

METHOD OF PRODUCING SOLDER BALLS

TECHNICAL FIELD

[0001]

The present invention relates to a method of producing solder balls.

Priority is claimed on Japanese Patent Application No. 2010-241029, filed October 27, 2010, the content of which is incorporated herein by reference.

BACKGROUND ART

[0002]

Recently, as a method of manufacturing an electronic circuit, a method has been widely used wherein a circuit pattern is formed on a plastic substrate, a ceramic substrate or an insulated substrate on which plastic or the like is coated, and electronic components such as an IC element, a semiconductor chip, a resistor and a capacitor are joined by solder to the substrate.

[0003]

As the method of bonding a lead terminal of the electronic components to a predetermined part of a circuit board, the following steps are subsequently performed in general, that is, a step of forming a solder thin layer in advance on the surface of a conductive circuit electrode provided on a circuit board, a step of printing a solder paste or flux on the solder thin layer, a step of positioning and mounting a predetermined electronic component on the circuit board, a step of reflowing the solder thin layer and the solder paste, and a step of solidifying the solder to bond the electronic component and the conductive circuit electrode.

[0004]

Furthermore, due to the recent miniaturization of electronic components and circuit boards, it has been requested to achieve a fine-pitch of the electronic components. For example, as electronic components which achieve a fine-pitch, GFP (quad flat package) and CSP (chip size package) which have a 0.3 mm pitch, FC (flip chip) which has a 0.15 mm pitch, and a LSI chip which has a BGA structure are known. Furthermore, as a method of mounting electronic components on a circuit board, a method is known wherein a solder bump which is formed at a lead terminal of an electronic component and a solder bump which is formed at a predetermined part of a circuit board are laminated and reflowed. In such a method, a solder bump is requested to have a fine-patterned form in order to correspond to a fine-pitch of electronic components.

[0005]

Furthermore, as a method of forming a solder bump on a circuit board, the electroplating method, the electroless plating method and the method wherein a paste of a solder powder is printed and reflowed are known. However, in the method of manufacturing a solder bump using the electroless plating method, it is difficult to increase the thickness of a solder layer, and therefore electronic components and a conductive circuit electrode cannot be adhered rigidly with each other. Furthermore, in the method of manufacturing a solder bump performed by the electroplating method, it is difficult to flow current, which is used for forming plating, in a complicated circuit, and therefore a solder bump having a fine pattern cannot be formed. Furthermore, in the method of printing a solder paste, it is difficult to correspond to a fine-pitch pattern, and therefore a solder bump having a fine pattern cannot be formed.

[0006]

Because of such circumstances, a method wherein solder balls having nearly spherical form are adhered to a circuit board has been used as a method of producing a

solder bump which can correspond to the fine pattern structure and has uniform and equal height.

[0007]

As the method of adhering solder balls on a circuit, a method is known wherein an adhesion-imparting compound is allowed to react with the surface of a conductive circuit electrode of a circuit board to impart adhesiveness to the surface, and solder balls are adhered to the position to which adhesiveness is imparted. Subsequently, the solder balls are melted to form a solder bump. (Refer to Patent document 1.) Furthermore, as a technique to which the method of Patent document 1 is applied, a technique has been developed wherein merely one solder ball is adhered on a required portion on a conductive circuit electrode. (Refer to Patent document 2.)

Prior art documents

Patent documents

[0008]

Patent Document 1: Japanese Unexamined Patent Application, First Publication No. H 7-7244

Patent Document 2: Japanese Unexamined Patent Application, First Publication No. 2008-41803

DISCLOSURE OF INVENTION

Problem to be solved by the Invention

[0009]

However, in a case where a fixed height of a solder bump is required for a semiconductor device having the BGA (ball grid array) structure, there is a problem that, when a semiconductor chip and a circuit board are bonded by reflowing conventional solder balls, the original form cannot be maintained due to melting of the solder balls.

Therefore, there is a possibility that the solder bump cannot maintain the fixed height, the semiconductor chip sinks unevenly, and bonding is performed while the inclined structure is maintained.

[0010]

With respect to the above problem, at present, a method is used wherein a solder bump is formed by melting solder balls having a high melting point at a high temperature temporarily, and then, a semiconductor chip and a circuit board are joined using other solder balls which have a melting point lower than that of the solder balls having a high melting point. As other methods, a method is known wherein metal balls such as copper balls which have been plated with a solder layer (copper-core solder balls) are used as solder balls. Due to the method, a solder bump can be manufactured by placing copper-core solder balls on a circuit board and melting the solder balls temporarily, and therefore it is possible to maintain a distance between the circuit board and an electronic component since core materials thereof act as spacers.

[0011]

However, in the aforementioned method, there are limited kinds of solder materials having a high melting point, and a solder wherein the composition thereof includes lead at a high concentration has been used. Furthermore, solders which have already been put into use as a high melting point solder include lead at a high concentration such as 95% or 80%, and α rays which are emitted from the lead can cause malfunction such as LSI. Accordingly, it is required to use expensive lead, which is obtained by separating an isotope of lead which emits few α rays, or to use a high melting point solder which includes absolutely no lead.

Furthermore, in the method wherein copper-core solder balls are used, it is technically difficult to adhere a solder uniformly on a copper-core ball, and therefore there

is a problem that manufacturing cost is extremely high. Accordingly, the method has not been used as a generic method.

[0012]

The present invention was made according to the aforementioned circumstance, and the purpose of the present invention is to provide a method of producing solder balls which can cope with the fine pattern structure and can be formed at a low cost.

Means for Solving the Problem

[0013]

The present inventors have intensively studied to solve the aforementioned problems, and arrived at the present invention.

That is, the present invention provides the following.

(1) A method of producing solder balls, comprising: a first step wherein core materials are adhered to a first adhesive layer provided on a surface of a substrate; a second step wherein an adhesion-imparting compound is coated on the surface of the core materials to form a second adhesive layer; a third step wherein solder particles are adhered to the second adhesive layer provided at the surface of the core materials; a fourth step wherein the solder particles are melted to form a solder layer on the surface of the core materials; and a fifth step wherein the substrate is removed from the core materials to obtain solder balls.

(2) The method of producing solder balls described in (1), wherein the core materials are made of Cu.

(3) The method of producing solder balls described in (1) or (2), wherein the method comprises, before the first step, a previous step wherein a first member having openings to expose a part of the surface of the first adhesive layer is provided on the first adhesive layer, and after the previous step, the core materials are adhered to the surface of

the first adhesive layer, which is exposed from the openings, in the first step.

(4) The method of producing solder balls described in (3), wherein the first member consists of a first layer and a second layer;

the previous step wherein the first member is provided on the first adhesive layer comprises: a step wherein a first layer of the first member, wherein the first layer has openings, is provided on the first adhesive layer, and a step wherein a second layer of the first member, wherein the second layer has openings which have a smaller diameter than that of the openings of the first layer, is provided on the first layer of the first member so that the center of the openings of the first layer and the center of the openings of the second layer coincide and

the method further comprises, between the first step and the second step, a step wherein the second layer of the first member is removed from the first layer of the first member.

(5) The method of producing solder balls described in (3), wherein the method further comprises, between the first step and the second step,

a step wherein the first member is removed from the surface of the first adhesive layer, and

a step wherein a mask, which consists of particles which have a diameter smaller than the thickness of the first member, is adhered to the surface of the first adhesive layer so that the mask covers the surface of the first adhesive layer.

(6) The method of producing solder balls described in (1) or (2), wherein the method comprises, before the first step, a previous step wherein plural dot-like adhesive layers, which are used as the first adhesive layer, are provided on the surface of the substrate so that the dot-like adhesive layers are separated from each other.

(7) The method of producing solder balls described in (6), wherein the previous

step, which forms the first adhesive layer, comprises a step wherein a second member, which has dot-like openings to expose a part of the surface of the substrate, is provided on the substrate, and a step wherein an adhesive material which forms the first adhesive layer is coated, using the second member as a mask, to form the plural dot-like adhesive layers which are the first adhesive layer.

(8) The method of producing solder balls described in (6), wherein the previous step wherein the first adhesive layer is formed as the dot-like adhesive layers comprises:

a step wherein dot-like metal films are formed on the surface of a transfer base to form the metal films which are spaced from each other,

a step wherein an adhesion-imparting compound is coated on the metal films; and

a step wherein the adhesion-imparting compound is transferred from the transfer base to the surface of the substrate to form the first adhesive layer.

(9) The method of producing solder balls described in (8), wherein the previous step, wherein the first adhesive layer is formed as the dot-like adhesive layers, comprises:

a step wherein the surface of the substrate is covered by a mask having openings, and the adhesion-imparting compound is transferred from the transfer base to the exposed surfaces of the substrate which are exposed from the openings of the mask, and

the second adhesive layer is formed on the core materials while the surface of the substrate is covered with the mask in the second step.

(10) The method of producing solder balls described in (6), wherein the previous step, wherein the first adhesive layer is formed, comprises:

a step wherein dot-like metal films are formed on the surface of the substrate to form the metal film separated from each other, and

a step wherein an adhesion-imparting compound is coated on the metal films to form the first adhesive layer.

(11) The method of producing solder balls described in (10), wherein the previous step, wherein the first adhesive layer is formed, comprises:

a step wherein dot-like metal films are formed on the surface of the substrate to form the metal films which are spaced from each other, and

a step wherein the surface of the substrate is covered by a mask having openings, and the adhesion-imparting compound is coated to the exposed surface of the metal films which are exposed from the openings.

(12) The method of producing solder balls described in (10) or (11), wherein the metal film is made of tungsten.

(13) The method of producing solder balls described in any of (1) to (12), wherein the average particle diameter of the solder particles is $1/2$ or less of the average particle diameter of the core material.

Effects of the Invention

[0014]

According to the method of producing solder balls of the present invention, the solder particles are melted after the solder particles are adhered to the surface of the core materials via the second adhesive layer, and therefore, a uniform solder layer can be formed on the surface of the core materials. Furthermore, the solder layer can be formed easily as compared with the conventional method wherein a solder layer is formed by plating or the like.

Furthermore, since the solder layer is formed on the core material while the core material is adhered on the surface of the substrate via the first adhesive layer, numerous core materials can be treated simultaneously as compared with the conventional method. Furthermore, since the core materials are adhered to the surface of the substrate via the first adhesive layer, the core materials can be removed easily from the substrate after the

solder layer is formed.

Due to the above characteristics, it is possible to greatly simplify the method of producing solder balls, and to produce solder balls efficiently. Accordingly, it is possible to reduce the cost for forming solder balls.

Furthermore, by coating the surface of the core materials with the solder layer, when a solder bump is manufactured using the solder balls produced as described above, the core materials can function as spacers. Accordingly, if the solder layer is melted, the solder bump can maintain the fixed height thereof. Therefore, if electronic components are provided on the solder bump, the electronic components do not sink due to the weight thereof. In this way, it is possible to maintain the distance between electronic components and an electronic circuit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

FIG. 1A is a process drawing which explains a producing step of solder balls of a first embodiment of the present invention.

FIG. 1B is a process drawing which explains a producing step of solder balls of the first embodiment of the present invention.

FIG. 1C is a process drawing which explains a producing step of solder balls of the first embodiment of the present invention.

FIG. 1D is a process drawing which explains a producing step of solder balls of the first embodiment of the present invention.

FIG. 1E is a process drawing which explains a producing step of solder balls of the first embodiment of the present invention.

FIG. 2A is a process drawing which explains a producing step of solder balls of a second embodiment of the present invention.

FIG. 2B is a process drawing which explains a producing step of solder balls of the second embodiment of the present invention.

FIG. 2C is a process drawing which explains a producing step of solder balls of the second embodiment of the present invention.

FIG. 2D is a process drawing which explains a producing step of solder balls of the second embodiment of the present invention.

