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MASAKI et al.(10) **Pub. No.: US 2025/0262692 A1**(43) **Pub. Date: Aug. 21, 2025**(54) **FLUX AND SOLDER PASTE****Publication Classification**(71) Applicant: **SENJU METAL INDUSTRY CO., LTD.**, Adachi-ku, Tokyo (JP)(51) **Int. Cl.****B23K 35/362** (2006.01)**B23K 35/02** (2006.01)**B23K 35/36** (2006.01)(72) Inventors: **Tsuyoshi MASAKI**, Tokyo (JP); **Tetsu TAKEMASA**, Tokyo (JP); **Kazuyori TAKAGI**, Tokyo (JP); **Tomoko NAGAI**, Tokyo (JP); **Yutaka HASHIMOTO**, Tokyo (JP); **Nanako MIYAGI**, Tokyo (JP); **Mutsuki KANEKO**, Tokyo (JP); **Megumi HAYAKAWA**, Tokyo (JP); **Ryo SAITO**, Tokyo (JP)(52) **U.S. Cl.**CPC **B23K 35/362** (2013.01); **B23K 35/025** (2013.01); **B23K 35/3612** (2013.01)(21) Appl. No.: **18/992,675**(22) PCT Filed: **Jul. 21, 2023**(86) PCT No.: **PCT/JP2023/026806**

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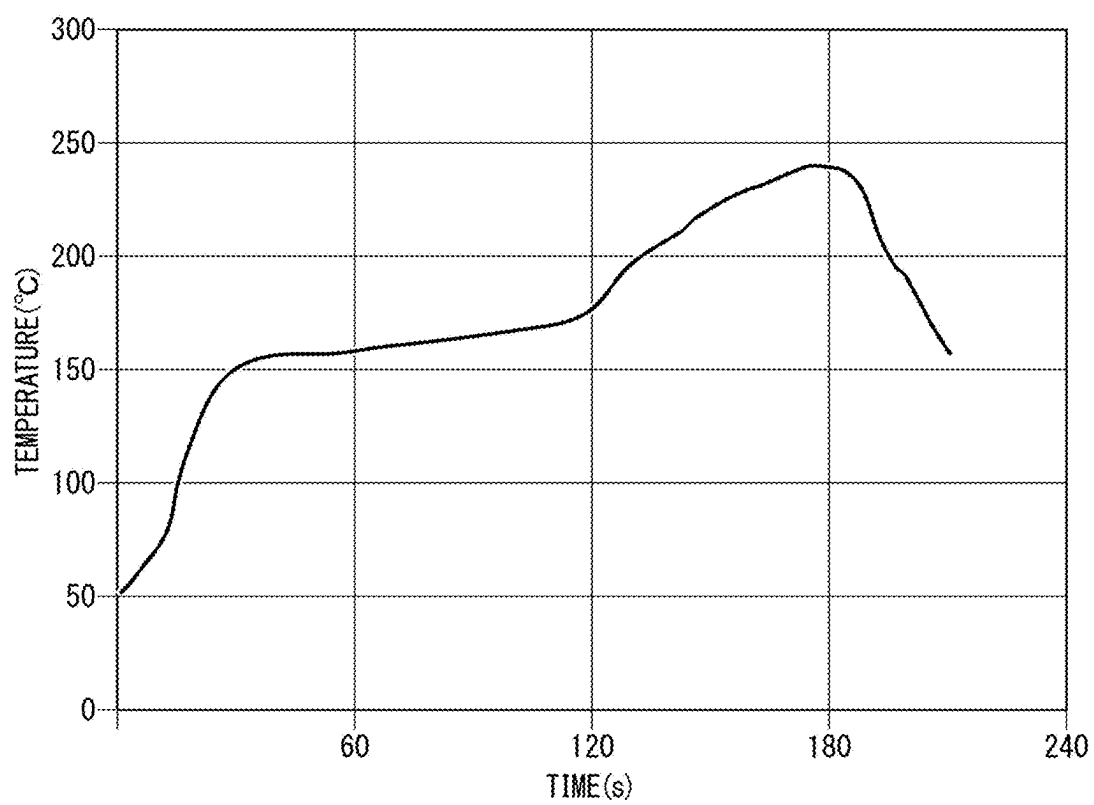
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ABSTRACT

A flux containing rosin, a solvent, a thixotropic agent, a thiol compound, and an activator, in which the thiol compound includes a compound (Tp) having a benzenethiol skeleton in which one or more hydrogen atoms on a benzene ring are substituted with a mercapto group (—SH), is provided in the present invention. As the compound (Tp), at least one thiol compound selected from the group consisting of 2-amino-benzenethiol, 4-aminobenzenethiol, 3-aminobenzenethiol, and benzenethiol is preferable. According to such flux, a change in viscosity of the solder paste with time can be further suppressed.

