

DESCRIPTION

SOLDER POWDER, FLUX, SOLDER PASTE, SOLDERING METHOD,
SOLDERED CIRCUIT BOARD, AND SOLDERED JOINT PRODUCT

Technical Field

The present invention relates to a solder powder, a flux, and a solder paste, which have excellent storage stability and ensure excellent properties in and after reflow; and further relates to a soldering method using the solder paste; a soldered circuit board, and a soldered joint product for electronic parts.

This application is based on Japanese Patent Applications No. Hei 10-161854, Hei 10-336898, Hei 11-26472, and Hei 11-88935, the contents of which are incorporated herein by reference.

Background Art

Solder paste is used for surface mounting of electronic parts in the electronics industry. Solder paste is suitable for automation because of its printing adaptability and tackiness, therefore, the amount thereof used has been increasing in recent years.

In the electronics industry, a solder paste is coated on a printed board by screen printing or, depending on the case, by a dispenser, then electronic parts are mounted thereon and subsequently, the board is subjected to reflow to fix the electronic parts. "Reflow" means a series of operations such that a board on which electronic parts are mounted is preheated and then the solder paste is heated at a temperature higher than its melting point to weld the parts.

On the other hand, miniaturization of electronic articles has been proceeding in recent years and many kinds of fine pitch parts are used, such as 0.3 mm-pitch QFP (quad flat package) type LSI or even CSP (chip size package). To keep up with this tendency, the solder paste must have capability for extremely fine pitch printing. This requirement is met by reducing the average particle size of the solder metal particles. However, this technique has a problem in that the specific surface area of particles as a whole is increased and reaction between solder metal particles and flux is accelerated, as a result, the storage stability of the solder paste is degraded.

One of the greatest causes of reduction in the storage stability of the solder paste is

in the fact that the solder powder preferentially reacts with flux during storage to allow oxidation to proceed and the activator to be consumed, whereby the activity of the flux decreases and due to the reaction product, the viscosity of the solder paste increases. Because of this, the solder paste cannot maintain its suitable printing property and does not melt at the time of reflow.

In order to improve the stability of solder paste, efforts have been heretofore made with an attempt to protect the surface of the solder metal particles and thereby reduce the reactivity of the metal.

For example, a method of covering solder powder with glycerin (see Japanese Examined Patent Application, Second Publication, No. Hei 5-26598) and a method of coating solder powder with a coating agent insoluble or sparingly soluble in the solvent of the solder paste (see Japanese Unexamined Patent Application, First Publication, No. Hei 1-113197) are known. In the latter case, suitable examples of the coating agent include silicone oil, silicone-based high molecular weight compounds, fluorinated silicone oil, fluorosilicone resin and fluorinated hydrocarbon-based polymer compounds.

In addition, a method of coating solder powder with a rosin-based mixture, namely, a resin mainly comprising rosin, incompatible with flux at room temperature but compatible with flux at the soldering temperature is known (see Japanese Unexamined Patent Application, First Publication, No. Hei 3-184698 and Japanese Unexamined Patent Application, First Publication, No. Hei 4-251691).

According to the above methods, although covering with a relatively large amount of coating agent may be effective in suppressing the oxidation of solder powder, the large amount of coating material is rather disadvantageous for the reflow of solder paste and many solder balls may be generated. Furthermore, there is a strong fear that the coating agent will come off during kneading at the production of solder paste or by treatment such as transportation, printing or the like on use, because only a physical covering is made and the adhesion seems to be very weak. Furthermore, the above-mentioned coating agent, that is, the resin mainly comprising rosin contains by itself many reactive organic acids and cannot successfully protect the metal powder.

Other than these methods, a method of using acidic phosphoric acid ester as an activator for solder paste and an incombustible or flame retardant low volatile diluent having compatibility with the acidic phosphoric acid ester (Japanese Unexamined Patent Application, First Publication, No. Sho 63-90390), adding a phenol-, phosphorus- or

sulfur-based antioxidant (Japanese Examined Patent Application, Second Publication, No. Sho 59-22632 and Japanese Unexamined Patent Application, First Publication, No. Hei 3-124092), or using a specific surface active agent (Japanese Unexamined Patent Application, First Publication, No. Hei 2-147194) is proposed. However, when using these methods, the storage stability of the solder paste is not satisfactory.

In recent years, due to environmental problems, a solder paste containing no lead, so-called Pb-free solder paste, is recommended and to cope with this, development is being driven so as to make the solder paste a Pb-free solder paste. As the most effective Pb-free solder paste, Sn-Zn system solder pastes are drawing attention, however, they are fairly bad in storage stability as compared with usual Pb-based solder paste, for example, oxidation of Zn in the solder powder proceeds or reaction between Zn and flux takes place at room temperature and the viscosity of the paste increases with the passage of time. In particular, it has been found that Zn reacts with halogen generated by the decomposition of an organic halogen compound in the flux at room temperature, so that the storage stability of the solder paste decreases. Furthermore, a halogen compound in the flux and Zn in the solder powder react to generate a small amount of hydrogen gas, and the small amount of hydrogen generated is imprisoned as a gas in the solder fillet, causing a serious problem in reliability.

The object of the present invention is to provide a flux, a solder paste, and a solder powder which can be used therein so as to prevent the generation of solder balls in reflow, each having excellent storage stability, reflow property, solderability, wettability to a metal to be welded, and printing property, and further, using the solder paste, to provide a soldering method, a soldered circuit board, and a joint product for a circuit board and electronic parts, respondent to the tendency toward fine pitch processing and diversified parts and the like.

Disclosure of Invention

As a result of extensive studies to attain the above-described object, the present inventors have accomplished the present invention.

The present invention provides;

- (1) A solder powder comprising solder particles having a distribution such that the number of particle having a particle diameter of 20 μm or less is 30% or less.
- (2) The solder powder according to (1), comprising the oxygen content of 500 ppm or less.
- (3) The solder powder according to (1) or (2), comprising Sn and Zn, or Sn and Ag.