FIG. 2E is a process drawing which explains a producing step of solder balls of the second embodiment of the present invention.

FIG. 3A is a process drawing which explains a producing step of solder balls of a third embodiment of the present invention.

FIG. 3B is a process drawing which explains a producing step of solder balls of the third embodiment of the present invention.

FIG. 3C is a process drawing which explains a producing step of solder balls of the third embodiment of the present invention.

FIG. 3D is a process drawing which explains a producing step of solder balls of the third embodiment of the present invention.

FIG. 3E is a process drawing which explains a producing step of solder balls of the third embodiment of the present invention.

FIG. 3F is a process drawing which explains a producing step of solder balls of the third embodiment of the present invention.

FIG. 4A is a process drawing which explains a producing step of solder balls of a fourth embodiment of the present invention.

FIG. 4B is a process drawing which explains a producing step of solder balls of the fourth embodiment of the present invention.

FIG. 4C is a process drawing which explains a producing step of solder balls of

the fourth embodiment of the present invention.

FIG. 4D is a process drawing which explains a producing step of solder balls of the fourth embodiment of the present invention.

FIG. 4E is a process drawing which explains a producing step of solder balls of the fourth embodiment of the present invention.

FIG. 5A is a process drawing which explains a producing step of solder balls of a fifth embodiment of the present invention.

FIG. 5B is a process drawing which explains a producing step of solder balls of the fifth embodiment of the present invention.

FIG. 5C is a process drawing which explains a producing step of solder balls of the fifth embodiment of the present invention.

FIG. 5D is a process drawing which explains a producing step of solder balls of the fifth embodiment of the present invention.

FIG. 5E is a process drawing which explains a producing step of solder balls of the fifth embodiment of the present invention.

FIG. 6A is a process drawing which explains a producing step of solder balls of a sixth embodiment of the present invention.

FIG. 6B is a process drawing which explains a producing step of solder balls of the sixth embodiment of the present invention.

FIG. 6C is a process drawing which explains a producing step of solder balls of the sixth embodiment of the present invention.

FIG. 6D is a process drawing which explains a producing step of solder balls of the sixth embodiment of the present invention.

FIG. 6E is a process drawing which explains a producing step of solder balls of the sixth embodiment of the present invention.

FIG. 7A is a plane photograph by which core materials and solder balls of the present invention are schematically explained.

FIG. 7B is a plane photograph by which core materials and solder balls of the present invention are schematically explained.

BEST MODE FOR CARRYING OUT THE INVENTION

[0016]

Hereinafter, suitable examples of the present invention are explained, but the present invention is not limited merely thereto. Modifications and additions of numbers, positions, sizes, values and the like can be made without departing from the scope of the present invention.

(First embodiment)

Hereinafter, a producing method of solder balls 70 as a first embodiment of the present invention is explained while referring to figures. Fig. 1A to Fig. 1E are process drawings which explain the producing method of solder balls of the present embodiment.

[0017]

The method of producing solder balls 70 of the first embodiment is schematically structured such that the method comprises: a first step wherein core materials 11 are adhered on the surface 1a of a substrate 1 on which a first adhesive layer 5 is provided; a second step wherein a second adhesive layer 13 is formed on a surface 11a of the core materials 11; a third step wherein solder particles 14 are adhered to the surface of the second adhesive layer 13; a fourth step wherein the solder particles 14 are melted to form a solder layer 15 on the core materials 11; and a fifth step wherein the substrate 1 is removed from the core materials 11.

A member 21 having openings (first member) is provided on the adhesive layer 13 before the core materials 11 are adhered, and the core materials 11 are adhered to the

exposed surfaces of the adhesive layer 5 wherein the exposed surfaces are exposed in the openings of the member 21.

Hereinafter, each step is explained in detail.

[0018]

First, a substrate 1 to which a first adhesive layer 5 has been provided is prepared.

As the substrate 1, for example, a substrate made of polyimide, a substrate made of an acid-resistant resin, a ceramic substrate, a glass substrate and the like can be used.

Furthermore, materials of the substrate 1 are not limited to the materials cited above.

In so far as the substrate can be formed using a material which can bear heat at the time of melting of solder balls 14 described below, any material can be used for the substrate of the present invention.

[0019]

The first adhesive layer 5 is provided on the substrate 1. As materials which form the adhesive layer 5, any material can be used in so far as the core materials 11 can be adhered by the material and the material can bear heat at the time of melting of the solder particles 14 described below. Concretely, an adhesive material which has heat resistance such as a silicon-based adhesive material can be used. Furthermore, as the substrate 1 to which the first adhesive layer 5 is provided, a polyimide tape can be used.

[0020]

Next, a first member 21 is provided so that the member covers the surface 5a of the first adhesive layer 5.

The first member 21 is a member which is used in the first step described below to provide the core materials 11 on the surface 5a of the first adhesive layer 5 so that the core materials are spaced from each other. The first member 21 has numerous dot-like first openings 31 which are spaced from each other. Here, the distance between the

openings and the arrangement forms of the openings can be selected optionally. When the first member 21 is provided on the surface 5a of the first adhesive layer 5, a part of the surface 5a of the first adhesive layer 5 is exposed in a dot-like manner.

Furthermore, as the first adhesive layer 5, materials may be used which have properties wherein adhesiveness of the surface 5a thereof is lost due to irradiation of ultraviolet, heating or the like. Furthermore, when such materials are used, irradiation of ultraviolet, heating or the like can be performed to lose adhesiveness of the first adhesive layer 5 by a step which is optionally performed.

[0021]

As the first member 21, a member can be used which is made of metal, is in the shape of a plate, has openings and has been generally used for placing core materials 11. Concretely, stainless or nickel having a thickness of about 60 μm can be used as the material of the first member 21.

Furthermore, the material of the first member 21 is not limited to metal. The material of the first member 21 is not limited, in so far as adhesiveness is not imparted to the part where the first member 21 covers in a step where the second adhesive layer 13 described below is formed on the core material 11. Furthermore, the first member 21 is not limited to a plate-like member, and the member may be a coating wherein a paste for solder resist is coated on the surface of the first adhesive layer 5 by screen printing.

[0022]

Furthermore, the thickness H (difference in level between a surface 1a of the substrate 1 and an upper surface of the first member 21) of the first member 21 is suitably set according to the particle diameter D of the core material 11. However, it is preferable that the thickness H be set to be smaller than the particle diameter D of the core material

11, and more preferably, to be 1 μm or more and less than or equal to 1/2 of the particle diameter D.

[0023]

On the other hand, when the thickness H is larger than the particle diameter D, it is not preferable since it is difficult for the core materials 11 to enter in the first openings 31. Furthermore, when the thickness H is less than 1 μm , the core materials 11 are easily displaced and therefore it is not preferable.

[0024]

Furthermore, it is preferable that the diameter F_1 of the first openings 31 be set as necessary according to the thickness H of the first member 21 and the particle diameter D of the core materials 11, so that two or more core materials 11 are not provided in one first opening 31. The range of the diameter F_1 is represented by the following formula (1).

[0025]

$$2\sqrt{H(D-H)} \leq F_1 < D + 2\sqrt{H(D-H)} \quad \cdot \cdot \cdot (1)$$

[0026]

Concretely, for example, when the particle diameter D is 100 μm and the thickness H of the first member 21 is 20 μm , the diameter F_1 of the first openings 31 is 80 μm or more and less than 180 μm according to the aforementioned formula.

[0027]

Furthermore, the particularly preferable range of the diameter F_1 of the first openings 31 can be represented by the formula (2) shown below, when the diameter of solder particles 14 which are adhered to the core materials 11 is shown by d.

[0028]

$$D + 2d \leq F_1 \leq D + 4d \quad \cdot \cdot \cdot (2)$$

[0029]

When the diameter F_1 is in the range shown by the formula (2), the core material 11 can be adhered within the first opening 31 easily.

[0030]

Furthermore, it is preferable that the distance G_1 between the adjacent first openings 31 be suitably set according to the particle diameter D of the core materials 11, the particle diameter d of the solder particles 14, and the thickness H of the first member 21. The distance G_1 between the adjacent first openings 31 can be represented by the following formula (3).

[0031]

$$2d + D - 2\sqrt{H(D-H)} < G_1 \quad \cdot \cdot \cdot (3)$$

[0032]

Furthermore, the particularly preferable range of the distance G_1 between the adjacent first openings 31 can be represented by the formula (4) shown below, when the diameter of solder particles 14 is shown by d .

[0033]

$$4d + D - 2\sqrt{H(D-H)} \leq G_1 \leq 8d + D - 2\sqrt{H(D-H)} \quad \cdot \cdot \cdot (4)$$

[0034]

When the distance G_1 between the adjacent first openings 31 is in the range of the formula (4), it is possible to form solder balls 70 on the substrate 1 with high density, and prevent adjacent solder balls 70 from being bonded with each other.

[0035]

On the other hand, when the distance G_1 between the adjacent first openings 31 is smaller than the minimum number represented by the formula (3), it is not preferable since solder balls 70 may be adhered to each other. Furthermore, when the distance between the adjacent first openings 31 is too large, the number of solder balls 70 which can be manufactured at once is limited, and therefore it is not preferable since manufacturing efficiency becomes poor.

[0036]

Furthermore, it is preferable that the first opening 31 have a circular shape when it is observed from above in plan view. However, the shape may be an ellipse or square.

[0037]

(First step)

Next, as shown in Fig. 1A, core materials 11 are adhered to the surfaces 5a of the first adhesive layer 5, which are exposed from the first openings 31.

At this time, the method of adhering the core materials 11 to the first adhesive layer 5 can be selected as necessary. For example, a method wherein core materials 11 are directly supplied to the first adhesive layer 5 in an inert atmosphere or air, or a method wherein core materials 11 are dispersed in a fluid dispersion to form slurry and the slurry is supplied to the first adhesive layer 5, can be used.

[0038]

First, examples of the method of adhering the core materials 11 to the first adhesive layer 5 in an inert atmosphere or air are explained. First, core materials 11 are

provided in a vessel to which an inert atmosphere or air has been filled. At this time, the amount of the core materials 11 can be selected optionally. Subsequently, a substrate 1 on which a first adhesive layer 5 has been formed is provided in the vessel. Then, the first adhesive layer 5 and the core materials 11 are contacted with each other by the method wherein the vessel is inclined, vibrated or the like. Due to the method, the core materials 11 are adhered to the surfaces 5a of the first adhesive layer 5. The core materials 11 which are not adhered can be removed as necessary.

[0039]

Next, examples of the method wherein the core materials 11 are adhered to the first adhesive layer 5 in a liquid are explained. First, a dispersing liquid such as water is provided in a vessel which is not shown, and the core materials 11 are further added to the dispersing liquid. Then, the vessel is inclined so that the core materials 11 and the dispersing liquid are put to one side, and a substrate 1 is provided in the vessel so that the dispersing liquid and the core materials 11 are not adhered to the substrate. Then, the vessel is moved to be tilted from side to side, in order to contact the core materials 11 and the first adhesive layer 5 on the substrate 1 in the dispersing liquid. Thus, the core materials 11 are adhered to the first adhesive layer 5.

[0040]

In this way, when the adhesion of the core materials 11 is performed in the dispersing liquid, the adhesion of the core materials 11 to a no-adhesive portion, wherein the adhesion of the core materials is caused by static electricity, and the aggregation of the core materials 11 caused by static electricity can be prevented. Accordingly, the method of adhering the core materials 11 in the dispersing liquid is particularly preferable, when fine core materials 11 are used.

The method of adhering the core materials 11 to the first adhesive layer 5 is not

limited to the method wherein the adhesion is performed in the liquid. A suitable method which is selected according to the conditions such as size of the core materials 11 and the like can be selected.

