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(54) **REINFORCING RESIN COMPOSITION, ELECTRONIC COMPONENT, METHOD FOR MANUFACTURING ELECTRONIC COMPONENT, MOUNTING STRUCTURE, AND METHOD FOR MANUFACTURING MOUNTING STRUCTURE**

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(57) **ABSTRACT**

A reinforcing resin composition includes an epoxy resin (A), a phenolic resin (B), and a benzoxazine compound (C).

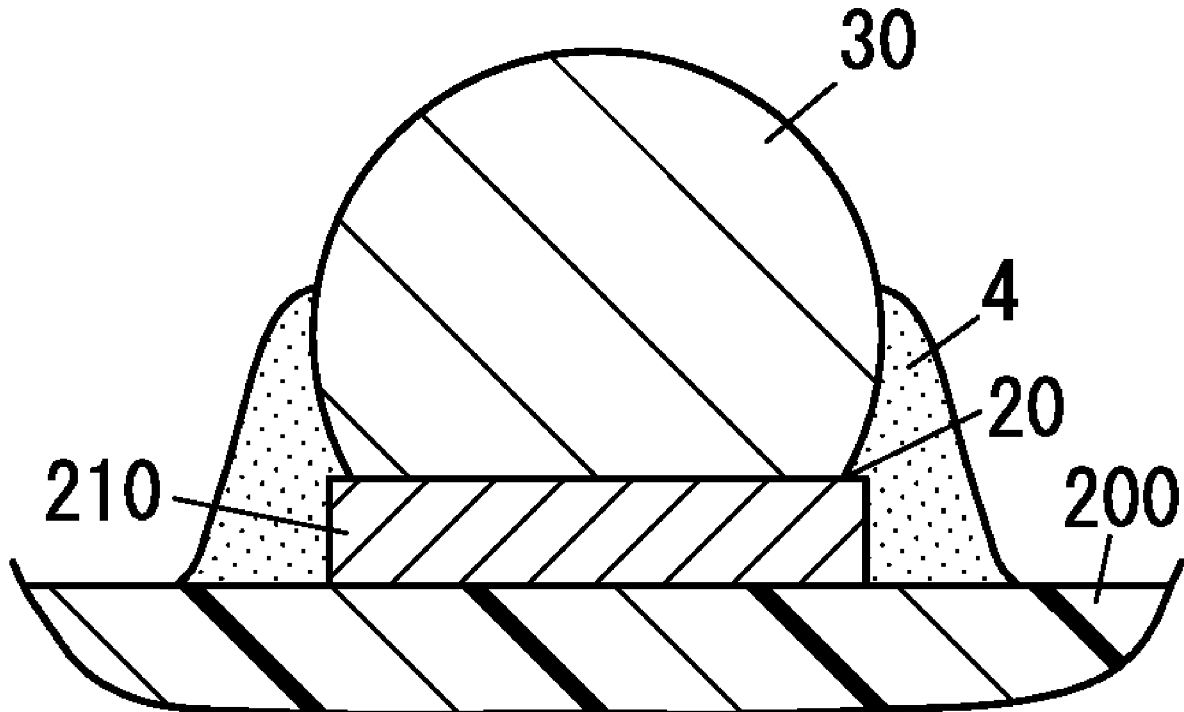


FIG. 1

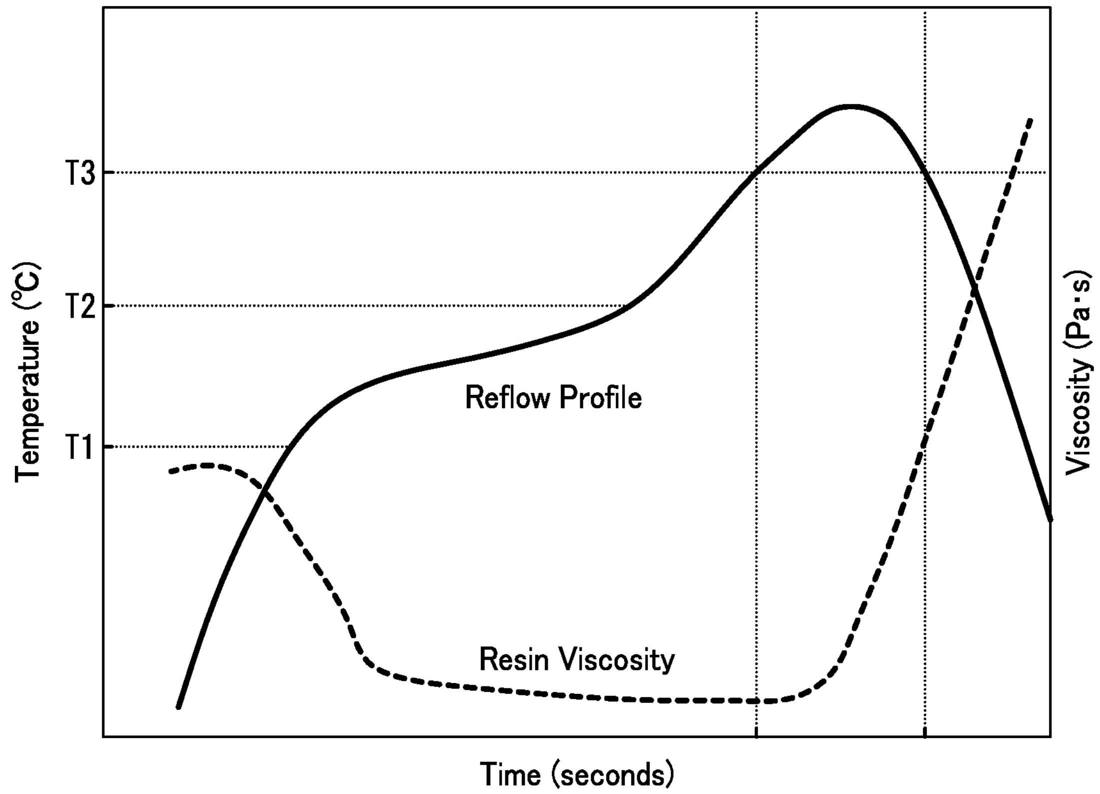


FIG. 2

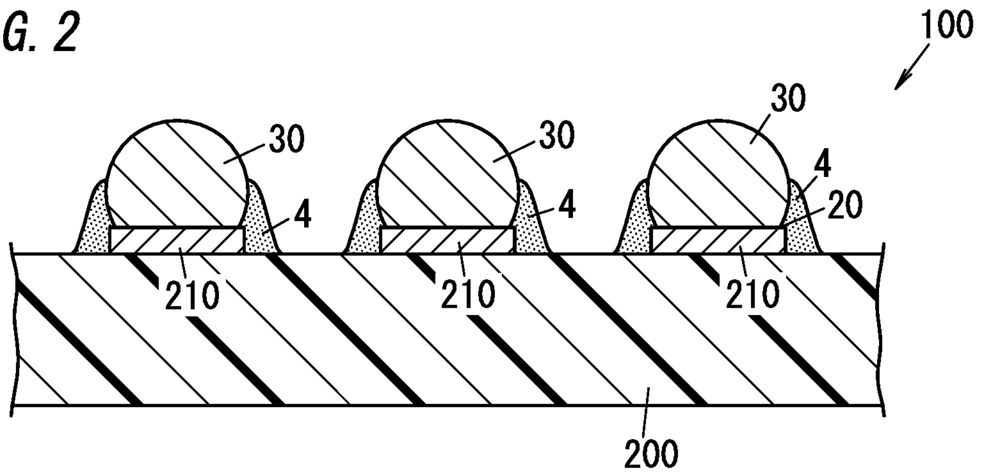


FIG. 3A

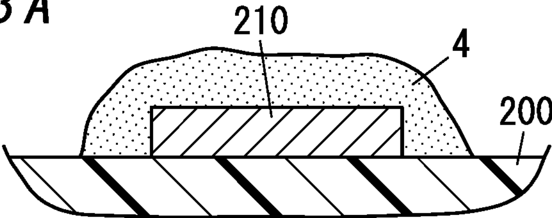


FIG. 3B

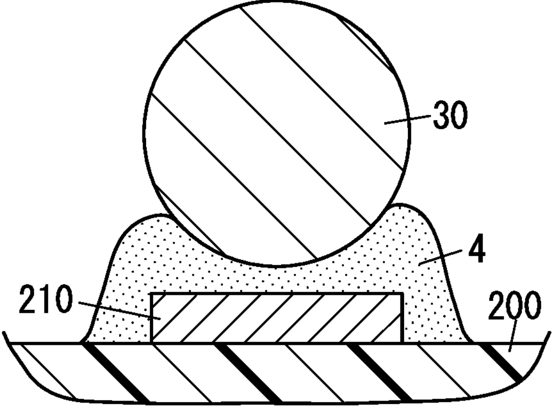


FIG. 3C

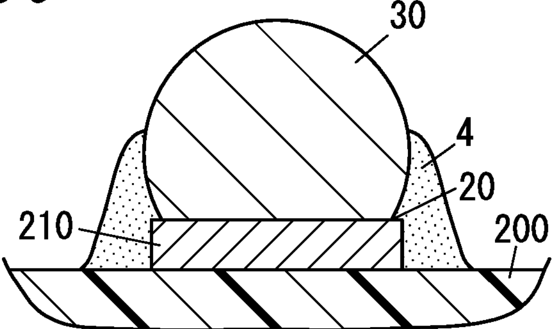


FIG. 4A

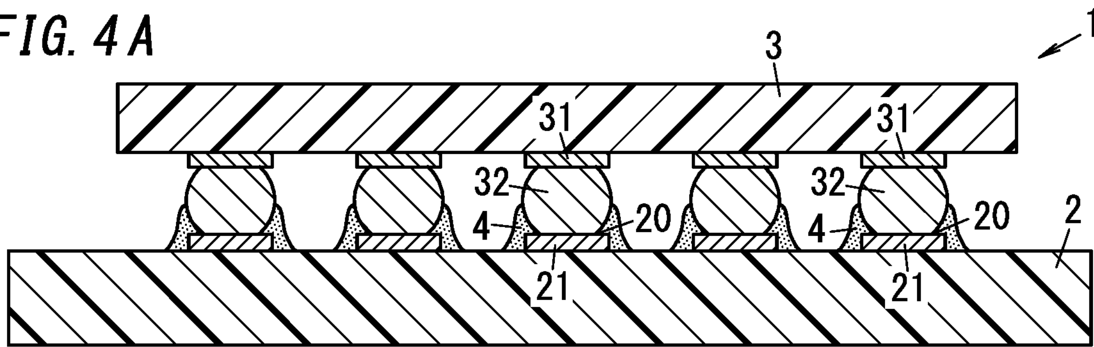


FIG. 4B

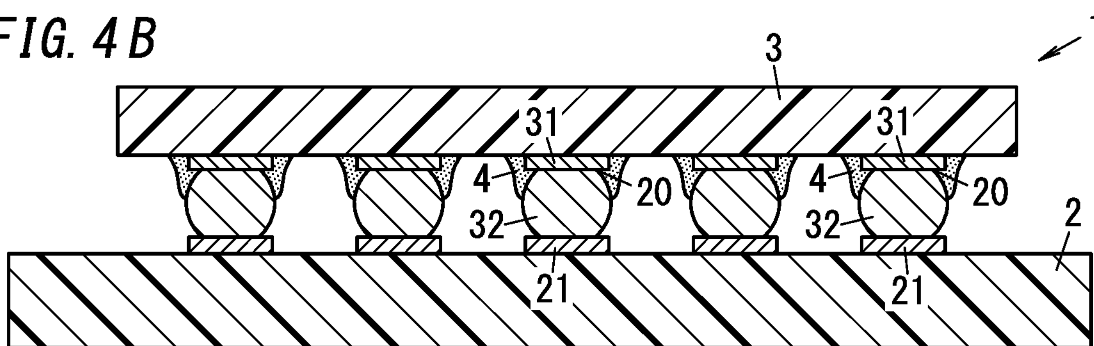


FIG. 4C

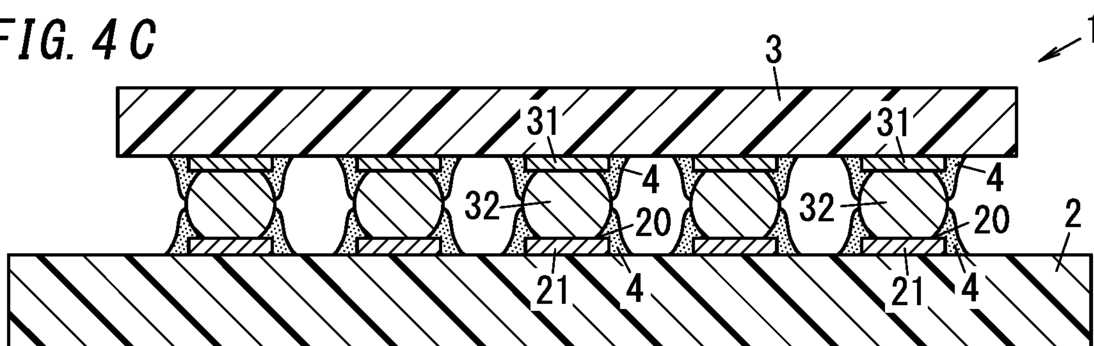


FIG. 5A