FIG. 1



FLUX AND SOLDER PASTE

TECHNICAL FIELD

[0001] The present invention relates to a flux and a solder paste.

[0002] Priority is claimed on Japanese Patent Application No. 2022-117440, filed Jul. 22, 2022, the content of which is incorporated herein by reference.

BACKGROUND ART

[0003] Fixing of components to a board and electrical connection of components to a board are generally performed by soldering. In soldering, a flux, a solder powder, and a solder paste in which a flux and a solder powder are mixed are used.

[0004] A flux has the effect of chemically removing metal oxides present on the metal surface of an object to be joined, which is a soldering target, and on a solder, thereby enabling the movement of metal elements at the boundary between the metal surface of the object to be joined and the solder. Therefore, by performing soldering using the flux, an inter-metallic compound is formed between the metal surface of the object to be joined and the solder. Thereby, strong joining can be obtained.

[0005] In the soldering using a solder paste, the solder paste is first printed on a board, components are mounted thereon, and the board on which the components are mounted is heated in a heating furnace called a reflow furnace. As a result, the solder powder contained in the solder paste is melted, and the components are soldered to the board.

[0006] The formulation components of the flux are appropriately selected depending on the type of solder or the metal species of the surface of the object to be joined. For example, Patent Document 1 proposes a solder paste using a flux containing a base resin, a solvent, a thixotropic agent, an activator, an antioxidant, and a rust inhibitor for a specific solder alloy powder.

CITATION LIST

Patent Document

[0007] Patent Document 1: Japanese Unexamined Patent Application, First Publication No. 2002-361484

SUMMARY OF INVENTION

Technical Problem

[0008] Incidentally, the solder paste obtained by mixing the flux and the solder powder may have a long storage period depending on the method of use. In addition, there is a problem in that the viscosity of the solder paste increases with time because of the storage conditions of the solder paste, thereby the initial printing performance cannot be exhibited. In recent years, as electronic components have become smaller and more complicated, this problem has become apparent.

[0009] Therefore, an object of the present invention is to provide a flux capable of further suppressing a change in viscosity of a solder paste with time, and a solder paste using the flux.

Solution to Problem

[0010] In order to achieve the above-described object, the present invention adopts the following configurations.

[0011] [1] A flux containing rosin, a solvent, a thixotropic agent, a thiol compound, and an activator, in which the thiol compound includes a compound (Tp) having a benzenethiol skeleton in which one or more hydrogen atoms on a benzene ring are substituted with a mercapto group ($-\text{SH}$).

[0012] [2] The flux according to [1], in which the compound (Tp) is at least one thiol compound selected from the group consisting of 2-aminobenzenethiol, 4-aminobenzenethiol, 3-aminobenzenethiol, and benzenethiol.

[0013] [3] The flux according to [2], in which the compound (Tp) is at least one thiol compound selected from the group consisting of 2-aminobenzenethiol, 4-aminobenzenethiol, and 3-aminobenzenethiol.

[0014] [4] The flux according to [3], in which the compound (Tp) is at least one thiol compound selected from the group consisting of 2-aminobenzenethiol and 4-aminobenzenethiol.

[0015] [5] The flux according to [4], in which as the compound (Tp), 2-aminobenzenethiol and 4-aminobenzenethiol are used in combination.

[0016] [6] The flux according to any one of [1] to [5], in which a content of the compound (Tp) is 0.005% to 0.7% by mass with respect to a total mass of the flux.

[0017] [7] The flux according to any one of [1] to [6], in which the activator includes an amine hydroiodide.

[0018] [8] The flux according to any one of [1] to [7], in which the solvent has both a solvent (S1) having a boiling point of 250° C. or higher and a solvent (S3) having a boiling point of 220° C. or lower.