[0041]

As materials of the core materials 11, metal such as tin (Sn) is preferably used, and copper (Cu) is still more preferably used. Materials of the core materials 11 are not limited to the materials described above, and other materials such as conductive materials or alloy can be used in so far as such materials have a melting point which is higher than a melting point of solder particles 14 described below and can obtain adhesiveness by the second adhesion-imparting compound. In addition to tin and copper, for example, metal, alloy and the like such as Ni, Ni-Au and Au-Su can be cited, as examples of such materials.

Furthermore, it is appropriate that the average particle diameter D of the core materials 11 be in the range of 20 to 200 μm from the viewpoint of workability, preferably in the range of 30 to 130 μm , and still more preferably in the range of 50 to 80 μm .

[0042]

(Second step)

Next, as shown in Fig. 1B, an adhesion-imparting compound is coated on the surface 11a of the core materials 11 to form the second adhesive layer 13.

First, at least one or more kinds selected from adhesion-imparting compounds (first adhesion-imparting compounds) shown below are dissolved in water or acidic water, and it is preferably adjusted to a weakly acidic condition of pH 3 to 4. In this way, an adhesive solution is formed. Subsequently, the substrate 1 obtained in the first step is immersed in the adhesive solution, or the adhesive solution is coated on the substrate 1 to generate a second adhesive layer 13 on the surface 11a of the core materials 11.

[0043]

Here, adhesion-imparting compound can be selected optionally, and for example, a naphotriazole-based derivative, benzotriazole-based derivative, imidazole-based derivative, benzoimidazole-based derivative, mercaptobenzothiazole-based derivative, and benzothiazole thio fatty acid-based derivative and the like can be used. These adhesion-imparting compounds have a function of imparting strong adhesiveness regarding metal or the like, particularly regarding copper. Furthermore, such compounds can impart adhesiveness to a conductive material and the like which are other than copper.

[0044]

Furthermore, the benzotriazole-based derivative which is preferably used in the present invention is shown by the general formula (1).

[0045]



[0046]

In in the general formula (1), R1 to R4 each independently represents a hydrogen atom, an alkoxy group, an alkyl group, which have 1 to 16 carbon atoms (preferably, 5 to 16), F, Br, Cl, I, a cyano group, an amino group or OH group.

[0047]

Furthermore, the naphthotriazole-based derivative which is preferably used in the present invention is shown by the general formula (2).

[0048]



[0049]

In the formula (2), R5 to R10 each independently represents a hydrogen atom, an alkoxy group, an alkyl group, which have 1 to 16 carbon atoms (preferably, 5 to 16), F, Br, Cl, I, a cyano group, an amino group or a OH group.

[0050]

Furthermore, the imidazole-based derivative which is preferably used in the present invention is shown by the general formula (3).

[0051]



[0052]

In the formula (3), R11 and R12 each independently represents a hydrogen atom, an alkoxy group, an alkyl group, which have 1 to 16 carbon atoms (preferably, 5 to 16), F, Br, Cl, I, a cyano group, an amino group or a OH group.

[0053]

Furthermore, the benzoimidazole-based derivative which is preferably used in the present invention is shown by the general formula (4).

[0054]



[0055]

In the formula (4), R13 to R17 each independently represents a hydrogen atom, an alkoxy group, an alkyl group, which have 1 to 16 carbon atoms (preferably, 5 to 16), F, Br, Cl, I, a cyano group, an amino group or a OH group.

[0056]

Furthermore, the mercaptobenzothiazole-based derivative which is preferably used in the present invention is shown by the general formula (5).

[0057]



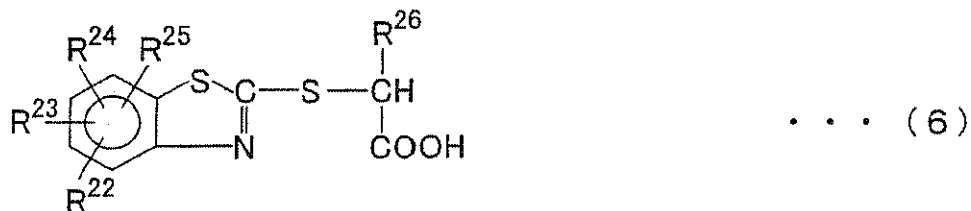
[0058]

In the formula (5), R18 to R21 each independently represents a hydrogen atom, an alkoxy group, an alkyl group, which have 1 to 16 carbon atoms (preferably, 5 to 16), F, Br, Cl, I, a cyano group, an amino group or a OH group.

[0059]

Furthermore, the benzothiazole thio fatty acid-based derivative which is preferably used in the present invention is shown by the general formula (6).

[0060]



[0061]

In the formula (6), R22 to R26 each independently represents a hydrogen atom, an alkoxy group, an alkyl group, which have 1 to 16 carbon atoms (preferably, 5 to 16), F, Br, Cl, I, a cyano group, an amino group or a OH group.

[0062]

Among the compounds, in the benzotriazole-based derivative represented by the general formula (1), the larger the carbon number of R1 to R4, the greater the adhesiveness in general.

Furthermore, in the imidazole-based derivative and the benzoimidazole-based derivative represented by the general formulae (3) and (4), the larger the carbon number of R11 to R17, the greater the adhesiveness in general.

Furthermore, in the benzothiazole thio fatty acid-based derivative represented by the general formulae (6), it is preferable that the carbon number of R22 to R 26 be 1 or 2.

[0063]

Furthermore, as examples of materials which can be used for adjusting pH of the adhesive solution, an inorganic acid such as hydrochloric acid, sulfuric acid, nitric acid, phosphoric acid, and an organic acid can be cited. Furthermore, as examples of the organic acid, formic acid, lactic acid, acetic acid, propionic acid, malic acid, oxalic acid, malonic acid, succinic acid, tartaric acid and the like can be used.

The concentration of the adhesion-imparting compound included in the adhesive

solution is not limited in particular. The concentration can be suitably selected and adjusted, according to the solubility thereof and the conditions used. It is particularly preferable that the concentration thereof be in a range of 0.05% by mass to 20% by mass based on the total adhesive solution. When the concentration of the adhesive compound is in the range as described above, the adhesiveness to the core materials 11 can be achieved sufficiently. On the other hand, when the concentration is less than 0.05% by mass with respect to the total adhesive solution, the adhesiveness is provided insufficiently, and when the concentration exceeds 20% by mass with respect to the total adhesive solution, a large quantity of the adhesion-imparting compound is consumed, and it is not preferable from the viewpoint of efficiency.

[0064]

It is preferable that a processing temperature at the time of providing the adhesiveness to the surface 11a of the core materials 11 be somewhat higher than room temperature. Due to the condition, the forming speed and the formed amount of the second adhesive layer 13 become sufficient. Furthermore, although the appropriate processing temperature is varied according to the concentration of the adhesion-imparting compound, the kinds of metal, and materials of the second adhesive layer 13, the temperature is generally preferable when it is in a range of about 30°C to 60°C. Furthermore, it is preferable that other conditions be controlled so that the immersing time in the adhesive solution is in a range of about 5 seconds to 5 minutes.

[0065]

Furthermore, it is preferable that 50 to 1000 ppm of copper coexist as an ion in the adhesive solution. When copper ions coexist in the above range, it is possible to increase forming efficiency such as the forming speed and the formed amount of the second adhesive layer 13.

[0066]

(Third step)

Next, as shown in Fig. 1C, solder particles 14 are adhered to the second adhesive layer 13 existing on the surface of the core materials 11.

Examples of the method of adhering solder particles 14 to the second adhesive layer 13 include a method wherein solder particles 14 are directly adhered to the second adhesive layer 13 in an inert atmosphere or air, and a method wherein solder particles 14 are dispersed in a dispersing solution, which is not shown, to provide a slurry condition and the slurry obtained is supplied to the second adhesive layer 13. The method of adhering the solder particles 14 to the second adhesive layer 13 is similar to the method of adhering the core materials 11 to the surface 1a of the substrate 1 described in the first step, and therefore detailed explanations are omitted.

[0067]

Here, when a material, which is used for forming the first adhesive layer 5 and has a property wherein adhesiveness of the surface 5a is lost due to heating, irradiation of ultraviolet rays or the like, is used before the core materials are adhered, it may be possible to remove the first material 21 after the core materials 11 are provided on the first adhesive layer 5. In this case, it is possible to prevent the solder particles 14 from adhering to the surface 5a of the first adhesive layer, due to treatment such as irradiation of ultraviolet rays, heating or the like, which is performed to remove the adhesiveness of the surface 5a after the first member 21 is removed.

[0068]

Furthermore, the solder particles 14 are used wherein the particle diameter d thereof is smaller than the average particle diameter D of the core materials 11, so that plural solder particles 14 can be adhered to one core material 11. The particle diameter d

of the solder particles 14 can be suitably selected according to the particle diameter D of the core material 11, but it is preferable that the particle diameter d be $1\ \mu\text{m}$ or more and less than or equal to one-half of the particle diameter D . When the particle diameter d of the solder particles 14 is in the above range, the plural solder particles 14 can be adhered to one core material 11.

[0069]

On the other hand, when the particle diameter d of the solder particles 14 is less than $1\ \mu\text{m}$, the thickness of the solder layer becomes too thin, and the solder amount becomes insufficient when formed solder balls 70 are reflowed. Accordingly, a solder bump is easily removed from a circuit board when the solder balls 70 are reflowed, and it is not preferable. That is, it is not preferable since lack of the solder layer 15 is caused. Furthermore, when the particle diameter d of the solder particles 14 is more than or equal to one-half of the particle diameter D of the core materials 11, it is not preferable since a sufficient number of the solder particles 14 cannot be adhered to one core material 11.

[0070]

Furthermore, as the metal composition of the solder particles 14, for example, a composition such as a Sn-Pb-based, Sn-Pb-Ag-based, Sn-Pb-Bi-based, Sn-Pb-Bi-Ag-based, and Sn-Pb-Cd-based composition can be cited. Furthermore, from the viewpoint of recent trends wherein Pb is eliminated from industrial waste, a composition which does not include Pb, such as a Sn-In-based, Sn-Bi-based, In-Ag-based, In-Bi-based, Sn-Zn-based, Sn-Ag-based, Sn-Cu-based, Sn-Sb-based, Sn-Au-based, Sn-Bi-Ag-Cu-based, Sn-Ge-based, Sn-Bi-Cu-based, Sn-Cu-Sb-Ag-based, Sn-Ag-Zn-based, Sn-Cu-Ag-based, Sn-Bi-Sb-based, Sn-Bi-Sb-Zn-based, Sn-Bi-Cu-Zn-based, Sn-Ag-Sb-based, Sn-Ag-Sb-Zn-based, Sn-Ag-Cu-Zn-based, and Sn-Zn-Bi-based composition, can be used suitably.

[0071]

As concrete examples of the metal composition, an eutectic solder which includes 63% by mass of Sn and 37% by mass of Pb (hereinafter, referred to as 63Sn/37Pb) can be cited as a main example, and 62Sn/36Pb/2Ag, 62.6Sn/37Pb/0.4Ag, 60Sn/40Pb, 50Sn/50Pb, 30Sn/70Pb, 25Sn/75Pb, 10Sn/88Pb/2Ag, 46Sn/8Bi/46Pb, 57Sn/3Bi/40Pb, 42Sn/42Pb/14Bi/2Ag, 45Sn/40Pb/15Bi, 50Sn/32Pb/18Cd, 48Sn/52In, 43Sn/57Bi, 97In/3Ag, 58Sn/42In, 95In/5Bi, 60Sn/40Bi, 91Sn/9Zn, 96.5Sn/3.5Ag, 99.3Sn/0.7Cu, 95Sn/5Sb, 20Sn/80Au, 90Sn/10Ag, 90Sn/7.5Bi/2Ag/0.5Cu, 97Sn/3Cu, 99Sn/1Ge, 92Sn/7.5Bi/0.5Cu, 97Sn/2Cu/0.8Sb/0.2Ag, 95.5Sn/3.5Ag/1Zn, 95.5Sn/4Cu/0.5Ag, 52Sn/45Bi/3Sb, 51Sn/45Bi/3Sb/1Zn, 85Sn/10Bi/5Sb, 84Sn/10Bi/5Sb/1Zn, 88.2Sn/10Bi/0.8Cu/1Zn, 89Sn/4Ag/7Sb, 88Sn/4Ag/7sb/1zn, 98Sn/1Ag/1Sb, 97Sn/1Ag/1Sb/1Zn, 91.2Sn/2Ag/0.8Cu/6Zn, 89Sn/8Zn/3Bi, 86Sn/8Zn/6Bi and 89.1Sn/2Ag/0.9Cu/8Zn can be cited. Furthermore, as the solder particles 14 of the embodiment, a mixture of two or more kinds of solder particles, which have different compositions, can be used.