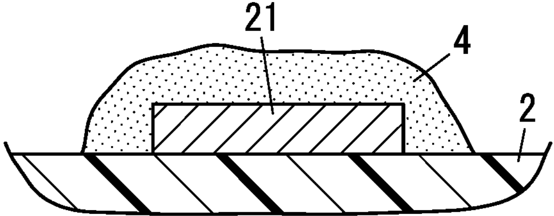


FIG. 5B

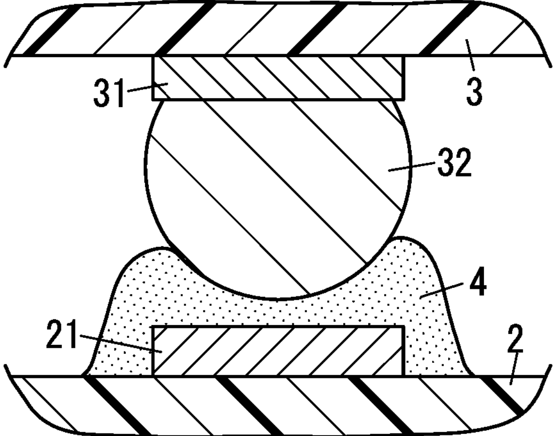
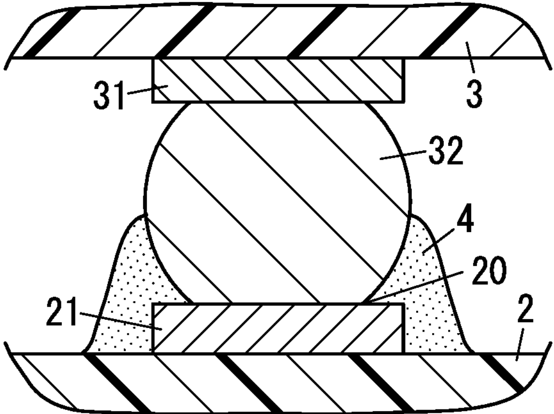


FIG. 5C



REINFORCING RESIN COMPOSITION, ELECTRONIC COMPONENT, METHOD FOR MANUFACTURING ELECTRONIC COMPONENT, MOUNTING STRUCTURE, AND METHOD FOR MANUFACTURING MOUNTING STRUCTURE

TECHNICAL FIELD

[0001] The present disclosure generally relates to a reinforcing resin composition, an electronic component, a method for manufacturing the electronic component, a mounting structure, and a method for manufacturing the mounting structure. More particularly, the present disclosure relates to a reinforcing resin composition, an electronic component including a cured product of the reinforcing resin composition and a manufacturing method thereof, and a mounting structure including the cured product of the reinforcing resin composition and a manufacturing method thereof.