[0019] [9] The flux according to [8], in which the solvent (S3) is a solvent (S31) having a boiling point of 190° C. or higher and 220° C. or lower.

[0020] [10] The flux according to [9], in which a ratio of the solvent (S1) to the solvent (S31) is 55/45 or more and 95/5 or less in a mass ratio represented by solvent (S1)/solvent (S31).

[0021] [11] A solder paste containing a solder alloy powder and the flux according to any one of [1] to [10].

Advantageous Effects of Invention

[0022] According to the present invention, a flux capable of further suppressing a change in viscosity of a solder paste with time, and a solder paste using the flux can be provided.

BRIEF DESCRIPTION OF DRAWINGS

[0023] FIG. 1 A diagram showing a reflow profile in the evaluation of [Effect of suppressing void generation] in the present example.

DESCRIPTION OF EMBODIMENTS

(Flux)

[0024] The flux of the present embodiment contains rosin, a solvent, a thixotropic agent, a thiol compound, and an activator. The thiol compound includes a compound (Tp) having a benzenethiol skeleton in which one or more hydrogen atoms on a benzene ring are substituted with a mercapto group ($-\text{SH}$).

<Rosin>

[0025] As the rosin, raw material rosin such as gum rosin, wood rosin, and tall oil rosin, and derivatives obtained from the raw material rosin are examples.

[0026] Examples of the derivatives include purified rosin, hydrogenated rosin, disproportionated rosin, polymerized rosin, acid-modified rosin, acid-modified hydrogenated rosin, phenol-modified rosin, and α,β -unsaturated carboxylic acid-modified products (acrylated rosin, maleated rosin, fumarated rosin, and the like), and purified products, hydrides, and disproportionated products of the polymerized rosin, purified products, hydrides, and disproportionated products of the α,β -unsaturated carboxylic acid-modified products, and the like.

[0027] For the rosin, one type may be used alone, or two or more types may be mixed and used.

[0028] As the rosin, among these, it is preferable to use at least one type selected from the group consisting of polymerized rosin, acid-modified hydrogenated rosin, and hydrogenated rosin.

[0029] As the acid-modified hydrogenated rosin, it is preferable to use an acrylic acid-modified hydrogenated rosin.

[0030] Examples of the hydrogenated rosins include hydrogenated natural resins containing a mixture of abietic acid and its isomer, for example, a rosin containing dihydroabietic acid and tetrahydroabietic acid as main components. The term "main component" refers to a component contained in a compound by an amount of 40% by mass or more, among components constituting the compound.

[0031] The content of the rosin in the flux according to the present embodiment is preferably 10% by mass or more and 60% by mass or less, more preferably 20% by mass or more and 50% by mass or less, and still more preferably 25% by mass or more and 40% by mass or less with respect to the total mass (100% by mass) of the flux.

<Solvent>

[0032] Examples of the solvent include water, an alcohol-based solvent, a glycol ether-based solvent, and terpineols and the like.

[0033] Examples of the alcohol solvents include isopropyl alcohol, 1,2-butanediol, 1,3-butanediol, 1,4-butanediol, 2,3-butanediol, isobornyl cyclohexanol, 2,4-diethyl-1,5-pentanediol, 2,2-dimethyl-1,3-propanediol, 2,5-dimethyl-2,5-hexanediol, 2,5-dimethyl-3-hexyne-2,5-diol, 2,3-dimethyl-2,3-butanediol, 2-methylpentane-2,4-diol, 1,1,1-tris(hydroxymethyl)propane, 2-ethyl-2-hydroxymethyl-1,3-propanediol, 2,2'-oxybis(methylene)bis(2-ethyl-1,3-propanediol), 2,2-bis(hydroxymethyl)-1,3-propanediol, 1,2,6-trihydroxyhexane, 1-ethynyl-1-cyclohexanol, 1,4-cyclohexanediol, 1,4-cyclohexanedimethanol, 2,4,7,9-tetramethyl-5-decyne-4,7-diol, 2-hexyl-1-decanol, 2-methyl-2,4-pentanediol (hexylene glycol), octanediol, and the like.

