes of the semiconductor chips are connected, and lands to which the bonding portions are electrically connected; and

external electrodes electrically connected to the lands, with the electrodes facing the bonding portion, part of the substrate is bent to have two or more plane regions and a curved region therein, the external electrodes are provided on at least one of the plane regions, and at least two of the semiconductor chips have their first surfaces facing each other, the first surfaces different from second surfaces which the substrate faces.

13. The semiconductor device as defined in claim 12 which comprises two of the plane regions, wherein the external electrodes are provided on one of the plane regions.

14. The semiconductor device as defined in claim 12 which comprises two of the plane regions, wherein the external electrodes are provided on both of the plane regions.

15. A method of manufacturing a semiconductor device, comprising the steps of:

providing a substrate on which an interconnect pattern is formed, the interconnect pattern having a plurality of bonding portions and a plurality of lands electrically connected to the bonding portions, and providing a plurality of semiconductor chips having electrodes;

providing anisotropically conductive materials including conductive particles dispersed in an adhesive at least on the bonding portions;

positioning the electrodes over the bonding portions on the anisotropically conductive materials, and mounting the semiconductor chips over the substrate;

applying pressure to at least one of the semiconductor chips and the substrate so that the bonding portions and the electrodes are electrically connected by the conductive particles;

bending a part of the substrate, after the step of mounting the semiconductor chips on the substrate, so that a surface of one of the semiconductor chips opposite to a surface where the electrodes are provided is adhered to a surface of another of the semiconductor chips opposite to a surface on which the electrodes are formed; and

forming external electrodes on the lands.

16. The method of manufacturing a semiconductor device as defined in claim 15,

wherein the substrate is a flexible substrate and is formed to be larger than the regions where the semiconductor chips are mounted; and

wherein a flat support member is provided on a periphery of the substrate.

17. The method of manufacturing a semiconductor device as defined in claim 15,

wherein the substrate has at least one hole formed along a region to be bent.

18. A method of manufacturing a semiconductor device comprising the steps of:

providing a substrate on which are formed a plurality of bonding portions and a plurality of lands electrically connected to the bonding portions, and providing a plurality of semiconductor chips having electrodes;

mounting the semiconductor chips on the substrate with the electrodes positioned on the bonding portions;

forming external electrodes electrically connected to the lands; and

bending the substrate to form two or more plane regions and a curved area therein, and positioning at least two of the semiconductor

chips with their first surfaces facing each other, the first surfaces different from second surfaces which the substrate faces.

19. The method of manufacturing a semiconductor device as defined in claim 18 which comprises two of the plane regions, wherein the external electrodes are provided on one of the plane regions.

20. The semiconductor device as defined in claim 18 which comprises two of the plane regions, wherein the external electrodes are provided on both of the plane regions.

21. A circuit board on which the semiconductor device as defined in any one of claims 1 to 14 is mounted.

22. An electronic instrument on which the circuit board as defined ni claim 21 is mounted.