- (4) A flux for solder paste comprising an organic acid component consisting of an organic acid ester and an ester decomposer catalyst, an organic halogen compound, and a reducing agent for flux components.
- (5) The flux for solder paste according to (4), wherein ester decomposer catalyst is an organic base hydrohalogenated acid salt.
- (6) The flux for solder paste according to (4) or (5), wherein the organic halogen compound comprises at least one of a bromide of a benzyl compound containing a substituent having an alkyl chain with a carbon number of 10 or higher, and a polybromine compound containing a fatty acid or an alicyclic compound with a carbon number of 10 or higher wherein the polybromine comprises four or more bromine atoms in one molecule.
- (7) The flux for solder paste according to any one of (4) to (6), wherein the reducing agent is at least one selected from the group consisting of phenol compounds, phosphorus compounds, sulfur compounds, tocopherol, tocopherol derivatives, L-ascorbic acid and L-ascorbic acid derivatives.
- (8) The flux for solder paste according to any one of (4) to (6), wherein the reducing agent is a combination of at least one of tocopherol and a tocopherol derivative with at least one of L-ascorbic acid and an L-ascorbic acid derivative.
- (9) The flux for solder paste according to any one of (4) to (8), comprising, based on the total amount of the flux, 0.01 to 20% by weight of an organic acid component, 0.02 to 20% by weight of an organic halogen compound, and 0.05 to 20% by weight of a reducing agent.
- (10) The flux for solder paste according to any one of (4) to (9), comprising a pH adjusting agent, wherein a solution prepared by dissolving 4g of the flux comprising a pH adjusting agent in a mixture of 50 ml of toluene, 49.5 ml of isopropyl alcohol, and 0.5 ml of water, has a pH value of 4 to 9 when measured with a pH meter.
- (11) The flux for solder paste according to (10), comprising, based on the total amount of the flux, 0.01 to 20% by weight of an organic acid component, 0.02 to 20% by weight of an organic halogen compound, 0.05 to 20% by weight of a reducing agent, and 0.05 to 20% by weight of a pH adjusting agent.
- (12) The flux for solder paste according to (10) or (11), wherein the pH adjusting agent comprises at least one amine selected from the group consisting of alkanolamines, aliphatic primary, secondary or tertiary amines, aliphatic unsaturated amines, alicyclic amines, and aromatic amines.

- (13) A solder paste mainly comprising a flux and a solder powder, wherein a water content is 0.5% by weight or less.
- (14) The solder paste according to (13), comprising a pH adjusting agent which has a pH value of 4 to 9 measured by the method described in (10).
- (15) The solder paste according to (14), wherein the pH adjusting agent comprises at least one amine selected from the group consisting of alkanolamines, aliphatic primary, secondary or tertiary amines, aliphatic unsaturated amines, alicyclic amines and aromatic amines.
- (16) A solder paste comprising a mixture of the solder powder according to any one of (1) to (3) and a flux.
- (17) A solder paste mainly comprising a flux and a solder powder, comprising, based on the total amount of the solder paste, 86 to 92% by weight of the solder powder according to any one of (1) to (3) and 8 to 14% by weight of the flux for solder paste according to any one of (4) to (12).
- (18) The solder paste according to (17), wherein a water content is 0.5% by weight or less.
- (19) A soldering method for a circuit board comprising the steps of applying the solder paste according to any one of (13) to (18) to a circuit board and causing the solder paste applied on the circuit board to reflow.
- (20) The soldering method for a circuit board according to (19), comprising the step of placing electronic parts on the circuit board, wherein a part or all of the solder paste which has been caused to reflow is used to join the circuit board and the electronic parts together.
- (21) A circuit board produced by the soldering method for a circuit board according to (19).
- (22) A joint product produced by the soldering method for a circuit board according to (19).

Best Mode for Carrying Out the Invention

Examples of the metal composition for solder powder which can be used in the solder paste of the present invention include Sn-Pb systems, Sn-Pb-Ag systems, Sn-Pb-Bi systems, Sn-Pb-Bi-Ag systems and Sn-Pb-Cd systems. In addition, from the standpoint of eliminating Pb in recent years, Pb-free systems such as Sn-In systems, Sn-Bi systems, In-Ag systems, In-Bi systems, Sn-Zn systems, Sn-Ag systems, Sn-Cu systems, Sn-Sb systems,

Sn-Au systems, Sn-Bi-Ag-Cu systems, Sn-Ge systems, Sn-Bi-Cu systems, Sn-Cu-Sb-Ag systems, Sn-Ag-Zn systems, Sn-Cu-Ag systems, Sn-Bi-Sb systems, Sn-Bi-Sb-Zn systems, Sn-Bi-Cu-Zn systems, Sn-Ag-Sb systems, Sn-Ag-Sb-Zn systems, Sn-Ag-Cu-Zn systems and Sn-Zn-Bi systems may be used.

Specific examples of the above systems include a eutectic solder comprising 63 % by weight of Sn and 37 % by weight of Pb (hereinafter written as 63Sn/37Pb), 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, Sn90/Bi7.5/Ag2/Cu0.5, 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. Furthermore, as the solder powder of the present invention, a mixture of two or more kinds of solder powders having different metal compositions respectively may be used.

Among these, Pb-free solder, preferably an alloy composition selected from the group consisting of all solders containing Sn and Zn or Sn and Ag is used for preparing the solder paste of the present invention. Such solder paste can have a lower reflow temperature equal to the reflow temperature of an Sn-Pb system solder, so that mounting parts can have long life and be varied.

The solder powder has a particle size standard specified in JIS of from 63 to 22 μm , from 45 to 22 μm , from 38 to 22 μm , and the like, according to the sieving method. The particle size distribution of the solder powder is generally determined with a method of using a standard sieve and a balance specified by JIS. However, solder fine particles in the solder powder often adhere to the surface of the solder powder due to static electricity or the like and the fine particles cannot efficiently be separated from the surface of the solder powder by the above method, therefore, the amount of solder fine particles in the solder powder detected in the method is smaller than the actual amount of solder fine particles in the solder powder. For example, when the solder powder is observed through a microscope after sieving the solder powder according to the particle size distribution measurement specified in JIS, it is found that many fine particles of solder are adhering to the surface of larger

solder particles. As the amount of these fine particles in the solder powder increases, the solder powder tends to oxidize and storage stability and reflow property of the solder paste are degraded.

Furthermore, for the particle size distribution measurement, using the distribution of fine particles by number in the solder powder with the measuring method specified in JIS, it was found that the solder powder has excellent properties.