BACKGROUND ART

[0002] When a semiconductor chip is mounted on a circuit board, a solder bump and a conductor included in the circuit board are electrically connected. When the bump and the conductor are connected, a joint between the bump and the conductor may be covered and reinforced with a cured product of a resin composition. For example, by placing the resin composition between the bump and the conductor and heating the resin composition, the bump will be connected to the conductor, and the joint may be covered with the cured product of the resin composition. An example of such a resin composition that may be used to reinforce the joint is disclosed in Patent Literature 1.

[0003] When the bump and the conductor are connected, a contact failure may occur between the bump and the conductor. In particular, the contact failure is likely to occur if the temperature is high at the time of heating.

CITATION LIST

Patent Literature

[0004] Patent Literature 1: JP 2010-254895 A

SUMMARY OF INVENTION

[0005] It is therefore an object of the present disclosure to provide a reinforcing resin composition that facilitates covering the joint between the conductor and the bump while reducing the chances of causing a contact failure between the bump and the conductor.

[0006] A reinforcing resin composition according to an aspect of the present disclosure includes an epoxy resin (A), a phenolic resin (B), and a benzoxazine compound (C).

[0007] An electronic component according to another aspect of the present disclosure includes: an electronic component body; a conductor formed on a surface of the electronic component body; a solder bump arranged on the conductor and electrically connected to the conductor; and a reinforcing portion. The reinforcing portion is a cured product of the reinforcing resin composition and covers a joint between the conductor and the bump.

[0008] A method for manufacturing the electronic component according to still another aspect of the present disclosure includes curing the reinforcing resin composition after covering a joint between the conductor and the bump with the reinforcing resin composition.

[0009] A mounting structure according to yet another aspect of the present disclosure includes: a circuit board including a first conductor; an electronic component including a second conductor; a solder bump; and a reinforcing portion. The bump is interposed between the first conductor and the second conductor and electrically connects the first conductor and the second conductor to each other. The reinforcing portion is a cured product of the reinforcing resin composition and covers at least one of a joint between the first conductor and the bump or a joint between the second conductor and the bump.

[0010] A method for manufacturing the mounting structure according to yet another aspect of the present disclosure includes curing the reinforcing resin composition after covering, with the reinforcing resin composition, at least one of a joint between the first conductor and the bump or a joint between the second conductor and the bump.

BRIEF DESCRIPTION OF DRAWINGS

[0011] FIG. **1** is a graph showing a reflow profile when a reinforcing resin composition according to an exemplary embodiment of the present disclosure and solder are heated;

[0012] FIG. **2** is a schematic cross-sectional view of an electronic component according to the exemplary embodiment of the present disclosure;

[0013] FIGS. **3**A-**3**C are schematic cross-sectional views illustrating an exemplary manufacturing method of the electronic component;

[0014] FIGS. **4**A-**4**C are schematic cross-sectional views of exemplary mounting structures according to the exemplary embodiment of the present disclosure; and

[0015] FIGS. **5**A-**5**C are schematic cross-sectional views illustrating an exemplary manufacturing method of the mounting structure.

DESCRIPTION OF EMBODIMENTS

[0016] 1. Overview

[0017] A reinforcing resin composition (hereinafter also referred to as a "resin composition (X)") according to an embodiment of the present disclosure includes an epoxy resin (A), a phenolic resin (B), and a benzoxazine compound (C).

[0018] If the resin composition (X) is thermally cured by increasing its temperature, the viscosity of the resin composition (X) is easily lowered before the start of a curing reaction of the resin composition (X), and the state of low viscosity is easily maintained even when the temperature increases. In other words, the temperature at which the viscosity of the resin composition (X) starts to rise may be easily increased.

[0019] Moreover, if the resin composition (X) is thermally cured by increasing the temperature of the resin composition (X), the curing reaction of the resin composition (X) may be advanced sharply and the viscosity may be increased steeply, once the reaction has started.

[0020] Therefore, the conductor and the bump may be easily connected by melting a solder bump before the curing reaction of the resin composition (X) starts. Subsequently, in a state where a joint between the conductor and the bump is covered with the resin composition (X), the resin composition (X) may be rapidly cured, and therefore, the manufac-

turing efficiency is easily enhanced. This reduces the chances of causing a contact failure between the conductor and the bump even if the bump is made of solder with a high melting point such as SAC solder and the heating temperature is high.

[0021] 2. Details

[0022] Next, a resin composition (X), an electronic component **100** (see FIG. **2**), a method for manufacturing the electronic component **100** (see FIGS. **3**A-**3**C), a mounting structure **1** (see FIGS. **4**A-**4**C), and a method for manufacturing the mounting structure **1** (see FIGS. **5**A-**5**C) according to an exemplary embodiment will be described in further detail.

[0023] 2-1. Resin composition (X)

[0024] As described above, the resin composition (X) according to this exemplary embodiment includes an epoxy resin (A), a phenolic resin (B), and a benzoxazine compound (C). Moreover, the resin composition (X) preferably further includes an activator (D). The details of the epoxy resin (A), the phenolic resin (B), the benzoxazine compound (C), and the activator (D) will be described below.

[0025] (1) Epoxy resin (A)

[0026] The epoxy resin (A) is a compound having an epoxy group and the property of getting cured by heating. Therefore, the epoxy resin (A) may impart a thermosetting property to the resin composition (X).

[0027] The epoxy resin (A) is preferably liquid at a normal temperature. In this case, in the resin composition (X), the epoxy resin (A) and the other components may be mixed more easily. In addition, being liquid at a normal temperature means having fluidity under the atmospheric pressure and at an ambient temperature within the range of 5° C. to 28° C. (particularly around 20° C.). In order for the epoxy resin (A) to be liquid at the normal temperature, only components that are in liquid state at the normal temperature may be included in the epoxy resin (A), or a component that is in liquid state at the normal temperature and a component that is not in liquid state at the normal temperature may be included in the epoxy resin (A), or the epoxy resin (A) may be in liquid state at the normal temperature due to the presence of, for example, a reactive diluent, or a solvent.

[0028] The epoxy resins (A) preferably includes a liquid epoxy resins (A1) having two or more epoxy groups in one molecule. The epoxy resin (A1) may contain, for example, one or more components selected from the group consisting of glycidyl ether type epoxy resins, glycidyl amine type epoxy resins, glycidyl ester type epoxy resins, and olefin oxidation type (alicyclic) epoxy resins.

[0029] The epoxy resin (A1) may contain, for example, one or more components selected from the group consisting of: bisphenol type epoxy resins such as bisphenol A type epoxy resins and bisphenol F type epoxy resins; hydrogenated bisphenol type epoxy resins such as hydrogenated bisphenol A type epoxy resins and hydrogenated bisphenol F type epoxy resins; biphenyl type epoxy resins; naphthalene ring-containing epoxy resins; alicyclic epoxy resins; dicyclopentadiene type epoxy resins; phenol-novolac type epoxy resins; cresol-novolac type epoxy resins; triphenylmethane type epoxy resins; aliphatic epoxy resins; and triglycidyl isocyanurate.

[0030] It is particularly preferable that the epoxy resin (A1) contain one or both of a bisphenol type epoxy resin and a hydrogenated bisphenol type epoxy resin. In this case, it is easier to reduce the viscosity of the resin composition (X) and improve the physical properties of a cured product of the resin composition (X).

[0031] A commercially available product may be used as the epoxy resin (A1). Examples of commercially available products include bisphenol A type epoxy resins (such as product number jER828 manufactured by Mitsubishi Chemical Corporation) and bisphenol F type epoxy resins (such as product number jER806 manufactured by Mitsubishi Chemical Corporation).

[0032] The epoxy resin (A) may include only the epoxy resin (A1) or may include the epoxy resin (A1) and an epoxy resin other than the epoxy resin (A1).