[0072]

(Fourth step)

Subsequently, a reflow step is performed as shown in Fig. 1D to form a solder layer 15.

When the solder particles 14 are adhered to the core materials 11 in the liquid dispersion in the third step, the substrate is dried subsequently.

[0073]

Next, fixing between the solder particles 14 and the core materials 11 is performed. The fixing is a reaction wherein, between the core materials 11 and the solder particles 14, structural material of the core materials 11 is diffused in the side of the

solder particles 14. When the reaction proceeds, the solder particles 14 are fixed to the core materials 11.

Here, a fixing temperature is preferably in a range from a temperature which is the value of the melting point of used solder minus 50°C, to a temperature which is the value of the melting point of used solder plus 50°C; and more preferably in a range from a temperature which is the value of the melting point of used solder minus 30°C, to a temperature which is the value of the melting point of used solder plus 30°C. When the fixing temperature is in the above range, the solder particles 14 are not melted, or, even if the content of the solder particles is melted, the melted content does not run out due to the effect of the oxide films which exist at the surface of the particles. Accordingly, it is possible to perform fixing while the form of the solder particles 14 is maintained.

[0074]

Next, a water-soluble flux is coated on the substrate 1 on which the core materials 11, to which the solder particles 14 have been fixed, are provided. As the water-soluble flux, for example, a flux can be used which is disclosed in Japanese Unexamined Patent Application, First Publication No. 2004-282062. When a water-soluble flux is coated on the substrate 1, an oxide film can be removed from the surface of the solder particles 14 and the surface 11a of the core materials 11.

[0075]

Next, reflow is performed to melt the solder particles 14. Due to the reflow, the solder particles 14 are melted and spread all over the surface 11a of the core materials 11 to form a solder layer 15. At this time, the heating temperature is preferably in a range of 200 to 300°C, and it is particularly preferable that the heating temperature be 10 to 50°C higher than the melting point of the used solder. When heating is performed at a temperature in the range shown above, melted solder of the solder particles 14 and the

surface 11a of the core materials 11 can be sufficiently reacted to form a diffusion layer.

[0076]

(Fifth step)

Next, as shown in Fig. 1E, the first member 21 is removed from the surface 5a of the first adhesive layer 5. Subsequently, the core materials 11 are removed from the substrate 1. Here, the method of removing the core materials 11 from the substrate 1 can be suitably selected according to the materials of the first adhesive layer 5. Concretely, for example, a method wherein vibration is provided to the substrate 1 by an ultrasonic cleaner, a method wherein the first adhesive layer 5 is dissolved by a solvent and the like can be used. The method of removing the core materials 11 from the substrate 1 is not limited to the method described above, and the core materials 11 may be removed by bending the substrate 1 if the substrate 1 has flexibility.

In this way, the solder balls 70 can be formed.

[0077]

According to the producing method of solder balls 70 of the first embodiment, the solder particles 14 are adhered to the surface 11a of the core material 11 via the second adhesive layer 13, and then the solder particles 14 are melted. Accordingly, a uniform solder layer 15 can be formed on the surface 11a of the core material 11. Furthermore, the solder layer 15 can be easily formed as compared with the conventional method wherein a solder layer is formed with plating or the like.

[0078]

Furthermore, the solder layer 15 is formed while the core materials 11 are adhered to the surface 1a of the substrate 1 via the first adhesive layer 5, and therefore, numerous core materials 11 can be treated simultaneously as compared with the conventional method. Furthermore, since the core materials 11 are adhered to the surface

1a of the substrate 1 via the first adhesive layer 5, the core materials 11 can be removed easily from the substrate 1 after the solder layer 15 is formed.

In this way, the forming step of the solder balls 70 can be highly simplified as compared with the conventional methods, and the solder balls 70 can be manufactured with great efficiency. Therefore, it is possible to reduce the manufacturing cost of solder balls 70.

[0079]

Furthermore, by covering the surface 11a of the core materials 11 by the solder layer 15, the core materials 11 function as spacers when a solder bump is formed using the solder balls 70 manufactured. Accordingly, even when the solder layer 15 is melted, the height of the solder bump can be maintained uniformly. Accordingly, even when electronic components are provided on the solder bump, the electronic components do not sink due to the weight thereof. Accordingly, it is possible to maintain the fixed distance between the electronic components and an electronic circuit.

[0080]

Furthermore, since the core materials 11 are made of metal, conduction between electronic components and an electronic circuit can be achieved when the solder balls 70 are used. When the core materials 11 are made of copper, excellent conduction between the electronic components and the electronic circuit can be obtained, since electrical resistance of copper is low.

[0081]

Furthermore, when the core materials 11 are made of Cu, an adhesion-imparting compound can be easily coated. Accordingly, sufficient thickness of the second adhesive layer 13 can be provided. Accordingly, the solder particles 14 are easily adhered to the surface 11a of the core material 11 via the second adhesive layer 13. Therefore, the

solder layer 15 which has uniform and sufficient film thickness can be formed. In this way, it is possible to form solder balls 70 having uniform particle diameter, and it is possible to perform favorable bonding between the electronic components and the circuit board.

[0082]

Furthermore, since the core materials 11 are used as spacers, it is possible to maintain the distance between the electronic components and the substrate. Accordingly, problems wherein the electronic components provided on the substrate sink non-uniformly can be solved, and it is possible to obtain a substrate which has high reliability and achieves a uniform height with respect to the core materials 11. Furthermore, since the solder particles 14 are adhered to the core material 11 via the second adhesive layer 13, it is not necessary to use expensive copper-core solder balls which have been conventionally used. Accordingly, it is possible to achieve cost reduction and simplification of steps. In this way, the producing method of the present embodiment is capable of forming a fine substrate, and electronic equipment which has a high degree of integration and high reliability can be provided by the present embodiment.

[0083]

Furthermore, according to the above method, solder balls 70 can be formed without using high-melting-point solder which includes a large amount of lead. Accordingly, it is possible to provide solder balls 70 which include absolutely no lead. Therefore, α rays are not emitted from Pb which is included in a solder bump. Accordingly, it is possible to prevent malfunction of electronic components which is caused by α ray.

[0084]

Furthermore, when a plated metal member is used as a first member 21, it is

possible to use the first member repeatedly in the method of producing solder balls 70. Accordingly, it is possible to reduce the manufacturing cost in the producing steps of solder balls 70.

[0085]

Furthermore, when the thickness H of the first member 21 is set to be 1 μm or more and less than or equal to 1/2 of the particle diameter D, the core material 11 easily enters in the first opening 31. Accordingly, the workability increases and the solder balls 70 can be manufactured efficiently. Furthermore, since the side-surfaces of the core materials 11 are held by the sidewalls of the first openings 31, displacement of the core materials 11 can be prevented.

[0086]

Furthermore, since the second adhesive layer 13 is formed on the core material 11 while the first member 21 having the first openings 31 is placed on the substrate 1, the second adhesive layer 13 is not formed on the portion where the surface 11a of the core material 11 does not exist. The reason why the second adhesive layer is not formed on the first member 21 is that materials which are used for forming core materials made of metal, conductive materials, or the like, are materials to which adhesiveness is given by an adhesion-imparting compound, and on the other hand, materials which are used for forming the first member or the first adhesive compound are materials to which adhesiveness is not given by an adhesion-imparting compound. Accordingly, it is possible to make the solder particles 14 be adhered to the core materials selectively. Furthermore, since the core materials 11 are adhered in the first openings 31, it is possible to prevent falling off of the core materials 11 to the outside of the first openings 31 even if the adhesiveness of the first adhesive layer 5 is low. Thus, it is possible to adhere the core materials 11 to all the first openings 31 without fail.

[0087]

(Second embodiment)

Next, a producing method of solder balls 70 as a second embodiment of the present invention is explained while referring to figures. Fig. 2A to Fig. 2E are process drawings which explain the producing method of solder balls 70 of the second embodiment.

[0088]

The method of producing solder balls 70 of the second embodiment is schematically structured such that the method comprises: a first step wherein core materials 11 are adhered on a surface 5a of a first adhesive layer 5 which is provided on the surface 1a of a substrate 1; a second step wherein a second adhesive layer 13 is formed on the surface 11a of the core materials 11; a third step wherein solder particles 14 are adhered to the surface of the second adhesive layer 13; a fourth step wherein the solder particles 14 are melted to form a solder layer 15; and a fifth step wherein the substrate 1 is removed from the core materials 11.

[0089]

The embodiment is similar to the first embodiment except that the first member 12 is structured with a first layer 21 a (a first layer of the first member) and a second layer 21b (a second layer of the first member), and a step wherein the second layer 21b is removed from the first layer 21a is provided between the first step and the second step. Accordingly, detailed explanation is omitted with respect to the same characteristics.

Hereinafter, the first step is explained.

[0090]

(First step)

A first step of the second embodiment comprises, as the steps wherein a first

member 21 is provided on a first adhesive layer 5 (previous step): a step (i) wherein a first layer 21a of the first member, wherein the first layer has openings 32a (lower portions of the second openings), is provided on the first adhesive layer 5, and a step (ii) wherein the second layer 21b of the first member, wherein the second layer has openings 32b (upper portions of the second openings) having a smaller diameter than that of the openings 32a, is provided on the first layer 21a of the first member, so that the openings 32a and the center of the openings 32b coincide.

Hereinafter, each step is explained in detail.

[0091]

First, the first layer 21 of the first member is provided to cover the surface 5a of the first adhesive layer 5. Openings 32a are provided at the first layer 21a of the first member, wherein the openings are spaced from each other and can expose the surface 5a of the first adhesive layer 5. Although materials of the first layer 21a of the first member are not limited in particular, specifically, for example, a member may be used which is obtained by coating a paste for solder resist on the substrate 1.

[0092]

Furthermore, the range of the diameter F_{2a} of the openings 32a of the first layer 21a can be represented by the following formula (5), when the diameter of the openings 32b of the second layer 21b described below is represented by F_{2b} .

[0093]

$$F_{2b} + 2d \leq F_{2a} \quad \cdots (5)$$

[0094]

The particularly preferable range of the openings 32a can be represented by the formula (6) shown below.

[0095]

$$F_{2b} + 3d \leq F_{2a} \leq F_{2b} + 4d \quad \cdot \cdot \cdot (6)$$

[0096]

Next, the second layer 21b of the first member is provided on the first layer 21a of the first member. Openings 32b which have a smaller diameter than that of the openings 32a are provided in the second layer 21b of the first member. When the second layer 21b of the first member is provided, positions to be arranged are controlled so that the openings 32a and the openings 32b coincide.

As the second layer 21b of the first member, a plated metal member can be used. When such a material is used as the second layer 21b of the first member, it is possible to use the member repeatedly in the producing steps and to reduce the manufacturing cost in the producing steps of solder balls 70.