The fine particle content of solder powder may be obtained by performing image analysis using a microscope and determining by a Coulter counter using an electrozone method. The principle of the Coulter counter is described in "Funtai Kogaku Binran (Handbook of Powder Engineering)", Second Edition, pages 19-20 (which is edited by Funtai Kogaku Kai). More specifically, a solution having powder dispersed therein is passed through a slit bored in a partition wall and change in the electric resistance at both sides of the slit is measured to determine the particle size distribution of the powder, where the particle number ratio of the powder can be measured with good reproducibility.

When using the above method to determine the particle size distribution of the solder powder, dispersing the solder powder in a solution causes the fine particle component adhering to the solder particle to separate from the solder powder, therefore, the fine particle component adhering to the solder particle, which cannot be identified in the measurement of weight distribution or volume distribution by conventional sieving methods, can be quantified.

In either method by image analysis using a microscope or by a Coulter counter, the lower limit of the fine particle size which can be measured is about 1 μm . In the case of fine particles of less than 1 μm , the amount of contamination by the fine particle cannot be determined by either method, however, fine particles prepared by ordinary atomizing methods scarcely contain particles of less than 1 μm in size. Therefore, for distribution of fine particles by number measurement of fine particles of solder powder by the above methods, the fine particles may be limited 1 μm or more size.

The distribution of fine particles by number is preferably controlled so that the content of the solder particles having a particle size of 20 μm or less in the solder powder is 30% by number or less, and preferably 20% by number or less. When the content of the solder particles having a particle size of 20 μm or less exceeds 30% by number or less, the surface area of the solder powder per unit weight increases and oxidation occurs easily, so that the melting property of the solder powder is adversely affected in reflow when preparing

the solder paste. Furthermore, since the solder powder readily reacts with the flux, storage stability is shortened and the tackiness is reduced.

In order to reduce the amount of contamination by fine particles in the solder powder, the classification can be performed by setting the classification point for the solder powder at a level higher than the target particle size, repeating air classification and sieving of the solder powder until the amount of contamination by fine particles in the solder powder attains a predetermined level or less, reducing the powder feeding rate to easily remove the fine particles, or using wet classification with a solvent excluding water.

In the solder powder used in the present invention, a solder powder having a particle size equal to or less than a sieve opening for specifying the upper limit of the particle size by sieving accounts for 90% or more, preferably 95% or more in the weight distribution.

The oxygen content in the solder powder used in the present invention is preferably as low as possible and is adjusted to preferably 500 ppm or less, and more preferably 300 ppm or less, therefore, the storage stability and reflow property of the solder paste are improved. In order to reduce the oxygen content in the solder powder, it is effective that the atomizing step to prepare the solder powder is carried out under a condition so that oxidation of the solder powder is very low and the prepared solder powder is treated under the condition of very low oxidizing. Specifically, the above step is preferably carried out under nitrogen gas or inert gas.

The solder paste mainly comprises a flux and a solder powder, wherein the water content of the solder paste is 0.5 % by weight or less. The flux comprises a resin component, an organic acid component, a reducing agent, an organic halogen compound, a solution, a thixotropic agent, and the like.

The organic acid component consisting of organic acid ester and ester decomposer catalyst in the flux component of the present invention effectively removes oxide of metal surface of the circuit board and oxide of the solder powder during the reflow process. However, even if a large amount of the flux is added so as to remove a large amount of oxide or the like, excessive flux reacts with the solder powder in storage and, at the same time, accelerates decomposition of the organic halogenated compound which is the other effective component in the flux, so that the solder paste deteriorates.

As a result of extensive investigations of the present inventors, the solder paste of the present invention was particularly developed for superior storage stability and reflow property by the addition of a reducing agent and an organic halogen compound to the flux

comprising a combination of an organic acid ester and an ester decomposer catalyst wherein the organic acid ester as an organic acid component is stably held in ester form in storage. Furthermore, using the solder paste for soldering makes it possible to respond to diversification of fine pitch circuit boards and parts because of improvement of the reflow property, and make it possible to provide a soldering method for the solder paste, a soldered circuit board, and a soldered joint product for electronic parts, and thereby the present invention has been accomplished.

In the present invention, examples of the organic acid ester as a compound which generates an organic acid at a reflow temperature include various aliphatic carboxylic acid esters, aromatic carboxylic acid esters, aliphatic sulfonic acid esters and aromatic sulfonic acid esters.

Among these organic acid esters, as the alcohol residue of these esters, alkyl and aryl are preferred, and a tert-butyl group, an isopropyl group and an isobutyl group which facilitate the decomposition of ester are particularly preferred. The compound may contain a halogen.

Specific examples of the compound include n-propyl paratoluenesulfonate, isopropyl paratoluenesulfonate, isobutyl paratoluenesulfonate, n-butyl paratoluenesulfonate, n-propyl benzenesulfonate, isopropyl benzenesulfonate, isobutyl benzenesulfonate, n-propyl salicylate, isopropyl salicylate, isobutyl salicylate, n-butyl salicylate, isopropyl 4-nitrobenzoate, tert-butyl 4-nitrobenzoate, tert-butyl methacrylate, tert-butyl acrylate, tert-butyl malonate and tert-butyl bromoacetate.

Among these, n-propyl paratoluenesulfonate, isobutyl salicylate and tert-butyl bromoacetate are particularly preferred. The amount of the compound added is from 0.01 to 20% by weight, preferably from 0.05 to 5% by weight, based on the flux as a whole.

The above decomposable organic acid ester exhibits low decomposability by itself even at the reflow temperature, therefore, it is effective to add a slight amount of ester decomposer catalyst to accelerate the decomposition. As an ester decomposer catalyst, any decomposable organic acid ester is effective as long as it accelerates the decomposition at the reflow temperature for generation of organic acids, particularly a hydrohalogenated acid salt of an organic base is effective.

Specific examples of the hydrohalogenated acid salt of an organic base include hydrohalogenated acid amine salts such as isopropylamine hydrobromide, butylamine hydrochloride and cyclohexylamine hydrobromide and 1, 3-diphenylguanidine

hydrobromide.

With regard to the flux and solder paste of the present invention, the storage stability of the solder paste can be remarkably improved by using a reducing agent as a stabilizer in combination with the above-described organic acid component.