[0033] (2) Phenolic resin (B)

[0034] The phenolic resin (B) is a compound having a phenolic hydroxyl group. This phenolic hydroxyl group may react with the epoxy group of the epoxy resin (A).

[0035] The phenolic resin (B) preferably has two or more phenolic hydroxyl groups in one molecule. Examples of the phenolic resin (B) having two or more phenolic hydroxyl groups in one molecule include polyfunctional phenols such as a bisphenol A type, a phenol-novolac type, and a cresol-novolac type. The phenolic resin (B) may contain one or more of these components. The phenolic resin (B) may be a commercially available product. Examples of commercially available phenolic resins include products such as phenol formaldehyde novolac resins (such as product number MEH-8000H manufactured by Meiwa Plastic Industries, Ltd.), phenol-novolac resins (such as product number HF-1M manufactured by Meiwa Plastic Industries, Ltd.), phenol aralkyl resins (such as product number MEH-7800 manufactured by Meiwa Plastic Industries, Ltd.), and biphenyl aralkyl resins (such as product number MEH-7851SS manufactured by Meiwa Plastic Industries, Ltd.).

[0036] It is particularly preferable that the phenolic resin (B) include a phenol-novolac resin (B1) having a hydroxyl equivalent of 70 g/eq to 150 g/eq. In this case, the solubility of the phenolic resin (B) with respect to the epoxy resin (A) may be increased. Moreover, in this description, a hydroxyl equivalent refers to a value which is measured by a neutralization titration method compliant with JISK 0070.

[0037] It is particularly preferable that the phenol-novolac resin (B1) is in liquid state. In other words, the phenolic resin (B) preferably includes the phenol-novolac resin (B1) having two or more phenolic hydroxyl groups in one molecule, having a hydroxyl equivalent of 70 g/eq to 150 g/eq, and exhibiting liquid state. This may improve the wettability of the resin composition (X). Examples of commercially available products of such a phenol-novolac resin (B1) include a phenol formaldehyde novolac resin (such as product number MEH-8000H manufactured by Meiwa Plastic Industries, Ltd.).

[0038] The phenolic resin (B) may include only the phenol-novolac resin (B1) or may include the phenol-novolac resin (B1) and a phenolic resin other than the phenol-novolac resin (B1).

[0039] (3) Benzoxazine compound (C)

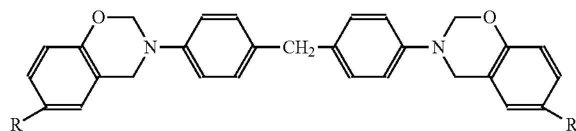
[0040] The benzoxazine compound (C) is a compound containing a dihydrobenzoxazine ring. The benzoxazine compound (C) has a structure that varies according to the type of its material.

[0041] The benzoxazine compound (C), for example, may be a synthetic compound of various types of phenols, amines, formaldehydes, and other substances.

[0042] Under a normal condition, the polymerization reaction of the benzoxazine compound (C) does not proceed, because the dihydrobenzoxazine ring is chemically stable. However, by heating the benzoxazine compound (C) to about 170° C. or a higher temperature, the dihydrobenzoxazine ring is opened, and a polybenzoxazine compound having a diaminodiphenyl structure composed of a phenolic hydroxyl group and a basic amino group is produced. The basic amino group included in the diaminodiphenyl structure formed by opening the ring may function as a curing accelerator in a reaction between the epoxy resin (A) and the phenolic resin (B) and may accelerate the reaction at a high temperature. In detail, a reaction at a temperature higher than a melting point of SAC solder may be accelerated by the basic amino group. Therefore, the curing action of the resin composition (X) may be accelerated after the melting of the solder starts. Moreover, the dihydrobenzoxazine ring does not open until it reaches 170° C., and therefore, the reaction between the epoxy resin (A) and the phenolic resin (B) does not proceed, and curing of the resin composition (X) may be inhibited before the solder melts. Furthermore, after the dihydrobenzoxazine ring opens, the phenolic hydroxyl group of the phenolic resin (B) may cause self-polymerization without producing a by-product, and may react with the epoxy resin (A). Therefore, after the solder has melted, the resin composition (X) sharply reacts to opening of the dihydrobenzoxazine ring.

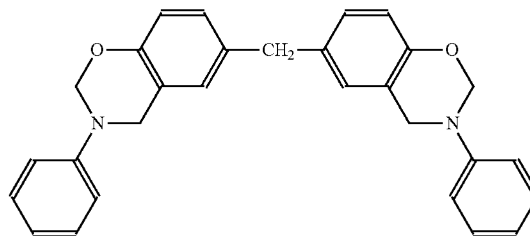
[0043] The benzoxazine compound (C) preferably includes a polyvalent oxazine compound (C1) having a plurality of oxazine rings in a molecule. The polyvalent oxazine compound (C1) may easily form a three-dimensional cross-linked structure through reaction with the epoxy resin (A). Therefore, the benzoxazine compound (C) including the polyvalent oxazine compound (C1) may increase the glass transition temperature (Tg) of a cured product of the resin composition (X) compared to the benzoxazine compound (C) including no polyvalent oxazine compound (C).

[0044] A commercially available product may be used as the polyvalent oxazine compound (C1). An example of a typical commercially available benzoxazine compound (C1) is a P-d-type benzoxazine compound such as: a polymer of a phenol, diaminodiphenylmethane and formaldehyde (manufactured by Shikoku Chemicals Corporation). The P-d-type benzoxazine compound, for example, has the following structure:



[0045] (In this formula, R indicates a hydrogen atom or an allyl group. The allyl group may be an electron withdrawing group or an electron-donating group).

[0046] An example of a typical commercially available polyvalent oxazine compound (C1) is an F-a type benzoxazine compound such as: a polymer of a bisphenol F, an aniline, and formaldehyde (manufactured by Shikoku Chemicals Corporation). The F-a type benzoxazine compound has the following structure:



[0047] (4) Activator (D)

[0048] As described above, the resin composition (X) preferably includes an activator (D). The activator (D) has the function of removing a metal oxide film. Therefore, adding the activator (D) to the resin composition (X) may impart a flux action to the resin composition (X) by. As used herein, the flux action means a reduction action of removing an oxide film formed on the surface of a metal to which solder paste is applied, and the action of lowering a surface tension of the melted solder and improving the wettability of the solder to the joining metal surface.

[0049] The activator (D) preferably includes at least one of an organic acid (D1) having a melting point of 130° C. to 220° C. or an amine (D2) having a melting point of 130° C. to 220° C. This allows the activator (D) to decelerate the curing reaction of the epoxy resin (A). Moreover, even when solder having a melting point of around 200° C. or equal to or higher than 200° C. is used, an oxide film of the solder may be removed before the solder is melted. Furthermore, by having the organic acid (D1) or the amine (D2) melted before melting the solder, the viscosity of the resin composition (X) may be lowered before the solder is melted, and the wettability of the resin composition (X) may be improved.

[0050] The organic acid (D1) may include, for example, one or more substances selected from the group consisting of a rosin component material, adipic acid, glutaric acid, succinic acid, malonic acid, citric acid, suberic acid (cork acid), sebacic acid, and pimelic acid. The organic acid (D1) preferably includes, among other things, succinic acid (having a melting point of 186° C.), adipic acid (having a melting point of 152° C.), suberic acid (cork acid) (having a melting point of 142° C.), and sebacic acid (having a melting point of 133° C.).

[0051] The amine (D2) is not limited to any particular one as long as the amine may be used as a flux, but may include, for example, one or more substances selected from the group consisting of various amine salts, triethanolamine (TEA), and guanidine.

[0052] The activator (D) may include components besides the organic acid (D1) and the amine (D2). The activator (D) may include an organic acid or an amine having a melting point below 130° C., or an organic acid or an amine having a melting point above 220° C.

[0053] (5) Other components (E)

[0054] The resin composition (X) may include components (E) other than the epoxy resin (A), the phenolic resin (B), the benzoxazine compound (C), and the activator (D). The component (E) may include, for example, a component modifier such as rosin, a filler, and/or a thixophilic imparting agent.