[0097]

Furthermore, when the total thickness of the first layer 21a and the second layer 21b of the first member is represented by H, H is larger than or equal to 1/2 of the particle diameter D of the core materials 11, and the range of the diameter F_{2b} of the openings 32b can be represented by the formula (7) shown below.

[0098]

$$D \leq F_{2b} < 2D \quad \cdot \cdot \cdot (7)$$

[0099]

Furthermore, the particularly preferable range of the diameter F_{2b} of the openings 32b can be represented by the formula (8) shown below.

[0100]

$$1.1D \leq F_{2b} \leq 1.5D \quad \dots (8)$$

[0101]

Furthermore, the distance G_2 between the adjacent first openings 32b can be represented by the formula (9) shown below, when the thickness of the second layer 21b of the first member is represented by H_b .

[0102]

$$2d + D - 2\sqrt{H_b(D - H_b)} \leq G_2 \leq 4d + D - 2\sqrt{H_b(D - H_b)} \quad \dots (9)$$

[0103]

When the distance G_2 between the adjacent first openings 32b is in the range represented by the formula (9), it is possible to form solder balls 70 on the substrate 1 with high density, and prevent bonding between the adjacent solder balls 70.

[0104]

Subsequently, the core materials 11 are adhered to the surfaces 5a of the first adhesive layer 5 as shown in Fig. 2A.

Then, as shown in Fig. 2B, the second layer 21b of the first member is removed from the first layer 21a of the first member. Since the diameter F_{2b} of the openings 32b

is smaller than the diameter F_{2a} of the openings 32a, the core material 11 is provided at the center of the lower portion 32a of the second opening.

[0105]

(Second step)

Next, as shown in Fig. 2B, a second adhesive layer 13 is formed by coating an adhesion-imparting compound on the surface 11a of the core materials 11, while the first layer 21a of the first member covers the surface 5a of the first adhesive layer 5. Here, since almost all of the surface 5a of the first adhesive layer 5 is covered by the first layer 21a of the first member, the second adhesive layer 13 is prevented from being formed on positions other than the surface 11a of the core materials 11. That is, the core materials are made of a material to which adhesiveness is given due to the adhesion-imparting compound, and the first adhesive layer and the first layer 21a of the first member are made of a material to which adhesiveness is not given due to the adhesion-imparting compound. Accordingly, an adhesive layer 13 is not formed on the first layer 21a.

[0106]

Subsequently, as shown in Figs 2C to 2E, the third step, the fourth step and the fifth step are performed. With respect to the third step and steps subsequent to the third step, detailed explanation of the steps is omitted since the steps are similar to those of the first embodiment.

[0107]

According to the producing method of solder balls 70 of the second embodiment, since the second layer 21b of the first member, wherein the second layer has openings 32b which have a smaller diameter than that of the openings 32a, is provided on the first layer 21a of the first member so that the center of the openings 32a and the center of the openings 32b coincide, the openings 32b can be provided so that the openings 32b are

arranged on the center of the openings 32a. Furthermore, since the second layer 21b of the first member is removed from the first layer 21a of the first member after the first adhesive layer 5 is adhered to the core materials 11, it is possible to maintain the distance between the core materials 11 and the first layer of the first member. That is, when the core materials 11 are adhered to the first adhesive layer 5, the core materials 11 can be provided at the center of the openings 32a.

[0108]

According to the producing method of solder balls 70 of the second embodiment, in addition to the effects of the first embodiment, it is possible to more effectively prevent bonding of adjacent solder balls 70.

[0109]

(Third embodiment)

Next, a producing method of solder balls 70 as a third embodiment of the present invention is explained while referring to figures. Fig. 3A to Fig. 3F are process drawings which explain the producing method of solder balls 70 of the third embodiment.

[0110]

The method of producing solder balls 70 of the third embodiment is schematically structured such that the method comprises: a first step wherein core materials 11 are adhered on a surface 5a of a first adhesive layer 5 which is provided on a substrate 1; a second step wherein a second adhesive layer 13 is formed on the surface 11a of the core materials 11; a third step wherein solder particles 14 are adhered to the surface of the second adhesive layer 13; a fourth step wherein the solder particles 14 are melted to form a solder layer 15; and a fifth step wherein the substrate 1 is removed from the core materials 11.

[0111]

The third embodiment is different from the first embodiment from the points where, between the first step and the second step, a step wherein the first member 21 is removed is included, and a mask 41 (first mask) is formed by adhering particles having a diameter r , which is smaller than the thickness H of the first member 21, to the first adhesive layer so that the mask covers the surface 5a of the first adhesive layer 5. Therefore, with respect to the steps which are similar to those of the first embodiment, detailed explanation is omitted.

[0112]

First, as shown in Fig. 3A, the core materials 11 are adhered in the first step to the surfaces 5a of the first adhesive layer 5 of the substrate 1 which has the first member 21. Here, it is preferable that the distance G_3 between the adjacent openings 33 (third openings) of the first member 1 be about 10 to 20 times of the particle diameter d of solder particles 14 which are used in the third step. Furthermore, it is preferable that the thickness H of the first member 21 be more than or equal to $1/2$ times of the particle diameter D of the core materials 11. Furthermore, it is preferable that the diameter F_3 of the openings 33 of the first member be larger than the particle diameter D of the core materials 11 and less than two times of the particle diameter D of the core materials, but it is particularly preferable that the diameter F_3 be 10 to 20 μm larger than the particle diameter D .

[0113]

Subsequently, as shown in Fig. 3B, the first member 21 is removed from the first adhesive layer 5.

Therefore, the surface 5a of the first adhesive layer 5 is exposed to air.

[0114]

Next, as shown in Fig. 3C, a mask 41 which is formed by a granular material is

adhered so that the surface 5a of the first adhesive layer 5 is covered. As the material of the mask 41, for example, glass, ceramic, polymer and the like can be used, and the material is not limited in so far as the material is not dissolved in water and has properties wherein the second adhesive layer 13 is not formed on the surface thereof.

[0115]

Furthermore, the diameter r of the material of the mask 41 is smaller than the thickness H of the first member 21. The smaller the diameter and the height r , the better it is. From the viewpoint of work efficiency, it is preferable that the diameter be from about several submicrons to several microns. As a concrete example thereof, a material which has diameter of 0.5 to 2 μm can be preferably used. When the height and diameter r of the mask 41 are set in the range, the solder particles 14 can be adhered to the vicinity of the contact surface of the core materials 11 and the first adhesive layer 5. Accordingly, it is possible to form the solder layer 15 all over the surface 11a of the core materials 11.

[0116]

On the other hand, when the height and diameter r are larger than or equal to the thickness H of the first member 21, it is not preferable since the solder particles 14 are insufficiently adhered to the vicinity of the contact surface of the core materials 11 and the first adhesive layer 5. Furthermore, when the mask 41 is adhered to cover the surface 5a of the first adhesive layer 5, a gap is generated between the adjacent materials of the mask 41, and there is a possibility that the solder particles 14 are adhered to the surface of the first adhesive layer 5 in the third step. Accordingly, there is a possibility that said solder particles 14 adhering to the surface of the first adhesive layer 5 are melted and bonded with the solder ball 70 in the fourth step. Therefore, the particle diameter of the solder balls 70 becomes non-uniform, and it is not preferable.

[0117]

Subsequently, the second step, the third step and the fourth step are performed as shown in Fig. 3C to Fig. 3F. With respect to steps from the second to the fourth steps, detailed explanation of the steps is omitted since the steps are similar to those of the first embodiment. Here, as shown in Fig. 3F, the method of removing the first mask 41 from the first adhesive layer 5 can be optionally selected. Concretely, for example, a method can be used wherein a vibration is provided to the substrate 1 by an ultrasonic cleaner.

In this way, the solder balls 70 are formed.

[0118]

According to the method of producing solder balls 70 of the third embodiment, it is possible to maintain the suitable distance between the core materials 11, since the core materials 11 are provided on the surface 5a of the adhesive layer 5 using the first member 21 and then the first member is removed. Furthermore, it is possible to adhere the solder particles 14 to the vicinity of the contact surface of the core materials 11 and the first adhesive layer 5, since the first mask 41 is adhered to the surface 5a of the adhesive layer 5 and then the solder particles 14 are adhered to the surface 11a of the core material 11. Therefore, it is possible to form the solder layer 15 all over the surface 11a of the core materials 11. Furthermore, since a material, which is not dissolved in water and has properties wherein the second adhesive layer 13 is not formed on the surface thereof, is used as a material of the first mask 41, it is possible to prevent the second adhesive layer 13 from being formed on the surface of the first mask 41. Accordingly, it is possible to prevent the adhesion of the solder particles 14 to the surface of the first mask 41.

[0119]

According to the producing method of solder balls 70 of the third embodiment, in addition to the effects of the first embodiment, it is possible to form solder balls 70 wherein the solder layer 15 thereof has a uniform thickness.

[0120]

(Fourth embodiment)

Next, a producing method of solder balls 70 as a fourth embodiment of the present invention is explained while referring to figures. Fig. 4A to Fig. 4E are process drawings which explain the producing method of solder balls 70 of the fourth embodiment.

[0121]

The method of producing solder balls 70 of the fourth embodiment is schematically structured such that the method comprises: a first step wherein core materials 11 are adhered on a surface 5a of a first adhesive layer 5 which is provided on a substrate 1; a second step wherein a second adhesive layer 13 is formed on the surface 11a of the core materials 11; a third step wherein solder particles 14 are adhered to the surface of the second adhesive layer 13; a fourth step wherein the solder particles 14 are melted to form a solder layer 15; and a fifth step wherein the substrate 1 is removed from the core materials 11.

[0122]

The fourth embodiment is different from the first embodiment, wherein the first member is provided on the adhesive layer, from the points where, before the first step, plural dot-like first adhesive layers 5 are formed on the surface 1a of the substrate 1 so that they are separated from each other by coating an adhesive layer via a mask. With respect to the steps which are similar to those of the first embodiment, detailed explanation is omitted.

[0123]

First, a second member 22 is provided so that the surface 1a of the substrate 1 is covered. As the second member 22, a member which is in the shape of a plate can be

used. In the second member 22, openings 34 (fourth openings), which expose a part of the surface 1a of the substrate 1 in a dot-like manner, are formed so that the openings are spaced from each other. Here, the second member 22 may be separated from the substrate 1, or may contact with the substrate 1.

[0124]

Furthermore, the range of the diameter F_4 of the openings 34 can be represented by the following formula (10), when the thickness of the adhesive material is represented by H.

[0125]

$$F_4 < D - 2\sqrt{H(D-H)} \quad \cdot \cdot \cdot (10)$$

[0126]

Furthermore, the particularly preferable range of the diameter F_4 of the openings 34 can be represented by the following formula (11).

[0127]

$$0.7 (D - 2\sqrt{H(D-H)}) \leq F_4 \leq 0.9 (D - 2\sqrt{H(D-H)}) \cdot \cdot \cdot (11)$$

[0128]

The distance G_4 between the adjacent openings 34 can be represented by the following formula (12), when the thickness of the adhesive material is represented by H and the diameter of the fourth openings 34 is represented by F_4 .

[0129]

$$2d + D + 2\sqrt{H(D-H)} < G_4 \quad \dots (12)$$

[0130]

Furthermore, the particularly preferable distance G_4 between the adjacent openings 34 can be represented by the formula (13).

[0131]

$$4d + D + 2\sqrt{H(D-H)} \leq G_4 \leq 8d + D + 2\sqrt{H(D-H)} \quad \dots (13)$$

[0132]

Next, as shown in Fig. 4A, an adhesive material is coated so that the openings 34 are filled using the second member 22 as a mask. If necessary, a method other than the coating method can be used. In this way, plural dot-like first adhesive layers 5 which have the thickness H and the diameter F_4 can be formed on the surface 1a of the substrate 1 so that the layers are separated from each other.