[0034] Examples of the glycol ether solvents include diethylene glycol mono-2-ethylhexyl ether, ethylene glycol monophenyl ether, ethylene glycol monobutyl ether (butyl glycol), ethylene glycol monohexyl ether (hexyl glycol), diethylene glycol monohexyl ether (hexyl diglycol), diethylene glycol dibutyl ether, triethylene glycol monobutyl ether, methylpropylene triglycol, triethylene glycol butyl

methyl ether, tetraethylene glycol, tetraethylene glycol dimethyl ether, tripropylene glycol-n-butyl ether, and the like.

[0035] Examples of the terpineols include α -terpineol, β -terpineol, γ -terpineol, terpineol mixtures (that is, mixtures containing β -terpineol or γ -terpineol with α -terpineol as a main component), and the like.

[0036] Examples of other solvents include dioctyl sebacate (DOS) and liquid paraffin.

[0037] For the solvent, one type may be used alone, or two or more types may be mixed and used. The flux according to the present embodiment is useful for suppressing a change in viscosity of the solder paste containing the flux of a composition in which solvents having different boiling points are combined, with time.

[0038] In the present specification, the "boiling point of a solvent" means a temperature of the solvent in a case where the saturated vapor pressure of the solvent of interest is equal to 1 atm.

[0039] Examples of a suitable form of the solvents having different boiling points include a solvent has both a solvent (S1) having a boiling point of 250° C. or higher and a solvent (S3) having a boiling point of 220° C. or lower.

[0040] Hereinafter, the solvent having a boiling point of 250° C. or higher is also referred to as a component (S1), and the solvent having a boiling point of 220° C. or lower is also referred to as a component (S3). In addition, a solvent having a boiling point of higher than 220° C. and lower than 250° C. is referred to as a component (S2).

<<Solvent (S1) Having Boiling Point of 250° C. or Higher>>

[0041] Examples of the component (S1) include diethylene glycol mono-2-ethylhexyl ether (boiling point of 272° C.), diethylene glycol monohexyl ether (hexyl diglycol) (boiling point of 258° C.), diethylene glycol dibutyl ether (boiling point of 256° C.), triethylene glycol monobutyl ether (boiling point of 278° C.), triethylene glycol butylmethyl ether (boiling point of 261° C.), tetraethylene glycol dimethyl ether (boiling point of 275° C.), and the like.

<<Solvent (S2) Having Boiling Point of Higher than 220° C. and Lower than 250° C.>>

[0042] Examples of the component (S2) include 1,4-butanediol (boiling point of 228° C.), phenyl glycol (boiling point of 237° C.), butyl carbitol (boiling point of 231° C.), tripropylene glycol monomethyl ether (boiling point of 243° C.), and the like.

<<Solvent (S3) Having Boiling Point of 220° C. or Lower>>

[0043] Examples of the component (S3) include 1,3-butanediol (boiling point of 203° C.), 1,2-butanediol (boiling point of 194° C.), 2-methyl-2,4-pentanediol (hexylene glycol) (boiling point of 198° C.), ethylene glycol monohexyl ether (hexyl glycol) (boiling point of 208° C.), 2,2-dimethyl-1,3-propanediol (boiling point of 210° C.), 2,5-dimethyl-2,5-hexanediol (boiling point of 215° C.), 2,5-dimethyl-3-hexyne-2,5-diol (boiling point of 206° C.), and α -terpineol (boiling point of 218° C.) (all of which are solvents having a boiling point of 190° C. or higher and 220° C. or lower (these solvent are also referred to as a "solvent (S31)" or a "component (S31)")); ethylene glycol monobutyl ether (butyl glycol) (boiling point of 171° C.), 2,3-butanediol (boiling point of 183° C.), 2,3-dimethyl-2,3-butanediol (boiling point of 174° C.), and 1-ethynyl-1-cyclohexanol

(boiling point of 180° C.) (all of which are solvents having a boiling point of 160° C. or higher and lower than 190° C. (these solvent are also referred to as a “solvent (S32)” or a “(S32) component”)); and the like.

[0044] As the form of the solvent having a different boiling point, it is preferable to have both the component (S1) and the component (S31) since the change in viscosity of the solder paste with time is easily suppressed.