[0055] (6) Content of each component

[0056] In the resin composition (X), the proportion of the epoxy resin (A) with respect to the total of the epoxy resin (A), the phenolic resin (B), the benzoxazine compound (C), and the activator (D) is preferably within a range from 20% by weight to 60% by weight.

[0057] Moreover, in the resin composition (X), the proportion of the phenolic resin (B) with respect to the total of the epoxy resin (A), the phenolic resin (B), the benzoxazine compound (C), and the activator (D) is preferably within a range from 10% by weight to 40% by weight.

[0058] Moreover, in the resin composition (X), the proportion of the benzoxazine compound (C) with respect to the total of the epoxy resin (A), the phenolic resin (B), the benzoxazine compound (C), and the activator (D) is preferably within a range from 5% by weight to 30% by weight.

[0059] Moreover, in the resin composition (X), the proportion of the activator (D) with respect to the total of the epoxy resin (A), the phenolic resin (B), the benzoxazine compound (C), and the activator (D) is preferably within a range from 3% by weight to 40% by weight.

[0060] In the resin composition (X), if the proportions of the epoxy resin (A), the phenolic resin (B), the benzoxazine compound (C), and the activator (D) meet the conditions specified above, the glass transition temperature of the cured product of the resin composition (X) may be lowered and the modulus of elasticity of the cured product of the resin composition (X) may be increased. Therefore, the reinforcement effect achieved by covering the periphery of the solder with the cured product of the resin composition (X) may be improved.

[0061] In particular, the proportion of the epoxy resin (A) with respect of the total of the epoxy resin (A), the phenolic resin (B), the benzoxazine compound (C), and the activator (D) is preferably 60% by weight or less. This allows the resin composition (X) to rapidly cure and allows the delay in curing of the resin composition (X) to be reduced.

[0062] In particular, the proportion of the benzoxazine compound (C) with respect of the total of the epoxy resin (A), the phenolic resin (B), the benzoxazine compound (C), and the activator (D) is preferably 30% by weight or less. This may reduce generation of voids (bubbles) in the cured product of the resin composition (X).

[0063] 2-2. Reinforcement of joint between conductor and bump using resin composition (X).

[0064] A method for making a reinforcing portion for reinforcing the joint between the conductor and the solder bump by using the resin composition (X) will be described below.

[0065] The conductor and the bump may be electrically connected by placing the solder bump on the conductor and melting the bump. The joint between the conductor and the bump may be reinforced by covering the joint between the conductor and the bump with a cured product of the resin composition (X). For example, if the bump and the resin composition (X) are heated in a state where the resin composition (X) is placed between the conductor and the bump, the viscosity of the resin composition (X) decreases, causing the resin composition (X) to flow. Accordingly, the bump comes into contact with the conductor. The bump melts and adheres to the conductor while the resin composition maintains its flowability. The resin composition (X) covers the joint between the conductor and the joint and is cured in that state to make the reinforcing portion. As a result, the conductor and the bump may be electrically connected and the joint between the conductor and the bump may be reinforced by covering it with the reinforcing portion which is the cured product of the resin composition (X). In order to melt the bump, the bump and the resin composition (X) are heated to a temperature higher than the melting point of the solder.

[0066] An example of a heating temperature profile and a variation in the viscosity of the resin composition (X) when the conductor and the bump are electrically connected while the reinforcing portion is being made are shown in the graph of FIG. **1**. In the graph of FIG. **1**, the solid curve indicates the heating temperature, and the dashed curve indicates the viscosity of the resin composition (X). In FIG. **1**, T3 (° C.) is the melting point of the bump, and T1 (° C.) and T2 (° C.) are predetermined temperatures which meets the relation: room temperature <T1<T2<T3.

[0067] First, as shown in FIG. **1**, the heating temperature is raised from room temperature to T1 (° C.). Next, with a temperature increase rate of the heating temperature decreased, the heating temperature is raised to T2 (° C.). Then, with the temperature increase rate increased, the heating temperature is raised to a temperature higher than T3 (° C.) (i.e., raised to a peak temperature). Then, the heating temperature is lowered to room temperature.

[0068] The melting point T3 (° C.) of the bump depends on the composition of the solder as a constituent material of the bump. For instance, if the bump is made of a Sn—Ag—Cu (SAC) based solder, T3 (° C.) is, for example, between 217° C.-230° C. T1 (° C.) preferably is defined around the temperature at which the resin composition (X) starts melting. T1 (° C.) may be, but does not have to be, 140° C.-160° C., for example. T2 (° C.) preferably is defined to be higher than T1 (° C.) and lower than the temperature at which the resin composition (X) starts curing. T2 (° C.) may be, but does not have to be, 160° C.-200° C., for example. The peak temperature preferably is defined to be higher than T3 (° C.) and higher than the temperature at which the resin composition (X) starts curing. The peak temperature may be, but does not have to be, 232° C.-255° C., for example. The temperature increase rate of the heating temperature at which the heating temperature rises from room temperature to T1 (° C.) may be, but does not have to be, 5° C./second or less, for example. A period of time it takes for the heating temperature to rise from T1 (° C.) to T2 (° C.) may be, but does not have to be, 60 seconds-100 seconds, for example. The temperature increase rate at which the heating temperature rises from T2 (° C.) to the peak temperature (° C.) may be, but does not have to be, 4° C./second or less, for example. The duration for which the heating temperature remains equal to or higher than T3 (° C.) may be, but does not have to be, 30 seconds to 90 seconds, for example.

[0069] As shown in FIG. **1**, from around T1 (° C.), the viscosity of the resin composition (X) starts to decrease to cause the resin composition (X) to start flowing. Therefore, the period of time it takes for the resin composition (X) to start flowing since the start of the heating may be controlled by controlling the temperature increase rate of the heating temperature from room temperature to T1 (° C.).

[0070] As shown in FIG. **1**, even if the heating temperature is raised from T1 (° C.) to T2 (° C.), the resin composition (X) is maintained at a low viscosity. Therefore, the duration for which the resin composition (X) maintains flowability may be controlled by controlling the temperature

increase rate from T1 (° C.) to T2 (° C.). This allows the resin composition (X) to flow sufficiently to reduce the chances of causing voids in the reinforcing portion.

[0071] As shown in FIG. **1**, as the heating temperature rises from T2 (° C.) toward the peak temperature, the viscosity of the resin composition (X) hardly increases, and the state in which the resin composition (X) having flowability is maintained for a while even after the heating temperature exceeds T3 (° C.). Subsequently, the viscosity starts to increase steeply. In other words, even after the heating temperature exceeds the melting point of the solder, the resin composition (X) is allowed to be flowable for a while. Therefore, flowing of the resin composition (X) allows the bump to come into contact with the conductor and to be fused and adhered to the bump easier. Moreover, this reduces the chances of the resin composition (X) inhibiting a self-alignment effect of the melted bump. Furthermore, if the resin composition (X) includes the activator (D), the oxide film of the solder may be quickly removed by the flux action of the activator (D) while the heating temperature rises from T2 (° C.) to T3 (° C.). This allows the conductor and the solder to be connected smoothly and further reduces the chances of causing a contact failure.

[0072] Next, the reinforcing portion covering the joint between the conductor and the solder is formed by having the resin composition (X) cured in a state in which the joint between the conductor and the solder is covered with the resin composition (X). As shown in FIG. **1**, the viscosity of the resin composition (X) continues increasing even if the heating temperature lowers from the peak temperature towards room temperature. Therefore, the resin composition (X) may be rapidly cured with the joint between the conductor and the bump kept covered with the resin composition (X).

[0073] Such viscosity behavior is realized by the resin composition (X) probably because the resin composition (X) includes the epoxy resin (A), the phenolic resin (B), benzoxazine compound (C), and the activator (D).