Subsequently, the second member 22 is removed from the surface 1a of the substrate 1 to expose the surface 1a.

Then, as shown in Fig. 4B, the core materials 11 are adhered to the first adhesive layer 5.

[0133]

Subsequently, as shown in Figs 4C to 4E, the second step, the third step, the fourth step and the fifth step are performed. With respect to the second step and steps subsequent to the second step, detailed explanation of the steps is omitted since the steps are similar to those of the first embodiment.

In this way, the solder balls 70 are formed.

[0134]

According to the method of producing solder balls 70 of the fourth embodiment, it is possible to form a dot-like first adhesive layer 5, since the second member 22 is removed from the substrate 1 after the plural dot-like first adhesive layers 5 are formed on the surface 1a of the substrate 1 so that the layers are spaced from each other. Accordingly, the core materials 11 can be easily adhered to the first adhesive layer 5. Furthermore, when the solder particles 14 are adhered to the surface 11a of the core material 11, it is possible to adhere the solder particles 14 to the vicinity of the contact surface of the core materials 11 and the first adhesive layer 5, since the surface 1a of the substrate 1 is exposed. Accordingly, it is possible to form the solder layer 15 all over the surface 11a of the core material 11.

[0135]

According to the producing method of solder balls 70 of the fourth embodiment, in addition to the effects of the first embodiment, it is possible to form the solder balls 70 wherein the solder layer 15 thereof has a uniform thickness.

[0136]

(Fifth embodiment)

Next, a producing method of solder balls 70 as a fifth embodiment of the present invention is explained while referring to figures. Fig. 5A to Fig. 5E are process drawings which explain the producing method of solder balls of the fifth embodiment.

[0137]

The method of producing solder balls 70 of the fifth embodiment is schematically structured such that the method comprises: a first step wherein core materials 11 are adhered on a surface 5a of a first adhesive layer 5 which is provided on a substrate 1; a

second step wherein a second adhesive layer 13 is formed on the surface 11a of the core materials 11; a third step wherein solder particles 14 are adhered to the surface of the second adhesive layer 13; a fourth step wherein the solder particles 14 are melted to form a solder layer 15; and a fifth step wherein the substrate 1 is removed from the core materials 11.

The fifth embodiment is different from the first embodiment, wherein the first member is provided on the adhesive layer, from the points where, before the first step, plural dot-like first adhesive layers are formed on the surface of the substrate by transferring an adhesion-imparting compound to the substrate using a transfer base so that the layers are spaced from each other.

Although each step is explained below, detailed explanation is omitted with respect to the steps which are similar to those of the first embodiment.

[0138]

(First step)

The first step of the fifth embodiment is structured such that the first step includes; a step wherein dot-like plural metal films 51 (first metal films) are formed on the surface 61a of a transfer base 61 so that the metal films are spaced from each other; a step wherein an adhesion-imparting compound 5b (first adhesion-imparting compound) is adhered to the metal films; a step wherein a first adhesive layer 5 is formed by transferring the adhesion-imparting compound from the transfer base 61 to the surface 1a of a substrate 1; and a step wherein core materials 11 are adhered to the first adhesive layer 5.

Hereinafter, each step is explained in detail.

[0139]

First, on the surface 61a of a transfer base 61, plural dot-like metal films 51 which have, for example, a thickness of 20 μm are formed so that the films are spaced

from each other. An optionally selected method can be used as the method of forming the films. As a material of the metal film 51, for example, it is preferable that tin (Sn) be used, and it is particularly preferable that copper (Cu) be used. The material of the first metal films 51 is not limited thereto, and other materials may be used in so far as the adhesion-imparting compound can provide adhesiveness to the materials. In addition to copper and tin, as examples of other materials, for example, alloys such as Ni-Au, Au-Sn and Ni are cited.

[0140]

Next, as shown in Fig. 5A, an adhesion-imparting compound 5b is adhered to the metal films 51 by the optionally selected method such as coating. The step is almost the same as the second step of the first embodiment, and therefore detailed explanations are omitted. In this way, the adhesion-imparting compound 5b which covers the surface of the metal films 51 is formed. Here, unlike the second step of the first embodiment, it is necessary to adhere the adhesion-imparting compound 5b to the metal films 51, and such a method can be selected optionally.

[0141]

Subsequently, as shown in Fig 5B, the adhesion-imparting compound 5b is transferred to the surface 1a of a substrate 1 from the transfer base 61.

At this time, it is preferable that the surface 1a of the substrate 1 be covered by a mask 42 (second mask). As the material of the mask 42, a member which is in the shape of a plate can be used. Furthermore, as the material of the mask, concretely, stainless, nickel, glass, ceramic and polymer and the like can be cited and used. However, the material is not limited in so far as the material is not dissolved in water, and has properties wherein the second adhesive layer 13 is not formed on the surface thereof.

[0142]

Furthermore, openings 35 (fifth openings) having a diameter F_5 are provided in the mask 42. The openings 35 have functions wherein solder balls 70 are not removed in the fourth step and the subsequent steps. Accordingly, the value of F_5 can be suitably set according to the diameter D of the core materials 11, the diameter d of the solder particles 14, and the thickness H of the mask 42.

[0143]

The distance G_5 between the adjacent openings 35 of the mask 42 can be represented by the following formula (14), when the thickness of the mask 42 is represented by H , the diameter of the core materials 11 is represented by D and the diameter of the solder particles 14 is represented by d .

[0144]

$$2d + D + 2\sqrt{H(2d + D - H)} \leq G_5 \quad \cdot \cdot \cdot (14)$$

[0145]

Furthermore, although it is necessary that the thickness H of the mask 42 be smaller than the sum of the thickness of the metal film 51 and the thickness of the adhesion-imparting compound 5b, it is particularly preferable that the thickness H of the mask 42 be approximately similar to the thickness of the metal film 51. When the thickness H of the mask 42 is larger than the sum of the thickness of the metal film 51 and the thickness of the adhesion-imparting compound 5b, it is not preferable since the adhesion-imparting compound 5b cannot be transferred to the surface 1a of the substrate 1.

In this way, plural dot-like first adhesive layers 5 are formed on the surface 1a of the substrate 1 so that they are spaced from each other.

[0146]

Next, as shown in Fig. 5C, core materials 11 are adhered to the surface 5a of the first adhesive layers 5. Subsequently, as shown in Figs 5C to 5E, the second step, the third step, the fourth step and the fifth step are performed. With respect to the second step and steps subsequent to the second step, detailed explanation of the steps is omitted since the steps are similar to those of the first embodiment except that the mask 42 is used instead of the first member 21.

In this way, the solder balls 70 are formed.

[0147]

According to the method of producing solder balls 70 of the fifth embodiment, it is possible to adopt the minimum amount of the adhesion-imparting compound 5b which is necessary to form the first adhesive layer 5, since the adhesion-imparting compound 5b is coated on the dot-like metal film 51. Furthermore, since the transfer base is used, it is possible to handle a finer pattern as compared with a case wherein the first adhesive layer 5 is formed merely using a mask.

[0148]

Furthermore, the first adhesive layer 5 can be formed more exactly on the correct position, since the adhesion-imparting compound 5b is transferred to the surface 1a of the substrate 1 while the surface 1a of the substrate 1 is covered with the mask 42.

Furthermore, since the second adhesive layer 13 is formed on the core material 11 while the surface 1a of the substrate 1 is covered with the mask 42, it is possible to prevent the second adhesive layer 13 from being adhered to the surface 1a of the substrate 1.

Accordingly, it is possible to prevent adhesion of the solder particles 14 to the surface 1a of the substrate 1.

[0149]

In the producing method of solder balls 70 in the fifth embodiment, in addition to the effects of the fourth embodiment, it is possible to adjust the location of the formed solder balls 70 according to a more fine pattern.

[0150]

(Sixth embodiment)

Next, a producing method of solder balls 70 as a sixth embodiment of the present invention is explained while referring to figures. Fig. 6A to Fig. 6E are process drawings which explain the producing method of solder balls 70 of the sixth embodiment.

[0151]

The method of producing solder balls 70 of the sixth embodiment is schematically structured such that the method comprises: a first step wherein core materials 11 are adhered on a surface 5a of a first adhesive layer 5 which is provided on a substrate 1; a second step wherein a second adhesive layer 13 is formed on the surface 11a of the core materials 11; a third step wherein solder particles 14 are adhered to the surface of the second adhesive layer 13; a fourth step wherein the solder particles 14 are melted to form a solder layer 15; and a fifth step wherein the substrate 1 is removed from the core materials 11.

The sixth embodiment is different from the first embodiment, wherein the first member having openings is provided on the substrate on which the adhesive layer is formed before the first step, from the points where, before the first step, plural dot-like metal layers which are spaced from each other are formed on the surface of the substrate, and an adhesion-imparting compound is coated on the second adhesive layers to form an adhesive layer.

Therefore, although each step is explained below, detailed explanation is omitted with respect to the steps which are similar to those of the first embodiment.

[0152]

(First step)

The first step of the sixth embodiment is structured such that the first step includes: a step wherein core materials 11 are adhered to the first adhesive layer 5 existing on the substrate 1, and as a previous step to the first step, also includes: a step (i) wherein dot-like plural second metal films 52 are formed on the surface 1a of a substrate 1, and a step (ii) wherein an adhesion-imparting compound (first adhesion-imparting compound) is coated to the exposed second metal films 52 to form the first adhesive layers 5.

Hereinafter, each step is explained in detail.

[0153]

First, on the surface 1a of the substrate 1, plural dot-like metal films 52 (second metal films) are formed by the optionally selected method, so that the films are separated from each other. Materials used for the metal films 52 can be selected optionally, and metal which has wettability with respect to a solder is preferably used. It is particularly preferable that tungsten be used.

[0154]

Next, a mask 43 (third mask) having openings 36 (sixth openings) is provided so that the surface 1a of the substrate 1 is covered by the mask. Here, the mask 43 may be provided after the first adhesive layer 5 is formed.

The openings 36 having a diameter F_6 are provided in the mask 43. The openings 36 have functions wherein solder balls 70 are not removed in the fourth step and the subsequent steps thereof. Accordingly, the value of F_6 can be suitably set according to the diameter D of the core materials 11, the diameter d of the solder particles 14, and the thickness H of the mask 43. It is preferable that material used for the mask 43 have properties wherein the second adhesive layer 13 is not formed on the surface thereof.

[0155]

Here, the distance G_6 between the adjacent openings 36 can be represented by the following formula (15), when the thickness of the mask 43 is represented by H , the diameter of the core materials 11 is represented by D and the diameter of the solder particles 14 is represented by d .

[0156]

$$2d + D + 2\sqrt{H(2d + D - H)} \leq G_6 \quad \dots (15)$$

[0157]

Furthermore, although it is necessary that the thickness H of the mask 43 be smaller than the sum of the thickness of the metal films 52 and the thickness of the first adhesive layer 5, it is particularly preferable that the thickness H of the mask 43 be about 20 μm larger than the thickness of the second metal films 52. When the thickness H of the mask 43 is larger than the sum of the thickness of the metal films 52 and the thickness of the adhesive layer 5, it is not preferable since it is difficult to adhere the core materials 11 to the surface 5a of the first adhesive layer 5.

[0158]

Next, as shown in Fig. 6A, a first adhesive layer 5 is formed so that the layer covers the surface of the metal films 52. With respect to a method of forming the first adhesive layer 5, the first adhesive layer 5 can be formed by coating or the like of an adhesion-imparting compound on the metal films 52, similar to the method described in the fifth embodiment.

In this way, plural dot-like first adhesive layers 5 are formed on the surface 1a of the substrate 1 so that they are separated from each other.