Examples of the reducing agent include a phenol-based compound, a phosphorous-based compound, a sulfur-based compound, tocopherol or derivatives thereof, and L-ascorbic acid or derivative thereof, which are capable of dissolving in a solvent and usually used as antioxidants for resins and the like.

Specific examples of the phenol compound include hydroquinone, catechol, 2, 6-di-tert-butyl-*p*-cresol, butyl hydroxyanisol, 2, 2'-methylene bis(4-methyl-6-tert-butylphenol), and the like.

Specific examples of a phosphorus compound include triphenyl phosphite, trioctadecyl phosphite, tridecyl phosphite, and the like.

Specific examples of a sulfur compound include dilauryl-3, 3'-thiodipropionate, distearyl-3, 3'-thiodipropionate, dimyristyl-3, 3'-thiodipropionate, and the like.

The tocopherol or derivative thereof, or L-ascorbic acid or derivative thereof may be any compound insofar as it has a reducing property and solubility in the solvent, for example, these esters. In particular, good results may be obtained when tocopherol or a derivative thereof and L-ascorbic acid or a derivative thereof are used in combination. The blending ratio therebetween is from 0.5 : 1 to 1 : 0.5 (by weight), and preferably nearly 1:1 (by weight).

These reducing agents may be used either individually or in combination. The amount of reducing agent added may be sufficient if it is large enough to ensure the storage stability of the solder paste (particularly, to prevent the reaction of Zn with halogen in a Pb-free solder), however, the reducing agent is generally used in an amount of from 0.005 to 20% by weight, preferably from 0.01 to 10% by weight, based on the total amount of the flux. If the amount added is too small, the stabilizing effect is not obtained, whereas if the amount added is more than 20% by weight, improved effects corresponding to the increased concentration are not obtained, therefore, too small or too high an amount is not preferable.

The mechanism of action of the reducing agent cannot be fully elucidated, however, it is considered that the reducing agent suppresses oxidation of Zn in the solder paste and also acts as an acceptor of free halogen isolated from the halogen-containing component and the halogen isolated effectively prevents reaction with the solder powder, particularly with

Zn in the solder powder. In the case of Pb-containing solder, it is considered that the same effect is also brought out by the reducing agent.

In the present invention, an organic halogen compound is used in the flux and the solder paste. Organic halogen compounds commonly used as solder flux may be used, and in order to more improve solderability and wettability of the solder paste, an organic halogen compound which is stably present as an organic halogen compound during the storage of solder paste but decomposes at a reflow temperature to become active is preferably used, specifically an organic bromine compound is more preferably used.

Examples of an organic bromine compound having such performance include a bromide of a benzyl compound having a substituent containing an alkyl chain having 10 or more carbon atoms, and a polybromine compound containing four or more bromines within one molecule of an aliphatic or alicyclic compound having 10 or more carbon atoms.

These compounds may be used in combination.

The benzyl bromide compound containing an alkyl chain having 10 or more carbon atoms may be any compound insofar as it is a bromine compound where the bond between the alkyl chain and the benzyl halogenide is chemically stable.

Specific examples of the benzyl bromide compound include compounds such as 4-stearoyloxybenzyl bromide, 4-stearoyloxybenzyl bromide, 4-stearylbenzyl bromide, 4-bromomethylbenzyl stearate, 4-stearoylaminobenzyl bromide and 2,4-bisbromomethylbenzyl stearate. Other examples include 4-palmitoyloxybenzyl bromide, 4-myristoyloxybenzyl bromide, 4-lauroyloxybenzyl bromide and 4-undecanoyloxybenzyl bromide.

The polybromine compound may have a chemically stable functional group such as a carboxyl group, an ester group, an alcohol group, an ether group and a ketone group. The polybromine is a compound where four or more bromine atoms are bonded.

Specific examples of these compounds include 9,10,12,13,15,16-hexabromostearic acid, methyl 9,10,12,13,15,16-hexabromostearate, ethyl 9,10,12,13,15,16-hexabromostearate, 9,10,12,13-tetrabromostearic acid, methyl 9,10,12,13-tetrabromostearate, ethyl 9,10,12,13-tetrabromostearate, 9,10,12,13,15,16-hexabromostearyl alcohol, 9,10,12,13-tetrabromostearyl alcohol and 1,2,5,6,9,10-hexabromocyclododecane. Among these compounds, hexabromostearic acid and hexabromocyclododecane are preferred.

Other examples include bromides such as 1-bromo-2-butanol, 1-bromo-2-propanol, 3-bromo-1-propanol, 3-bromo-1,2-propanediol, 1,4-dibromo-2-butanol,

1,3-dibromo-2-propanol, 2,3-dibromo-1-propanol, 1,4-dibromo-2,3-butanediol, 2,3-dibromo-2-butene-1,4-diol, 1-bromo-3-methyl-1-butene, 1,4-dibromobutene, 1-bromo-1-propene, 2,3-dibromopropene, ethyl bromoacetate, ethyl α -bromocaprylate, ethyl α -bromopropionate, ethyl β -bromopropionate, ethyl α -bromoacetate, 2,3-dibromosuccinic acid, 2-bromosuccinic acid, 2,2-bromoadipic acid, 2,4-dibromoacetophenone, 1,1-dibromotetrachloroethane, 1,2-dibromo-1-phenylethane and 1,2-dibromostyrene, and compounds resulting from the displacement of bromine in these compounds by chlorine and iodine, however, the present invention is by no means limited to these examples.

The amount of the organic halogen compound added is suitably from 0.02 to 20% by weight, preferably from 0.05 to 5% by weight, based on the total amount of flux.

As the resin component blended into the flux and the solder paste of the present invention, conventionally well-known resin blended in the flux and the solder such as a natural rosin, disproportionated rosin, polymerized rosin or modified rosin, a synthetic resin such as polyester, polyurethane or acrylic resin, or the like may be used.

As the solvent, alcohol, ether, ester or an aromatic solvent may be used like in conventional solder fluxes and solder pastes. Examples thereof include benzyl alcohol, butanol, ethyl cellosolve, butyl cellosolve, butyl carbitol, diethylene glycol monohexylether, propyleneglycol monophenylether, dioctyl phthalate and xylene. These solvents may be used individually or as a mixture thereof.

The thixotropic agent added to improve the printing property may be an inorganic compound such as fine silica particles or kaolin particles, or an organic compound such as hydrogenated castor oil or an amide compound.