[0074] In detail, the viscosity hardly increases even if the heating temperature rises toward T2 (° C.) from T1 (° C.) during melting of the resin composition (X). This is probably because melting of the benzoxazine compound (C) causes the resin composition (X) to melt. Moreover, even if the heating temperature reaches T3 (° C.), the viscosity of the resin composition (X) does not immediately rise but starts to increase steeply after a while. This is probably because a ring-opening reaction of the benzoxazine compound (C) is caused at a high temperature of 170° C. or higher.

[0075] Furthermore, if the resin composition (X) includes the activator (D), the activator (D) preferably includes at least one of an organic acid (D1) or an amine (D2). This allows the activator (D) to decelerate the curing reaction of the epoxy resin (A). This also contributes to keeping the viscosity of the resin composition (X) low until the heating temperature reaches T3 (° C.).

[0076] Furthermore, the resin composition (X) cures rapidly even if the heating temperature lowers to room temperature from the peak temperature. This is probably because not only self-polymerization reaction of the benzoxazine compound (C), but a reaction between the benzoxazine compound (C) and the epoxy resin (A) contribute to forming a three-dimensional cross-linked structure. This allows the glass transition temperature (Tg) of the cured product of the resin composition (X) to increase.

[0077] Therefore, applying the resin composition (X) to an electronic component **100** shown in FIG. **2** allows forming a reinforcing portion **4** covering the joint **20** between the conductor **210** included in an electronic component body **200**, and a bump **32**.

[0078] Furthermore, applying the resin composition (X) to a mounting structure **1** as shown in FIG. **4**A allows forming a reinforcing portion **4** covering the joint **20** between a first conductor **21** and a bump **32**, when connecting the first conductor **21** of a circuit board **2** and the bump.

[0079] In the present embodiment, after the conductor and the bump are electrically connected, the resin composition (X) may be used for forming the reinforcing portion covering the joint between the conductor and the bump.

[0080] 2-3. Electronic component and its manufacturing method

[0081] The configuration of the electronic component **100** to which the resin composition (X) is applied, and a manufacturing method thereof will be described below.

[0082] (1) Configuration of electronic component

[0083] The electronic component **100** of the present embodiment will be described with reference to FIG. **2**. Note that the electronic component **100** to be described below is only an example and the configuration of the electronic component **100** should not be construed as limiting.

[0084] The electronic component **100** may be, but does not have to be, a surface-mount semiconductor chip, for example. The semiconductor chip may be, but does not have to be, a BGA (a ball-grid array), or a WLP (a wafer level package), for example.

[0085] The electronic component **100** includes an electronic component body **200**, conductors **210**, solder bumps **30**, and a reinforcing portion **4**.

[0086] The conductors **210** are formed on a surface of the electronic component body **200**, and therefore, the conductors **210** are exposed to the outside on the surface of the electronic component body **200**. If the electronic component **100** is a WLP, the electronic component body **200**, for example, includes a silicone substrate with a rewiring layer, and the conductors **210**, for example, are pillars electrically connected to the rewiring layer. If the electronic component **100** is a BGA, the electronic component body **200**, for example, is a package formed by encapsulating a die (chip) mounted on a substrate with an encapsulation resin, and the conductors **210**, for example, are electrode pads electrically connected to the die. The structure of the electronic component body **200** may be modified appropriately according to the type of the electronic component **100** and should not be construed as limiting.

[0087] The bumps **30** are arranged on the conductors **210** and electrically connected to the conductors **210**. Therefore, the joint **20** is formed between the bumps **30** and the conductors **210**. The bumps **30** may be, or do not have to be, made of, for example, SAC solder, or tin-copper based (Sn—Bi based) solder. The Sn—Bi based solder may contain, in addition to Sn and Bi, at least one type of material selected from the group consisting of Ag, Ni, Fe, Ge, Cu and In. To improve the mechanical performance of the Sn—Bi based solder, the Sn—Bi based solder preferably contains at least one type of material selected from the group consisting of Ag, Ni, Fe, and Ge.

[0088] The reinforcing portions **4** are a cured product of the resin composition (X). In the electronic component **100**, the reinforcing portions **4** cover the joint **20** between the bumps **30** and the conductors **210**. In other words, in the electronic component **100**, the joint **20** between the bumps **30** and the conductors **210** is covered with the cured product of the resin composition (X). Therefore, the reinforcing portions **4** allow reinforcing the joint **20** between the bumps **30** and the conductors **210** and improving the connection reliability of the electronic component **100**.

[0089] (2) Manufacturing method of electronic component

[0090] A manufacturing method of the electronic component **100** will be described with reference to FIGS. **3**A-**3**C.

[0091] First, an electronic component body **200** including a conductor **210** is provided and the resin composition (X) is arranged to cover the conductor **210** (see FIG. **3**A). The arranging method of the resin composition (X) may be, or does not have to be, for example, a printing method such as an inkjet method, or a transfer method.

[0092] Next, a bump **30** is arranged above the conductor **210** to bring the bump **30** into contact with the resin composition (X) (see FIG. **3**B). As for the bump **30**, for example, a solder ball may be used.

[0093] Next, the bump **30** and the resin composition (X) are heated in a state as shown in FIG. **3**B. The heating method may be, but does not have to be, heating with a reflow furnace, for example. In this case, for example, as shown in FIG. **1**, the bump **30** and the resin composition (X) may be heated based on the reflow profile as shown in FIG. **1**.

[0094] As described above in the "2-2. Reinforcement of joint between conductor and bump using resin composition (X)", the resin composition (X) is maintained at a low viscosity until the bump **30** melts. Moreover, even if the bump **30** starts melting, the viscosity of the resin composition (X) does not immediately rise but starts to increase steeply after a while. Therefore, the resin composition (X) may be cured after the joint **20** between the conductor **210** and the bump **30** is covered with the resin composition (X). This allows the conductor **210** and the bump **30** to connect smoothly. In addition, this may reduce the chances of causing a contact failure between the conductor **210** and the bump **30**. Furthermore, the joint **20** between the conductor **210** and the bump **30** may be covered with a cured product of the resin composition (X). Therefore, the joint **20** between the conductor **210** and the bump **30** may be reinforced.

[0095] 2-4. Mounting structure and its manufacturing method

[0096] (1) Mounting structure

[0097] A mounting structure 1 of the present embodiment will be described with reference to FIGS. **4**A-**4**C. Note that the mounting structure **1** to be described below is only an example and the configuration of the mounting structure **1** should not be construed as limiting.

[0098] The mounting structure **1** includes a circuit board **2**, an electronic component **3**, bumps **32**, and reinforcing portions **4**.

[0099] The circuit board **2** may be a motherboard, a package board, or an interposer board, for example. The circuit board **2** may be, for example, an insulating board made of glass epoxy, polyimide, polyester, a ceramic, or any other suitable material and the first conductor **21** is formed on the surface of the circuit board **2**. Thus, the circuit board **2** includes the first conductor **21**. The first conductor **21** may be, but does not have to be, conductor wiring.

[0100] The electronic component **3** may be a semiconductor chip, for example, and may more specifically be a flip-chip bonded chip such as a ball-grid array (BGA), a land-grid array (LGA), or a chip size package (CSP) chip. Alternatively, the electronic component **3** may also be a package on package (PoP) chip. The second conductor **31** is formed on the surface of the electronic component **3**. Thus, the electronic component **3** includes the second conductor **31**. The second conductor **31** may be, but does not have to be, electrode pads, for example.

[0101] The bumps **32** are interposed between the first conductor **21** of the circuit board **2** and the second conductor **31** of the electronic component **3**. The bumps **32** electrically connect the first conductor **21** and the second conductor **31** to each other. The bumps **32** may be, but do not have to be, made of, for example, SAC solder, or tin-copper based (Sn—Bi based) solder.

[0102] Each of the reinforcing portions **4** is a cured product of the resin composition (X). The reinforcing portion **4** covers each of the joints **20** between the bumps **32** and the first conductor **21** in this mounting structure **1**. In other words, in this mounting structure **1**, the joints **20** between the bumps **32** and the first conductor **21** are covered with the cured product of the resin composition (X). This allows the reinforcing portions **4** to reinforce the joints **20** between the bumps **32** and the first conductor **21** and thereby improve the connection reliability of the mounting structure **1**.