[0159]

Next, as shown in Fig. 6B, core materials 11 are adhered to the surface 5a of the first adhesive layers 5. Subsequently, as shown in Figs 6C to 6E, the second step, the third step, the fourth step and the fifth step are performed. With respect to the second step and the steps subsequent to the second step, detailed explanation of the steps is omitted, since the steps are similar to those of the first embodiment except that the mask 43 is used instead of the first member 21.

In this way, the solder balls 70 are formed.

[0160]

According to the method of producing solder balls 70 of the sixth embodiment, it is possible to adopt the minimum amount of material of the first adhesive layer 5, since the first adhesive layer 5 is formed by coating the adhesion-imparting compound 5b on the dot-like metal films 52. Furthermore, it is possible to handle a finer pattern as compared with a case wherein the first adhesive layer 5 is formed merely using a mask.

Furthermore, since the first adhesive layer 5 is directly formed on the surface of the metal films 52 existing on the substrate 1, it is possible to prevent the first adhesive layer 5 from being formed at the incorrect position.

[0161]

Furthermore, when tungsten is used as a material of the metal films 52, even if a solder layer 15 is adhered to the second metal film when the solder layer 15 is formed in the fourth step, the solder layer can be easily separated. Accordingly, when the solder balls 70 are formed on the second metal films 52, the solder balls 70 can be easily removed. [0162]

According to the producing method of solder balls 70 of the sixth embodiment, in addition to the effects of the fifth embodiment, it is possible to adjust the location of the

formed solder balls 70 according to a finer pattern.

EXAMPLES

[0163]

Hereinafter, the present invention is explained using examples, but the present invention is not limited thereto.

(Example 1)

First, as a substrate 1 to which a first adhesive layer 5 was formed, a polyimide tape was prepared. Next, as shown in Fig. 1A, a first member 21 made of metal was provided so that the member covered the surface 5a of the first adhesive layer 5. As the first member 21, a member having openings 31 (first openings), wherein the diameter F_1 thereof was 80 μm , was used. Furthermore, that distance between the adjacent first openings 31 was set to 200 μm . Here, the thickness of the first member 21 was about 25 μm .

[0164]

Next, as shown in Fig. 1A, core materials 11 which were made of copper and had a diameter D of 50 μm were adhered to the surface 1a of the substrate 1 in an air atmosphere. A state where the core materials 11 were adhered to the surface 1a of the substrate 1 is shown in Fig. 7A.

[0165]

Next, as shown in Fig. 1B, a second adhesive layer 13 was formed by coating an adhesion-imparting compound on the surface 11a of the core materials 11. Here, as an adhesive solution which included an adhesion-imparting compound, a 2% by mass aqueous solution of an imidazole-based compound represented by the aforementioned general formula (3) was prepared wherein R_{12} thereof is an alkyl group of $C_{11}H_{23}$ and R_{11}

represents a hydrogen atom. Subsequently, the adhesive solution was adjusted by acetic acid so that pH thereof became about 4, and heated to 40°C. Subsequently, the substrate 1 was immersed in the adhesive solution for three minutes to form the second adhesive layer 13 on the surface 11a of the core materials 11a.

[0166]

Subsequently, as shown in Fig. 1C, solder particles 14 wherein the metal composition thereof was Sn/3.5Ag and the diameter d thereof was about 10 µm were adhered on the second adhesive layer 13. After that, extra solder particles 14 were removed with an air knife.

[0167]

Next, as shown in Fig. 1D, a reflow step was performed to form a solder layer 15. First, the substrate 1 was heated for twenty minutes in an oven at a temperature of 180°C to fix the core material 11 and the solder particles 14. Then, a flux (SJ-FL2000, manufactured by Showa Denko K.K.) was sprayed on the surface of the substrate 1. Subsequently, the substrate 1 was heated at a temperature of 240°C in a reflow furnace for three minutes in a nitrogen atmosphere, and a solder layer 15 having a thickness of 5 µm was formed so that the surface 11a of the core material 11 was covered. In this way, as shown in Fig. 1E, solder balls 70 wherein the diameter thereof was about 60 µm were manufactured. The solder balls 70 are shown in Fig. 7B.

[0168]

(Example 2)

Next, Example 2 is explained. First, as shown in Fig. 2A, a first adhesive layer 5 made of a silicon-based adhesive was coated on a substrate 1 made of glass. Then, by screen printing, a first layer 21a of a first member, wherein the layer was formed by a paste for solder resist, was formed so that the layer covered the surface 5a of the first

adhesive layer 5.

Here, as the first layer 21a of the first member, a layer was used wherein openings 32a (lower portion of the second openings), in which the diameter thereof F_{2a} was 80 μm , had been formed.

[0169]

Subsequently, on the first layer 21a of the first member, a second layer 21b of the first member, which was made of metal, was provided. As the second layer 21b of the first member, a layer was used wherein openings 32b (upper portion of the second openings), in which the diameter thereof F_{2b} was 60 μm , had been formed. Furthermore, when the second layer 2b of the first member was provided, the position of the second layer 2b of the first member was adjusted so that the center of the openings 32a of the first layer 21a and the center of the openings 32b of the second layer 21b coincided. Furthermore, the distance G_2 between the adjacent openings 32b was set to 200 μm .

[0170]

Next, as shown in Fig. 2A, core materials 11 which were made of copper and had a diameter D of 50 μm were adhered to the surface 1a of the substrate 1 in an air atmosphere. Then, as shown in Fig. 2B, the second layer 21b of the first member was removed from the first layer 21a of the first member.

[0171]

Subsequently, as shown in Fig. 2B, a second adhesive layer 13 was formed by coating an adhesion-imparting compound on the surface 11a of the core materials 11. Here, as an adhesive solution which included an adhesion-imparting compound, a 2% by mass aqueous solution of an imidazole-based compound represented by the aforementioned general formula (3) was prepared wherein R_{12} thereof is an alkyl group of $C_{11}H_{23}$ and R_{11} represents a hydrogen atom. Then, the adhesive solution was adjusted

by acetic acid so that pH thereof became about 4, and heated to 40°C. Subsequently, the substrate 1 was immersed in the adhesive solution for three minutes to form the second adhesive layer 13 on the surface 11a of the core materials 11a.

[0172]

Subsequently, as shown in Fig. 2C, solder particles 14 wherein the metal composition thereof was Sn/3.5Ag and the diameter d thereof was about 10 μm were adhered on the second adhesive layer 13. Then, extra solder particles 14 were removed with an air knife.

[0173]

Next, as shown in Fig. 2D, a reflow step was performed to form a solder layer 15. First, the substrate 1 was heated for twenty minutes in an oven at a temperature of 180°C to fix the core material 11 and the solder particles 14. Then, the flux was sprayed on the surface of the substrate 1. Next, the substrate 1 was heated at a temperature of 240°C in a reflow furnace for three minutes in a nitrogen atmosphere, and a solder layer 15 having a thickness of 5 μm was formed so that the surface 11a of the core material 11 was covered. In this way, solder balls 70 wherein the diameter thereof was about 60 μm were manufactured.

[0174]

(Example 3)

Next, Example 3 is explained. First, as a substrate 1 to which a first adhesive layer 5 was formed, a polyimide tape was prepared as a substrate 1. Then, as shown in Fig. 3A, a first member 21 made of metal was provided so that the member covered the surface 5a of the first adhesive layer 5. As the first member 21, a member having first openings 31 wherein the diameter F_3 thereof was 70 μm was used. Furthermore, the distance between the adjacent first openings 31 was set to 200 μm .

[0175]

Next, as shown in Fig. 3A, core materials 11 which were made of copper and had a diameter D of 50 μm were adhered to the surface 1a of the substrate 1 in an air atmosphere. After that, as shown in Fig. 3B, the first member 21 was removed.

Subsequently, as shown in Fig. 3C, a first mask 41 which was formed with glass particles having a diameter of about 1 μm was adhered so that the mask covered the surface 5a of the first adhesive layer 5.

[0176]

Next, as shown in Fig. 3D, a second adhesive layer 13 was formed by coating an adhesion-imparting compound on the surface 11a of the core materials 11. Here, as an adhesive solution which included an adhesion-imparting compound, a 2% by mass aqueous solution of an imidazole-based compound represented by the aforementioned general formula (3) was prepared wherein R_{12} thereof is an alkyl group of $C_{11}H_{23}$ and R_{11} represents a hydrogen atom. Subsequently, the adhesive solution was adjusted by acetic acid so that pH thereof became about 4, and was heated to 40°C. Subsequently, the substrate 1 was immersed in the adhesive solution for three minutes to form the second adhesive layer 13 on the surface 11a of the core materials 11a.

[0177]

Subsequently, as shown in Fig. 3E, solder particles 14 wherein the metal composition thereof was Sn/3.5Ag and the diameter d thereof was about 10 μm were adhered on the second adhesive layer 13. Then, extra solder particles 14 were removed with an air knife.

[0178]

Next, as shown in Fig. 3F, a reflow step was performed to form a solder layer 15. First, the substrate 1 was heated for twenty minutes in an oven at a temperature of 180°C

to fix the core material 11 and the solder particles 14. Then, the flux was sprayed on the surface of the substrate 1. Subsequently, the substrate 1 was heated at a temperature of 240°C in a reflow furnace for three minutes in a nitrogen atmosphere, and a solder layer 15 having a thickness of 5 μm was formed so that the surface 11a of the core material 11 was covered. In this way, solder balls 70 wherein the diameter thereof was about 60 μm were manufactured.

[0179]

Next, Example 4 is explained. First, a substrate 1 made of glass was prepared.

Subsequently, as shown in Fig. 4A, a member 22 (second member) made of metal having a size of 5 μm was provided so that the surface 1a of the substrate 1 was covered. Here, as the member 22, a member was used wherein openings 34 (fourth openings), in which the diameter thereof F_4 was 25 μm , had been formed. Furthermore, distance between the adjacent openings 34 was set to 200 μm .

Furthermore, using the member 22 as a mask as shown in Fig. 4A, a silicon-based adhesive was coated so that the openings 34 were filled. In this way, the first adhesive layer 5 wherein the thickness H thereof was 5 μm and diameter F_4 was 25 μm was formed on the surface 1a of the substrate 1.

[0180]

Next, as shown in Fig. 4B, core materials 11 which were made of copper and had a diameter D of 50 μm were adhered to the surface 1a of the substrate 1 in an air atmosphere.

[0181]

Subsequently, as shown in Fig. 4C, a second adhesive layer 13 was formed by coating an adhesion-imparting compound on the surface 11a of the core materials 11. Here, as an adhesive solution which included an adhesion-imparting compound, a 2% by

mass aqueous solution of an imidazole-based compound represented by the aforementioned general formula (3) was prepared wherein R12 thereof is an alkyl group of $C_{11}H_{23}$ and R11 represents a hydrogen atom. Then, the adhesive solution was adjusted by acetic acid so that pH thereof became about 4, and heated to 40°C. Subsequently, the substrate 1 was immersed in the adhesive solution for three minutes to form the second adhesive layer 13 on the surface 11a of the core materials 11a.

[0182]

Next, as shown in Fig. 4D, solder particles 14 wherein the metal composition thereof was Sn/3.5Ag and the diameter d thereof was about 10 μm were adhered on the second adhesive layer 13. Then, extra solder particles 14 were removed with an air knife.

[0183]

Next, as shown in Fig. 4E, a reflow step was performed to form a solder layer 15. First, the substrate 1 was heated for twenty minutes in an oven at a temperature of 180°C to fix the core material 11 and the solder particles 14. Then, the flux was sprayed on the surface of the substrate 1. Next, the substrate 1 was heated at a temperature of 240°C in a reflow furnace for three minutes in a nitrogen atmosphere, and a solder layer 15 having a thickness of 5 μm was formed so that the surface 11a of the core material 11 was covered. In this way, solder balls 70 wherein the diameter thereof was about 60 μm were manufactured.