The flux of the present invention may consists of, based on the total amount of the flux, from 20 to 60% by weight of a resin component, from 0.04 to 20% by weight of a thixotropic agent, from 0.01 to 20% by weight of an organic acid component, from 0.02 to 20% by weight of an organic halogen compound, from 0.05 to 20% by weight of a reducing agent, and a solvent as the remaining part. The solder paste of the present invention is obtained by mixing from 8 to 14% by weight of the flux, based on the total amount of the solder paste, with from 86 to 92% by weight of the solder powder. The mixing is performed using a known apparatus such as a planetary mixer.

In the preparation and kneading of blended matter, the moisture of the flux or the humidity in the atmosphere is controlled so that the water content of the solder paste is preferably 0.5% by weight or less, and more preferably 0.3% by weight or less. If the

water content in the solder paste exceeds 0.5% by weight, dissociation of the halogen from the organic base hydrohalogenated acid salt may be accelerated and the halogen generated may react with the solder metal powder, therefore, the water content is preferably 0.5% by weight or less.

The pH of the solder paste is preferably adjusted to a predetermined range of from 4 to 9, and preferably from 6 to 8 so as to inhibit the reaction of the solder powder and the flux. In this case, any amine compounds such as alkanolamines, aliphatic primary, secondary or tertiary amines, aliphatic unsaturated amines, alicyclic amines and aromatic amines may be used as the pH adjusting agent.

Specific examples of the amine compound include ethanolamine, butylamine, aminopropanol, polyoxyethylene oleylamine, polyoxyethylene laurylamine, polyoxyethylene stearylamine, diethylamine, triethylamine, methoxypropylamine, dimethylaminopropylamine, dibutylaminopropylamine, ethylhexylamine, ethoxypropylamine, ethylhexyloxypropylamine, bispropylamine, isopropylamine and diisopropylamine.

The amount of the amine compound used is preferably from 0.05 to 20% by weight based on the total amount of the flux in the solder paste. If the amount used is less than 0.05% by weight, the effect as the pH adjusting agent is not satisfactory, whereas if it exceeds 20% by weight, the pH generally exceeds 9 and is shifted to the alkali side and, moreover, a problem that the solder paste becomes hygroscopic arises.

In order to prevent the circuit copper from rusting, azoles such as benzotriazole, benzimidazole or tolyltriazole may be further added to the flux. The amount of the rust inhibitor is added preferably from 0.05 to 20% by weight based on the total amount of the flux.

The flux can be applied to as to liquid flux for flow or as a flux-cored solder. When used as liquid flux, the flux may be used after diluting it to from 40 to 70% by weight using isopropyl alcohol as the solvent. When used as a flux-cored solder, the solvent is not used and the materials (except for a solvent) are mixed at a temperature higher than the softening point of rosin and then solidified at room temperature, thereby enabling use as a flux-cored solder.

The flux and the solder paste of the present invention are suitably used when a board such as a joint product is manufactured by connecting a printed wiring board and electronic parts. In the method of using the flux and the solder paste, and the

manufacturing method of a joint product for electronic parts of the present invention, for example, in the case of the solder paste, the solder paste is coated by a printing method or the like onto the portion to be soldered, electronic parts are placed thereon, and the entire assembly is heated to melt the solder particles and then solidified, and thereby the electronic parts are soldered to the board.

As a connecting method (or a mounting method) for the board and electronic parts, for example, an SMT (surface mount technology) can be used. In the mounting method, the solder paste is coated by a printing method onto the portion of a board such as a wiring board to be soldered, electronic parts such as tip parts and QFP are placed thereon, and the entire assembly is heated by the reflow heat source, and thereby the electronic parts are soldered to the board. The reflow heat source includes a hot blast stove, an infrared stove, a refrigerator for soldering, a device for light beam soldering, and the like.

The reflow process of the present invention is performed according to the solder alloy composition, in the case of an Sn-Zn system such as 91Sn/9Zn, 89Sn/8Zn/3Bi, or 86Sn/8Zn/6Bi, a two step process of preheating and reflow is preferred. The preheating temperature is from 130 to 180°C, and preferably from 130 to 150°C; the preheating time is from 60 to 120 seconds, and preferably from 60 to 90 seconds; the reflow temperature is from 210 to 230°C, and preferably from 210 to 220°C; and the reflow time is from 30 to 60 seconds, preferably from 30 to 40 seconds. Furthermore, the reflow temperature in another alloy composition is from +20 to +50°C, and preferably from +20 to +30°C based on the melting point of the alloy used, and the preheating temperature, the preheating time, and reflow time are preferably limited to within the above ranges.

By using the solder paste of the present invention, the above reflow process can be performed under either nitrogen or air. When the reflow is performed under nitrogen, the oxygen concentration is 5% by volume or less, and preferably 0.5% by volume so as to improve the wettability of the solder to the board such as a wiring board in comparison with the reflow under air and to prevent the generation of solder balls, and thereby the solder paste can be treated under stable conditions.

The surface mounting is concluded by cooling the above-mentioned board. In the manufacturing method of electronic parts soldered to the board by the mounting method, the electronic parts may be soldered to both sides of the board such as a printed wiring board. The electronic parts which can be used with the solder paste of the present invention are LSIs, resistors, capacitors, transes, inductance, filters, oscillators, and the like, however, the

present invention is by no means limited to these examples.

In the present invention, a more superior soldering property is obtained when the solder paste of the present invention is mounted by an SMT on the circuit board (see Japanese Unexamined Patent Application, First Publication, No. Hei 7-7244) after the steps of forming a tacky film by chemical reaction only on a predetermined surface of the board (for example, a predetermined surface of a metal circuit of the printed board), adhering the solder powder to the tacky film, coating the flux thereon, causing it to reflow by heating it at the melting temperature of the solder, and forming the solder bump on the circuit board.

By using the flux and a solder paste comprising the flux, the present invention can improve properties such as the reflow property, solderability, wettability to a metal to be welded, and the printing property; the generation of the solder balls at reflow is reduced; and the flux and the solder paste can be used into Pb-free solder alloys. Furthermore, the present invention obtains a fine pitch joint product for electronic parts, for example, a fine pitch mounting wiring board, by using the Pb-free solder alloy to decrease environmental pollution by wastes; responds to the diversification of parts; and thereby provides a wiring board whose parts have an excellent life-time.