[0103] In the mounting structure **1** shown in FIG. **4**A, the reinforcing portions **4** cover the joints **20** between the first conductor **21** of the circuit board **2** and the bumps **32**, but this configuration is only an example and should not be construed as limiting.

[0104] Alternatively, as in the mounting structure **1** as shown in FIG. **4**B, for example, each of the joints **20** between the second conductor **31** of the electronic component **3** and the bumps **32** may be covered with the reinforcing portion **4**.

[0105] Still alternatively, for example, as in the mounting structure 1 as shown in FIG. **4**C, each of the joints **20** between the first conductor **21** of the circuit board **2** and the bumps **32** may be covered with the reinforcing portion **4**, and each of the joints **20** between the second conductor **31** of the electronic component **3** and the bump **32** may be covered with the reinforcing portion **4**.

[0106] Yet alternatively, if an interval between adjacent parts of the first conductor **21** is short (narrow pitch) in the mounting structure **1** shown in the FIGS. **4**A and **4**C, or if an interval between adjacent parts of the second conductor **31** is short in the mounting structure **1** shown in FIGS. **4**B and **4**C, those adjacent parts of the reinforcing portions **4** may be connected and unified. Optionally, in the mounting structures **1** shown in the FIGS. **4**A-**4**C, all adjacent reinforcing portions **4** may be connected. In other words, the surface of the circuit board **2** may be covered with the reinforcing portion **4**, and the surface of the electronic component **3** may be covered with the reinforcing portion **4**.

[0107] Furthermore, in the mounting structure **1** shown in FIG. **4**C, each of the reinforcing portions **4** covering the joints **20** between the first conductor **21** and the bumps **32** and an associated one of the reinforcing portion **4** covering the joints **20** between the second conductor **31** and the bumps **32** may be connected and unified. However, if the

bumps **32** are heated a plurality of times at a temperature equal to or higher than the melting point of the solder as a constituent material for the bumps **32** (for example, reflow process and repair process), an internal pressure may increase at the time of remelting of the solder, and a solder flash may occur. Therefore, the reinforcing portions **4** covering the joints **20** between the first conductor **21** and the bumps **32** and the reinforcing portions **4** covering the joints **20** between the second conductor **31** and the bumps **32** preferably should not be unified.

[0108] (2) Manufacturing method of mounting structure

[0109] A manufacturing method of the mounting structure **1** shown in FIG. **4**A will be described with reference to FIGS. **5**A-**5**C.

[0110] First, a circuit board **2** including a first conductor **21** is provided and the resin composition (X) is arranged to cover the first conductor **21** (see FIG. **5**A). The arranging method of the resin composition (X) may be, or does not have to be, for example, a printing method, a transfer method, or an application method.

[0111] Next, an electronic component **3** including a second conductor **31** is provided. The bump **32** is provided on the second conductor **31**, and the second conductor **31** and the bump **32** are electrically connected. The electronic component **3** is arranged on the circuit board **2** to bring the bump **32** into contact with the resin composition (X) (see FIG. **5**B).

[0112] Next, the bump **32** and the resin composition (X) are heated in a state as shown in FIG. **5**B. The heating method may be, but does not have to be, heating with a reflow furnace, for example. In this case, for example, the bump **32** and the resin composition (X) may be heated based on the reflow profile shown in FIG. **1**.

[0113] As described above in the "2-2. Reinforcement of joint between conductor and bump using resin composition (X)", the resin composition (X) is maintained at a low viscosity until the bump **32** melts. Moreover, even if the bump **32** starts melting, the viscosity of the resin composition (X) does not immediately rise but starts to increase steeply after a while. Therefore, the resin composition (X) may be cured after the joint **20** between the first conductor **21** and the bump **32** is covered with the resin composition (X). This allows the first conductor **21** and the bump **32** to connect smoothly. In addition, this may reduce the chances of causing a contact failure between the first conductor **21** and the bump **32**. Furthermore, the joint **20** between the first conductor **21** and the bump **32** may be covered with a cured product of the resin composition (X). Therefore, the joint **20** between the first conductor **21** and the bump **32** may be reinforced.

[0114] In the manufacturing method of the mounting structure **1** described above, the bump **32** is arranged on the second conductor **31**, but this configuration is only an example and should not be construed as limiting. Alternatively, for example, the bump **32** may be arranged on the first conductor **21**. In this case, the resin composition (X) is arranged to cover the second conductor **31**, and when the second conductor **31** and the bump **32** are connected, the resin composition (X) may be cured after the joint **20** between the second conductor **31** and the bump **32** has been covered with the resin composition (X). In this case, as in the mounting structure **1** shown in FIG. **4**B, the joint **20** between the second conductor **31** and the bump **32** may be reinforced by the reinforcing portion 4.

EXAMPLES

[0115] 1. Preparation of resin composition

[0116] A resin composition was obtained by mixing the components shown in Tables 1 and 2 in the proportions shown in Tables 1 and 2. The details of the components shown in Table 1 are as follows:

[0117] EPICLON 835LV: Bisphenol F type epoxy resin in liquid state at 25° C., an epoxy equivalent of 160-170, viscosity of 2000-2500 mPa·s at 25° C.; product name EPICLON 835LV, manufactured by DIC Corporation.

[0118] MEH8000H: Phenolic resin in liquid state at 25° C., viscosity of 1500-3500 mPa·s at 25° C.; product number MEH-8000H, manufactured by Meiwa Plastic Industries, Ltd.

[0119] P-d: p-d type benzoxazine compound, manufactured by SHIKOKU CHEMICALS CORPORATION.

[0120] 2P4MHZ: 2-phenyl-4-hydroxymethyl-5-methylimidazole, product number 2P4MHZ-PW, manufactured by SHIKOKU CHEMICALS CORPORATION.

[0121] Adipic acid: adipic acid, melting point of 152-155° C., manufactured by Tokyo Chemical Industry Co., Ltd.

[0122] Succinic acid: succinic acid, melting point of 185-189° C., manufactured by Tokyo Chemical Industry Co., Ltd.

[0123] TEA: triethanolamine, melting point of 199° C., manufactured by Tokyo Chemical Industry Co., Ltd.

[0124] Guanidine: Guanidine hydrochloride, melting point of 185-189° C., manufactured by Tokyo Chemical Industry Co., Ltd.

[0125] 2. Evaluation

[0126] (1) Curability

[0127] The gel times at 240° C. of the resin compositions of Examples 1-10 and Comparative Examples 1-6 were measured. A rheometer (DISCOVERY HR-2) manufactured by TA Instruments was used for the gel time measurement. The gel time is a period of time it takes for the storage modulus and loss modulus of the resin composition (X) to match. In addition, the resin compositions were graded by gel time based on the following criteria. The results are shown in the following Tables 1 and 2.

[0128] Grade A: when the gel time was 120 seconds or more and less than 600 seconds (when curability thereof was particularly good);

[0129] Grade B: when the gel time was 60 seconds or more and less than 120 seconds (when curability thereof was good); and

[0130] Grade C: when the gel time was less than 60 seconds or 600 seconds or more (when the resin composition had some curability).

[0131] (2) Wettability

[0132] Using the resin compositions of Examples 1-10 and Comparative Examples 1-6, a film having a thickness of 0.1 mm was formed on a copper plate. SAC 305 solder having a melting point of 222° C. was shaped into a sphere having a diameter of 0.35 mm, and this SAC 305 solder was placed on the film Next, the plate including the film and the SAC 305 was heated at 240° C. for three minutes and then cooled to room temperature. Next, the diameter (D) and the height dimension (H) of the SAC 305 solder in a plan view were checked, and based on the result, a value was calculated by the formula $\{(D-H)/D\}\times 100(\%)$. This value was used as an index to wettability. The resin compositions were graded by this value based on the following criteria. The results are shown in the following Tables 1 and 2.

[0133] Grade A: when the value was 55% or more (when solder wettability thereof was particularly good);

[0134] Grade B: when the value was 40% or more and less than 55% (when solder wettability thereof was good); and

[0135] Grade C: when the value was less than 40% (when the resin composition had some solder wettability).