[0184]

(Example 5)

Next, Example 5 is explained. First, on a surface 61a of a transfer substrate 61, metal films 5 (first metal films) made of copper and having a thickness of 18 μm were formed. Here, a pattern of the metal films 51 was set to have a diameter of 25 μm , and a

distance between the adjacent patterns of the metal layers 51 was set to 200 μm .

Furthermore, as a substrate 1, a substrate was used wherein the surface 1a thereof had been covered with a mask 42 (second mask 42) having a thickness H of 18 μm . As the mask 42, a mask was used wherein openings 35 (fifth openings), in which the diameter thereof F_5 was 70 μm , had been formed. Furthermore, the distance between the adjacent openings 35 was set to 200 μm .

[0185]

Next, an adhesion-imparting compound 5b was adhered on the surface of the metal film 51. Here, as an adhesive solution which included an adhesion-imparting compound, a 2% by mass aqueous solution of an imidazole-based compound represented by the aforementioned general formula (3) was prepared wherein R12 thereof is an alkyl group of $\text{C}_{11}\text{H}_{23}$ and R11 represents a hydrogen atom. Subsequently, the adhesive solution was adjusted by acetic acid so that pH thereof became about 4, and heated to 40°C. Subsequently, the substrate 1 was immersed in the adhesive solution for ten minutes to adhere the adhesion-imparting compound 5b to the surface of the metal film 51.

Subsequently, as shown in Fig. 5B, the adhesion-imparting compound 5b was transferred from the transfer substrate 61 to the surface 1a of the substrate 1 to form the first adhesive layer 5.

[0186]

Next, as shown in Fig. 5C, core materials 11 which were made of copper and had a diameter D of 50 μm were adhered to the surface 1a of the substrate 1 in an air atmosphere.

Subsequently, as shown in Fig. 5C, a second adhesive layer 13 was formed by coating an adhesion-imparting compound on the surface 11a of the core materials 11.

[0187]

Next, as shown in Fig. 5D, solder particles 14 wherein the metal composition thereof was Sn/3.5Ag and the diameter d thereof was about 10 μm were adhered on the second adhesive layer 13. Then, extra solder particles 14 were removed with an air knife.

[0188]

Next, as shown in Fig. 5E, a reflow step was performed to form a solder layer 15. First, the substrate 1 was heated for twenty minutes in an oven at a temperature of 180°C to fix the core material 11 and the solder particles 14. Then, the flux was sprayed on the surface of the substrate 1. Next, the substrate 1 was heated at a temperature of 240°C in a reflow furnace for three minutes in a nitrogen atmosphere, and a solder layer 15 having a thickness of 5 μm was formed so that the surface 11a of the core material 11 was covered. In this way, solder balls 70 wherein the diameter thereof was about 60 μm were manufactured.

[0189]

(Example 6)

Next, Example 6 is explained. First, as shown in Fig. 6A, dot-like pattern was printed with a tungsten paste on a surface 1a of a substrate 1 made of alumina by screen printing. Then, the tungsten paste was fired to form dot-like metal films 52 (second metal films) made of tungsten. Here, the pattern of the metal film 52 was set to have a diameter of 25 μm , and the distance between the adjacent patterns of the metal films 52 was set to 200 μm .

[0190]

Next, a mask 43 (third mask) was provided so that the mask covered the surface 1a of the substrate 1.

Here, as the mask 43, a mask was used wherein openings 36 (sixth openings), in which the diameter thereof F_6 was 70 μm , had been formed. Furthermore, the distance between the adjacent openings 36 was set to 200 μm . Furthermore, the position of the mask 43 was adjusted so that the dots, which are the metal films 52, existed at the center of the openings 36.

[0191]

Next, an adhesion-imparting compound (first adhesion-imparting compound) was adhered on the surface of the metal films 52. Here, as an adhesive solution which included an adhesion-imparting compound, a 2% by mass aqueous solution of an imidazole-based compound represented by the aforementioned general formula (3) was prepared wherein R12 thereof is an alkyl group of $\text{C}_{11}\text{H}_{23}$ and R11 represents a hydrogen atom. Subsequently, the adhesive solution was adjusted by acetic acid so that pH thereof became about 4, and was heated to 40°C. Subsequently, the substrate 1 was immersed in the adhesive solution for ten minutes, and the first adhesive layer 5 was formed on the surface of the metal film 52, as shown in Fig. 6A.

[0192]

Next, as shown in Fig. 6B, core materials 11 which were made of copper and had a diameter D of 50 μm were adhered to the surface of first adhesive layer 5 in an air atmosphere.

Subsequently, as shown in Fig. 6C, a second adhesive layer 13 was formed by coating an adhesion-imparting compound on the surface 11a of the core materials 11.

[0193]

Next, as shown in Fig. 6D, solder particles 14 wherein the metal composition thereof was Sn/3.5Ag and the diameter d thereof was about 10 μm were adhered on the second adhesive layer 13. Then, extra solder particles 14 were removed with an air

knife.

[0194]

Next, as shown in Fig. 6E, a reflow step was performed to form a solder layer 15. First, the substrate 1 was heated for twenty minutes in an oven at a temperature of 180°C to fix the core material 11 and the solder particles 14. Then, the flux was sprayed on the surface of the substrate 1. The substrate 1 was heated at a temperature of 240°C in a reflow furnace for three minutes in a nitrogen atmosphere, and a solder layer 15 having a thickness of 5 μm was formed so that the surface 11a of the core material 11 was covered. In this way, solder balls 70 wherein the diameter thereof was about 60 μm were manufactured.

[0195]

In the results of Examples 1 to 6, falling off of the core materials 11 was not observed. Furthermore, no core material was observed wherein a solder layer 15 was not formed.

INDUSTRIAL APPLICABILITY

[0196]

According to the aforementioned methods, suitable solder balls 70 can be formed without using high-melting-point solder which includes a large amount of lead. Accordingly, it is possible to achieve solder balls 70 which include absolutely no lead. Therefore, α ray is not emitted from Pb which is included in a solder bump. Accordingly, it is possible to prevent malfunction of electronic components which is caused by α ray.

Furthermore, since solder balls 70 which include core materials 11 as cores thereof can be manufactured at a low cost, problems can be solved at low cost wherein the height of a solder bump becomes non-uniform or wherein a chip is sunk when reflow is performed when the chip is mounted. The producing method of the present invention is

suitable for a fine substrate 1, and electronic equipment which has a high degree of integration and high reliability can be provided by the present embodiment.

The purpose of the present invention is to provide a producing method of solder balls which can be applied to the formation of fine patterns and can be formed at a low cost.

Brief Description of Reference Symbols

1: Substrate

1a: Surface of the substrate

5: First adhesive layer

5a: Surfaces of the first adhesive layer

5b: First adhesion-imparting compound

11: Core material

11a: Surface of the core material

13: Second adhesive layer

14: Solder particle

15: Solder layer

21: First member

21a: First layer of the first member

21b: Second layer of the first member

22: Second member

31: First opening

32a: Lower portion of the second opening

32b: Upper portion of the second opening

33: Third opening

34: Fourth opening

35: Fifth opening

36: Sixth opening

41: First mask

42: Second mask

43: Third mask

51: First metal film

52: Second metal film

61: Transfer base

61a: Surface of the transfer base

70: Solder ball

F_1 : Diameter of first opening

F_{2a} : Diameter of the lower portion of the second opening

F_{2b} : Diameter of the upper portion 32b of the second opening

F_3 : Diameter of the third opening

F_4 : Diameter of the fourth opening

F_5 : Diameter of the fifth opening

F_6 : Diameter of the sixth opening

D : Particle diameter of a core material

d : Particle diameter d of a solder particle

r : Diameter of the first mask

CLAIMS

1. A method of producing solder balls, comprising:
 - a first step wherein core materials are adhered to a first adhesive layer provided on a surface of a substrate;
 - a second step wherein an adhesion-imparting compound is coated on the surface of the core materials to form a second adhesive layer;
 - a third step wherein solder particles are adhered to the second adhesive layer provided at the surface of the core materials;
 - a fourth step wherein the solder particles are melted to form a solder layer on the surface of the core materials; and
 - a fifth step wherein the substrate is removed from the core materials to obtain solder balls.
2. The method of producing solder balls according to Claim 1, wherein the core materials are made of Cu.
3. The method of producing solder balls according to Claim 1 or 2, wherein the method comprises, before the first step, a previous step wherein a first member having openings to expose a part of the surface of the first adhesive layer is provided on the first adhesive layer, and after the previous step, the core materials are adhered to the surface of the first adhesive layer, which is exposed from the openings, in the first step.
4. The method of producing solder balls according to Claim 3, wherein the first member consists of a first layer and a second layer;

the previous step wherein the first member is provided on the first adhesive layer comprises:

a step wherein a first layer of the first member, wherein the first layer has openings, is provided on the first adhesive layer, and

a step wherein a second layer of the first member, wherein the second layer has openings which have a smaller diameter than that of the openings of the first layer, is provided on the first layer of the first member so that the center of the openings of the first layer and the center of the openings of the second layer coincide, and

the method further comprises, between the first step and the second step, a step wherein the second layer of the first member is removed from the first layer of the first member.

5. The method of producing solder balls according to Claim 3, wherein the method further comprises, between the first step and the second step,

a step wherein the first member is removed from the surface of the first adhesive layer, and

a step wherein a mask which has a diameter smaller than the thickness of the first member is adhered to the surface of the first adhesive layer so that the mask covers the surface of the first adhesive layer, wherein the mask consists of particles.

6. The method of producing solder balls according to Claim 1 or 2, wherein the method comprises, before the first step, a previous step wherein plural dot-like adhesive layers, which are used as the first adhesive layer, are provided on the surface of the substrate so that the dot-like adhesive layers are separated from each other.

7. The method of producing solder balls according to Claim 6, wherein the previous step, which forms the first adhesive layer, comprises a step wherein a second member, which has dot-like openings to expose a part of the surface of the substrate, is provided on the substrate, and a step wherein an adhesive material which forms the first adhesive layer is coated, using the second member as a mask, to form the plural dot-like adhesive layers which are the first adhesive layer.

8. The method of producing solder balls according to Claim 6, wherein the previous step wherein the first adhesive layer is formed as the dot-like adhesive layers comprises:

a step wherein dot-like metal films are formed on the surface of a transfer base to form the metal films which are spaced from each other,

a step wherein an adhesion-imparting compound is coated on the metal films; and

a step wherein the adhesion-imparting compound is transferred from the transfer base to the surface of the substrate to form the first adhesive layer.

9. The method of producing solder balls according to Claim 8, wherein the previous step wherein the first adhesive layer is formed as the dot-like adhesive layers comprises:

a step wherein the surface of the substrate is covered by a mask having openings, and the adhesion-imparting compound is transferred from the transfer base to the exposed surfaces of the substrate which are exposed from the openings of the mask, and

the second adhesive layer is formed on the core materials while the surface of the substrate is covered with the mask in the second step in the second step.

10. The method of producing solder balls according to Claim 6, wherein the previous step wherein the first adhesive layer is formed comprises:

a step wherein dot-like metal films are formed on the surface of the substrate to form the metal films which are spaced from each other, and

a step wherein an adhesion-imparting compound is coated on the metal films to form the first adhesive layer.

11. The method of producing solder balls according to Claim 10, wherein the previous step wherein the first adhesive layer is formed comprises:

a step wherein dot-like metal films are formed on the surface of the substrate to form the metal films which are spaced from each other, and

a step wherein the surface of the substrate is covered by a mask having openings, and the adhesion-imparting compound is coated to the exposed surface of the metal films which are exposed from the openings.

12. The method of producing solder balls according to Claim 10 or 11, wherein the metal film is made of tungsten.

13. The method of producing solder balls according to any one of Claims 1 to 12, wherein the average particle diameter of the solder particles is $1/2$ or less of the average particle diameter of the core material.