The present invention is described in greater detail below by referring to Examples, however, the present invention is by no means limited to these examples.

Examples

(1) Distribution of Fine Particles by Number in Solder Powder

A Coulter Counter manufactured by Coulter, Inc. (multi-sizer II type) was used to determine the distribution of fine particles by number in the solder powder. The dispersion was prepared by dispersing 1 g of the solder powder into 100 ml of NaCl electrolyte solution (1% by concentration), which was then placed in a detector with a detector tube of 400 μm pore in size, and the distribution of fine particles having 1 μm or more in size by number in the solder powder was determined.

(2) Oxygen Concentration

An oxygen analyzer (infrared-absorbing analysis method) manufactured by Reco Co. was used to measure the oxygen concentration.

(3) Moisture

After the preparation of solder paste, the moisture in the paste was measured using Karl Fischer's method. More specifically, the paste was placed in a moisture vaporizer (ADP-351, manufactured by Kyoto Denshi Kogyo K.K.), vaporized by heating at 150°C, and introduced into a Karl Fischer's moisture meter (MKC-210, manufactured by Kyoto Denshi Kogyo K.K.) using nitrogen as the carrier gas. Then, the moisture in the vapor was measured.

(4) pH

The solution was prepared by dissolving 4 g of the flux into a mixture of 50 ml of toluene, 49.5 ml of isopropylalcohol, and 0.5 ml of water and then the pH was measured using a pH meter. In the case of the solder paste, the solder paste corresponding to 4 g of the flux was measured.

(5) Storage Stability of Solder Paste

The storage stability was evaluated by performing an acceleration test such that the solder paste was produced and then stored at 25°C for 7 days and then measuring the decomposition ratio of organic halogen compound immediately after the production of solder paste and the amount of hydrogen generated. The acceleration test conditions in this evaluation roughly correspond to cold storage at 5°C for 3 months.

The decomposition ratio of organic halogen compound was measured by ion chromatography after stirring 1 g of the paste with 5 ml of chloroform to dissolve the flux component and then extracting the halogen ions from the flux with 10 ml of pure water.

The amount of hydrogen generated was measured by charging 50 g of the solder paste prepared into a 100 ml-volume test tube, sealing the test tube with a silicone rubber plug, storing it at 25°C for 7 days, sampling the vapor through the rubber plug, and then subjecting it to gas chromatography. Then the hydrogen concentration was measured.

(6) Observation of Voids (Solderability)

A 150 μm -thick metal mask was applied to a 60 mm square copper plate, 6 mm (diameter) $\times$ 6 patterns were printed thereon, the plate was treated by a reflow in atmospheric air, and the copper plate was sectioned together with the solder by a cutter. The solder part was observed through a microscope and the void generation status was examined. In six

patterns, a void of 10 μm or more in size was measured, if average number of voids of 10 μm or more in size per one pattern was two, the sample was rejected.

(7) Printing Property

The printing property was measured using M3 in Appendix 5 of JIS Z-3284 (pattern configuration: pore width 0.25 mm, length 2.0 mm, and pitch 0.50 mm) and evaluated by observing it through a stereomicroscope. When thinning or pad breakage occurred, the sample was rejected even if it was one pad.

(8) Tackiness

Tackiness was determined by a Malcom-type tackiness tester. The tackiness was determined by printing the solder paste on a glass plate using a metal mask so as to form 5 circular patterns having diameters of 6.5 mm and thicknesses of 0.2 mm. After allowing the patterns to stand at 25°C and 50% humidity for 3 hours, a measuring probe was fitted to one pattern, a pressure of up to 50 g was applied at a speed of 2 mm/sec, and then the load required to pull up/peel off the pattern at a speed of 10 mm/sec and within 0.2 seconds was measured. An average load of five measurements made using this method of 100g or more was rated as acceptable.

(9) Solder Ball

This was evaluated according to JIS Z-3284. The solder paste was printed to an alumina test panel using a metal mask so as to form four circular patterns having diameters of 6.5 mm and thicknesses of 0.2 mm. The alumina test panel was dried at 150°C for one minute, heated up to 235°C so as to fuse the solder onto the panel, the board was pulled out horizontally within 5 seconds thereafter. The board was left in a horizontal state until the solder on the board solidified, thereafter, the appearance of the solder was observed through a 20 $\times$ magnifying glass and the generation of solder particles (solder balls) in the periphery was examined through a 50 $\times$ magnifying glass. Those generation state of solder balls was determined according to the JIS standard, 3 or less was rated as a reject.

(10) Wet Spreading Property

The wet spreading property was determined according to JIS Z-3284. The solder paste was printed to a copper or brass test panel using a metal mask so as to form four

circular patterns having diameters of 6.5 mm and thicknesses of 0.2 mm. The copper or brass test panel was dried at 150°C for one minute, heated up to 235°C so as to fuse the solder to the panel, the board was pulled out horizontally within 5 seconds thereafter. The board was left in a horizontal state until the solder on the board solidified, thereafter, the wet spreading property of the solder was observed. The wet spreading property was determined according to the JIS Z-3284 standard, 3 or less was rated as a reject.

(Examples 1 to 17, Comparative Examples 1 to 4)

Preparation of flux and solder paste

Fluxes were prepared by blending 17.5% by weight of polymerized rosin and 27.5% by weight of disproportionated rosin as resin components; 6% by weight of hydrogenated castor oil as a thixotropic agent; 0.5% by weight of t-butyl acetate, t-butyl malonate, i-butyl benzoate, n-propyl paratoluenesulfonate, i-butyl salicylate, i-butyl laurate or t-butyl bromoacetate as an organic acid ester, 0.08% by weight of cyclohexylamine hydrobromide or 1,3-diphenylguanidine hydrobromide as an ester decomposer catalyst; 3.5% by weight of hexabromocyclododecane, hexabromostearic acid, tetrabromostearic acid, 2,2-dibromoadipic acid, t-butyl bromoacetate or 2,3-dibromosuccinic acid as an organic halogen compound, 1.0% by weight of hydroquinone, triphenylphosphite, tocopherol, L-ascorbyl-2,6-dipalmitate, trioctadecylphosphite, distearyl 3,3'-thiodipropionate, or a 1:1 (by weight) mixture of tocopherol and L-ascorbyl-2,6-dipalmitate as a reducing agent; 2% by weight of triethylamine as a pH adjusting agent; 1% by weight of tolyltriazole as a rust inhibitor; and propylene glycol monophenylether as a solvent added to make 100% by weight.