[0136] (3) Void

[0137] Cured products were formed from the resin compositions of Examples 1-10 and Comparative Examples 1-6. In detail, a U-shaped piece of silicone rubber with a thickness of 0.5 mm was attached to a copper plate (2.5 cm×2.5 cm) and each of the resin compositions was poured inside the piece of silicone rubber. Moreover, a slide glass plate(2.5 cm×2 cm, 1 mm thick) was placed on top of the piece of silicon rubber and secured with a clip to prevent leakage of the resin composition. Next, a cured product having a thickness of 0.5 mm and a size of 2.0 cm×2.0 cm was formed by having the resin compositions heated for 20 minutes in a curing oven at 240° C. and cured. The voids (air bubbles) in the cured product were observed, and the resin compositions were graded by the number of voids based on the following criteria. The results are shown in the following Tables 1 and 2.

[0138] Grade A: when the number of voids was less than 10;

[0139] Grade B: when the number of voids was 10 or more and less than 30; and

[0140] Grade C: when the number of voids was more than 30.

[0141] (4) Total evaluation

[0142] Each of the resin compositions was graded based on the evaluation results of curability, wettability, and voids. The results are shown in the following Tables 1 and 2.

[0143] Grade A: when the resin composition was graded A in terms of all of curability, wettability, and voids;

[0144] Grade B: when the resin composition was graded B in one or more of curability, wettability, or voids and was not graded C in any of the three evaluation items; and

[0145] Grade C: when the resin composition was graded C in one or more of curability, wettability, or voids.

TABLE 1

			Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ex. 6	Ex. 7	Ex. 8
Composition	Epoxy	EPICLON 835LV	20	60	40	22.5	50	50	40	50
(parts by	Phenolic	MEH8000H	35	15	10	45	35	30	20	30
weight)	Benzoxadine	P-d	35	15	40	22.5	5	10	30	10
	Imidazole	2P4MHZ	—	—	—	—	—	—	—	—
	Activator	Adipic acid	10	10	10	10	10	10	10	—
		Succinic acid	—	—	—	—	—	—	—	—
		TEA	—	—	—	—	—	—	—	—
		Guanidine	—	—	—	—	—	—	—	—
Evaluation	Curability	240° C. gel time	A	A	A	A	A	A	A	A
	Wettability	Wet spread rate	A	A	A	A	A	A	A	A
		Voids	A	A	B	A	A	A	A	A
		Total Grade	A	A	B	A	A	A	A	A

TABLE 2

			Ex. 9	Ex. 10	Cmp. Ex. 1	Cmp. Ex. 2	Cmp. Ex. 3	Cmp. Ex. 4	Cmp. Ex. 5	Cmp. Ex. 6
Composition	Epoxy	EPICLON835LV	50	50	50	50	22.5	70	15	50
(parts by	Phenolic	MEH8000H	30	30	25	40	22.5	10	50	35
weight)	Benzoxadine	P-d	10	10	25	—	45	10	25	—
	Imidazole	2P4MHZ	—	—	—	—	—	—	—	3
	Activator	Adipic acid	—	—	—	10	10	10	10	12
		Succinic acid	—	—	—	—	—	—	—	—
		TEA	10	—	—	—	—	—	—	—
		Guanidine	—	10	—	—	—	—	—	—
Evaluation	Curability	240° C. gel time	A	A	A	C	B	C	C	C
	Wettability	Wet spread rate	A	A	C	A	B	A	C	C
		Voids	A	A	A	A	C	A	A	C
		Total Grade	A	A	C	C	C	C	C	C

Reference Signs List

[0146] **1** Mounting Structure
[0147] **2** Circuit Board
[0148] **3** Electronic Component
[0149] **20** Joint
[0150] **21** First Conductor
[0151] **30**, **32** Bump
[0152] **31** Second Conductor
[0153] **100** Electronic Component
[0154] **200** Electronic Component Body
[0155] **210** Conductor

1. A reinforcing resin composition comprising:
an epoxy resin (A);
a phenolic resin (B); and
a benzoxazine compound (C).

2. The reinforcing resin composition of claim **1**, further comprising an activator (D).

3. The reinforcing resin composition of claim **2**, wherein with respect to a total of the epoxy resin (A), the phenolic resin (B), the benzoxadine compound (C), and the activator (D):
proportion of the epoxy resin (A) is within a range from 20% by weight to 60% by weight;
proportion of the phenolic resin (B) is within a range from 10% by weight to 40% by weight;
proportion of the benzoxadine compound (C) is within a range from 5% by weight to 30% by weight; and
proportion of the activator (D) is within a range from 3% by weight to 40% by weight.

4. The reinforcing resin composition of claim **2**, wherein the activator (D) comprises at least one of an organic acid (D1) having a melting point of 130° C. to 220° C., and an amine (D2) having a melting point of 130° C. to 220° C.

5. The reinforcing resin composition of any one of claim **1**, wherein
the phenolic resin (B) comprises a phenol-novolac resin (B1) having a hydroxyl equivalent of 70 g/eq to 150 g/eq.

6. The reinforcing resin composition of claim **1**, wherein the benzoxazine compound (C) comprises a polyvalent oxazine compound (C1) having a plurality of oxazine rings in one molecule.

7. An electronic component comprising:
an electronic component body;
a conductor formed on a surface of the electronic component body;
a solder bump arranged on the conductor and electrically connected to the conductor; and
a reinforcing portion that is a cured product of the reinforcing resin composition according to claim **1** and covers a joint between the conductor and the solder bump.

8. A method for manufacturing the electronic component of claim **7**, the method comprising:
curing the reinforcing resin composition after covering the joint between the conductor and the bump with the reinforcing resin composition.

9. A mounting structure comprising:
a circuit board including a first conductor;
an electronic component including a second conductor;
a solder bump interposed between the first conductor and the second conductor and electrically connecting the first conductor and the second conductor to each other; and
a reinforcing portion that is a cured product of the reinforcing resin composition according to claim **1** and covers at least one of a joint between the first conductor and the bump or a joint between the second conductor and the bump.

10. A method for manufacturing the mounting structure of claim **9**, the method comprising:
curing the reinforcing resin composition after covering, with the reinforcing resin composition, at least one of the joint between the first conductor and the bump or the joint between the second conductor and the bump.

11. The reinforcing resin composition of claim **3**, wherein the activator (D) comprises at least one of an organic acid (D1) having a melting point of 130° C. to 220° C., and an amine (D2) having a melting point of 130° C. to 220° C.

12. The reinforcing resin composition of claim **2**, wherein the phenolic resin (B) comprises a phenol-novolac resin (B1) having a hydroxyl equivalent of 70 g/eq to 150 g/eq.

13. The reinforcing resin composition of claim **2**, wherein the benzoxazine compound (C) comprises a polyvalent oxazine compound (C1) having a plurality of oxazine rings in one molecule.

14. An electronic component comprising:
an electronic component body;
a conductor formed on a surface of the electronic component body;
a solder bump arranged on the conductor and electrically connected to the conductor; and
a reinforcing portion that is a cured product of the reinforcing resin composition according to claim **2** and covers a joint between the conductor and the solder bump.

15. A method for manufacturing the electronic component of claim **14**, the method comprising:
curing the reinforcing resin composition after covering the joint between the conductor and the bump with the reinforcing resin composition.

16. A mounting structure comprising:
a circuit board including a first conductor;
an electronic component including a second conductor;
a solder bump interposed between the first conductor and the second conductor and electrically connecting the first conductor and the second conductor to each other; and
a reinforcing portion that is a cured product of the reinforcing resin composition according to claim **2** and covers at least one of a joint between the first conductor and the bump or a joint between the second conductor and the bump.

17. A method for manufacturing the mounting structure of claim **9**, the method comprising:
curing the reinforcing resin composition after covering, with the reinforcing resin composition, at least one of the joint between the first conductor and the bump or the joint between the second conductor and the bump.

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