To 11% by weight of each flux, 89% by weight of Pb-free 89Sn/8Zn/3Bi solder powder having a particle size of from 20 to 45 μm (content of particles of 45 μm or less: 97% by weight) and having the distribution of fine particles by number shown in Table 2 was added and kneaded in a planetary mixer to prepare 3 kg of solder paste. The blended components are shown in Table 1, the distribution of fine particles by number in solder powder used, oxygen concentration in the solder powder, moisture in the solder paste and determined pH value of the flux are shown in Table 2.

Preparation of joint of circuit board and electronic parts

SMT was used as a mounting method. Solder pastes having the compositions of Examples 1 to 17 and Comparative Examples 1 to 4 were printed onto one sheet of circuit

board, and LSI, chip resistor and chip capacitor were placed on the solder paste and soldered by heating the assembly by a reflow heat source. A hot blast stove was used as the reflow heat source.

The reflow was performed under conditions such that the preheating temperature was 130°C, the preheating time was 80 seconds, the reflow peak temperature was 220°C and the reflow time at 200°C or more was 50 seconds.

Properties of prepared printing wired board and the used solder paste were determined by the above-mentioned measuring methods. The measurement results are shown in Table 3.

In Examples 1 to 17, when the amount of organic halogen compound blended was fixed at 3.5% by weight based on the total amount of the flux and the amount of reducing agent added was changed to 1.0%, the generation of hydrogen could be suppressed to 3% or less and the generation of voids could be more greatly prevented.

Furthermore, the flux and the solder paste were prepared by using Pb-free solder powder having a composition of 91Sn/9Zn or 86Sn/8Zn/6Bi and the properties thereof were determined by the same methods, so that the same results were obtained.

The solder alloy compositions after the reflow of Examples 1 to 17 and the solder alloy compositions of conventional Sn-Pb system solder pastes were compared. As a result, in the case of Sn-Pb systems, very coarse crystals were grown in a high temperature environment, whereas the growth of coarse crystals was reduced when the flux of the present invention and the Sn-Zn system alloys were used. From this, it was verified that the mechanical properties of the solder were improved and the life property of the mounted wiring boards was improved.

Industrial Applicability

By using the solder powder and the flux in the present invention, the reaction of the solder powder and the flux is greatly suppressed and very excellent storage stability can be successfully developed. In particular, the solder paste of the present invention can greatly improve the storage stability even in the Pb-free solder paste which has been heretofore considered to be poor in storage stability, and its effectiveness is revealed.

Furthermore, by developments of the solder paste of the present invention, a fine pitch mount wiring board, a soldering method for a circuit board corresponding to various parts, a soldered circuit board, a soldering method to join a circuit board and electronic parts

together, and the joint product can be provided.

Table 1

Example	Organic Halogen Compound	Reducing Agent	Organic Acid Ester	Ester Decomposer Catalyst
1	hexabromocyclododecane	hydroquinone	t-butyl acetate	cyclohexylamine· HBr
2	hexabromocyclododecane	hydroquinone	t-butyl malonate	cyclohexylamine· HBr
3	hexabromocyclododecane	triphenylphosphite	i-butyl benzoate	cyclohexylamine· HBr
4	hexabromocyclododecane	triphenylphosphite	t-butyl bromoacetate	cyclohexylamine· HBr
5	hexabromostearic acid	tocopherol	n-propyl p-toluenesulfonate	diphenylguanidine· HBr
6	hexabromostearic acid	L-ascorbyl-2,6-dipalmitate	n-propyl p-toluenesulfonate	diphenylguanidine· HBr
7	hexabromostearic acid	tocopherol	n-propyl p-toluenesulfonate	cyclohexylamine· HBr
8	tetrabromostearic acid	trioctadecylphosphite	i-butyl salicylate	cyclohexylamine· HBr
9	2,2-dibromoadipic acid	distearyl 3,3'-thiodipropionate	i-butyl laurate	cyclohexylamine· HBr
10	t-butyl bromoacetate	tocopherol	n-propyl p-toluenesulfonate	cyclohexylamine· HBr
11	2,3-dibromosuccinic acid	tocopherol	n-propyl p-toluenesulfonate	cyclohexylamine· HBr
12	hexabromostearic acid	tocopherol + L-ascorbyl-2,6-dipalmitate	n-propyl p-toluenesulfonate	diphenylguanidine· HBr
13	hexabromostearic acid	tocopherol	none	none
14	hexabromostearic acid	tocopherol	none	none
15	hexabromostearic acid	tocopherol	none	none

16	hexabromostearic acid	tocopherol	none	none
17	hexabromostearic acid	tocopherol + L-ascorbyl-2,6-dipalmitate	n-propyl p-toluenesulfonate	diphenylguanidine· HBr
Comparative Example				
1	2,3-dibromosuccinic acid	none	none	none
2	2,3-dibromosuccinic acid	none	none	none
3	2,3-dibromosuccinic acid	none	none	none
4	2,3-dibromosuccinic acid	none	none	none

Table 2

Example	Distribution of Fine Particles by Number in Solder Powder (% by number)		Oxygen Content (ppm)	Moisture (% by weight)	pH
	10 μm or less	20 μm or less			
1	15.0	28.8	160	0.19	8.5
2	10.2	14.5	132	0.13	5.0
3	18.3	27.1	208	0.45	5.0
4	12.8	18.3	154	0.32	6.0
5	16.4	25.1	183	0.22	6.0
6	13.8	20.1	156	0.16	5.5
7	16.8	24.3	196	0.29	4.5
8	11.4	16.8	129	0.36	5.5
9	13.8	19.1	163	0.34	6.0
10	16.8	25.6	221	0.42	6.5
11	18.1	28.1	251	0.40	4.5
12	10.8	15.1	130	0.11	7.5
13	19.3	29.1	495	0.51	3.7
14	19.2	29.5	142	0.42	3.5
15	11.0	16.5	205	0.48	6.0
16	19.1	29.9	495	0.11	8.5
17	15.4	29.4	485	0.49	3.7
Comparative Example					
1	20.3	45.1	290	0.60	6.0
2	22.0	50.0	520	0.61	5.5
3	19.9	49.3	400	0.70	3.1
4	20.1	60.0	540	0.55	3.8

Table 3

Example	Br Decomposition Ratio (%)		Amount of Hydrogen Generated (% by volume)	Void Generation State	Viscosity (PA·s)		Printing Property	Tackiness	Solder Ball	Wet Spreading Property
	Initial	After 7 days			Initial	After 7 days				
1	33.4	36.5	1.77	○	231	239	○	○	○	○
2	23.5	32.5	0.75	○	199	219	○	○	○	○
3	42.2	43.5	1.15	○	199	226	○	○	○	○
4	12.1	15.2	0.65	○	196	215	○	○	○	○
5	12.9	13.2	0.95	○	174	181	○	○	○	○
6	14.8	15.1	0.58	○	187	209	○	○	○	○
7	13.2	18.9	1.87	○	209	228	○	○	○	○
8	11.3	15.6	0.95	○	191	215	○	○	○	○
9	27.8	43.5	1.56	○	211	221	○	○	○	○
10	25.2	31.5	1.39	○	174	202	○	○	○	○
11	18.3	21.5	1.02	○	197	210	○	○	○	○
12	10.8	12.6	0.55	○	171	176	○	○	○	○
13	44.3	49.7	3.20	○	236	301	○	○	○	○
14	42.5	51.5	3.30	○	251	299	○	○	○	○
15	49.3	53.2	3.41	○	274	280	○	○	○	○

Example	Br Decomposition Ratio (%)		Amount of Hydrogen Generated (% by volume)	Void Generation State	Viscosity (PA· s)		Printing Property	Tackiness	Solder Ball	Wet Spreadi ng Property
	Initial	After 7 days			Initial	After 7 days				
16	48.1	55.3	3.55	○	266	295	○	○	○	○
17	21.5	33.5	2.10	○	211	229	○	○	○	○
Comparative Example										
1	100.0	100.0	8.20	×	335	immeasurable	×	×	×	×
2	100.0	100.0	7.11	×	351	immeasurable	×	×	×	×
3	100.0	100.0	5.03	×	338	immeasurable	×	×	×	×
4	100.0	100.0	5.11	×	350	immeasurable	×	×	×	×

CLAIMS

1. A solder powder comprising solder particles having a distribution such that the number of particles having a particle diameter of 20 μm or less is 30% or less.
2. The solder powder according to claim 1, wherein the oxygen content is 500 ppm or less.
3. The solder powder according to claim 1 or 2, comprising Sn and Zn, or Sn and Ag.
4. A flux for solder paste comprising an organic acid component consisting of an organic acid ester and an ester decomposer catalyst, an organic halogen compound, and a reducing agent.
5. The flux for solder paste according to claim 4, wherein the ester decomposer catalyst is an organic base hydrohalogenated acid salt.
6. The flux for solder paste according to claim 4 or 5, wherein the organic halogen compound comprises at least one of a bromide of a benzyl compound containing a substituent having an alkyl chain with a carbon number of 10 or higher, and a polybromine compound containing a fatty acid or an alicyclic compound with a carbon number of 10 or higher wherein the polybromine comprises four or more bromine atoms in one molecule.
7. The flux for solder paste according to any one of claims 4 to 6, wherein the reducing agent is at least one selected from the group consisting of phenol compounds, phosphorus compounds, sulfur compounds, tocopherol, tocopherol derivatives, L-ascorbic acid and L-ascorbic acid derivatives.
8. The flux for solder paste according to any one of claims 4 to 6, wherein the reducing agent is a combination of at least one of tocopherol and a tocopherol derivative with at least one of L-ascorbic acid and an L-ascorbic acid derivative.
9. The flux for solder paste according to any one of claims 4 to 8, which comprises,



based on the total amount of the flux, 0.01 to 20% by weight of an organic acid component, 0.02 to 20% by weight of an organic halogen compound, 0.05 to 20% by weight of a reducing agent.

10. The flux for solder paste according to any one of claims 4 to 9, which comprises a pH adjusting agent, wherein a solution prepared by dissolving 4g of the flux comprising a pH adjusting agent in a mixture of 50 ml of toluene, 49.5 ml of isopropyl alcohol, and 0.5 ml of water, has a pH value of from 4 to 9 when measured with a pH meter.

11. The flux for solder paste according to claim 10, which comprises, based on the total amount of the flux, 0.01 to 20% by weight of an organic acid component, 0.02 to 20% by weight of an organic halogen compound, 0.05 to 20% by weight of a reducing agent, 0.05 to 20% by weight of a pH adjusting agent.

12. The flux for solder paste according to claim 10 or 11, wherein the pH adjusting agent comprises at least one of amine selected from the group consisting of alkanolamines, aliphatic primary, secondary or tertiary amines, aliphatic unsaturated amines, alicyclic amines, and aromatic amines.

13. A solder paste mainly comprising a flux and a solder powder, wherein the water content is 0.5% by weight.

14. The solder paste according to claim 13, comprising a pH adjusting agent which has a pH value of from 4 to 9 measured by the method described in claim 10.

15. The solder paste according to claim 14, wherein the pH adjusting agent comprises at least one amine selected from the group consisting of alkanolamines, aliphatic primary, secondary or tertiary amines, aliphatic unsaturated amines, alicyclic amines and aromatic amines.

16. The solder paste comprising a mixture of the solder powder according to any one of claims 1 to 3 and a flux.



17. A solder paste mainly comprising a flux and a solder powder, comprising, based on the total amount of the solder paste, 86 to 92% by weight of the solder powder according to any one of claims 1 to 3 and 8 to 14% by weight of the flux for solder paste according to any one of claims 4 to 12.

18. The solder paste according to claim 17, wherein the water content of the solder paste is 0.5% by weight or less.

19. A soldering method for a circuit board comprising the steps of applying the solder paste according to any one of claims 13 to 18 to a circuit board and causing the solder paste applied on the circuit board to reflow.

20. The soldering method for a circuit board according to claim 19, comprising the step of placing electronic parts on the circuit board, wherein a part or all of the solder paste which has been caused to reflow is used to join the circuit board and the electronic parts together.

21. A circuit board produced by the soldering method for a circuit board according to claim 19.

22. A joint product produced by the soldering method for the circuit board according to claim 20.