[0045] In a case where the component (S1) and the component (S31) are both included, from the viewpoint of easily suppressing a ratio of a change in viscosity with time in a case of being used as a solder paste, the ratio (mass ratio) of the component (S1) to the component (S31), solvent (S1)/solvent (S31) is preferably 55/45 or more and 95/5 or less and more preferably 60/40 or more and 90/10 or less. Furthermore, from the viewpoint of easily suppressing the generation of voids during soldering, the ratio of the solvent (S1)/the solvent (S31) is preferably 60/40 or more and 85/15 or less.

[0046] The total content of the solvent is the remainder in the flux.

[0047] For example, the total content of the solvent in the flux according to the present embodiment is preferably 25% by mass or more and 60% by mass or less, more preferably 30% by mass or more and 50% by mass or less, and still more preferably 35% by mass or more and 45% by mass or less with respect to the total mass (100% by mass) of the flux.

<Thixotropic Agent>

[0048] Examples of the thixotropic agent include an ester-based thixotropic agent, an amide-based thixotropic agent, a sorbitol-based thixotropic agent, and the like.

[0049] Examples of the ester-based thixotropic agent include ester compounds, and specific examples thereof include hydrogenated castor oil, ethyl myristate, and the like.

[0050] Examples of the amide-based thixotropic agent include monoamides, bisamides, and polyamides.

[0051] Examples of the monoamides include lauric acid amide, palmitic acid amide, stearic acid amide, behenic acid amide, hydroxystearic acid amide, saturated fatty acid amide, oleic acid amide, erucic acid amide, unsaturated fatty acid amide, 4-methylbenzamide (p-toluamide), p-toluenemethanamide, aromatic amide, hexamethylene hydroxystearic amide, substituted amide, methylolstearic amide, methylolamide, and fatty acid ester amide.

[0052] Examples of the bisamides include ethylenebis fatty acid (fatty acid carbon number C6-24) amide, ethylenebis hydroxy fatty acid (fatty acid carbon number C6-24) amide, hexamethylenebis fatty acid (fatty acid carbon number C6-24) amide, hexamethylenebis hydroxy fatty acid (fatty acid carbon number C6-24) amide, and aromatic bisamide. Examples of fatty acids that are raw materials for the bisamides include stearic acid (carbon number C18), oleic acid (carbon number C18), and lauric acid (carbon number C12).

[0053] Examples of the polyamides include polyamides such as saturated fatty acid polyamides, unsaturated fatty acid polyamides, aromatic polyamides, 1,2,3-propanetricarboxylic acid tris(2-methylcyclohexylamide), cyclic amide oligomers, and acyclic amide oligomers.

[0054] Examples of the above-mentioned cyclic amide oligomers include an amide oligomer in which a dicarbox-

ylic acid and a diamine are cyclically polycondensed, an amide oligomer in which a tricarboxylic acid and a diamine are cyclically polycondensed, an amide oligomer in which a dicarboxylic acid and a triamine are cyclically polycondensed, an amide oligomer in which a tricarboxylic acid and a triamine are cyclically polycondensed, an amide oligomer in which a dicarboxylic acid and a tricarboxylic acid, and a diamine are cyclically polycondensed, an amide oligomer in which a dicarboxylic acid and a tricarboxylic acid, and a triamine are cyclically polycondensed, an amide oligomer in which a dicarboxylic acid, and a diamine and a triamine are cyclically polycondensed, an amide oligomer in which a tricarboxylic acid, and a diamine and a triamine are cyclically polycondensed, and an amide oligomer in which a dicarboxylic acid and a tricarboxylic acid, and a diamine and a triamine are cyclically polycondensed.

[0055] Examples of the above-mentioned acyclic amide oligomers include an amide oligomer in which a monocarboxylic acid, and a diamine and/or a triamine are acyclically polycondensed, an amide oligomer in which a dicarboxylic acid and/or a tricarboxylic acid, and a monoamine are acyclically polycondensed, and the like. In the case of an amide oligomer containing a monocarboxylic acid or a monoamine, the monocarboxylic acid and the monoamine function as terminal molecules, thereby resulting in an acyclic amide oligomer having a reduced molecular weight. In addition, when the acyclic amide oligomer is an amide compound in which a dicarboxylic acid and/or a tricarboxylic acid, and a diamine and/or a triamine are acyclically polycondensed, it is an acyclic polymer-based amide polymer. Furthermore, the acyclic amide oligomer also includes an amide oligomer in which a monocarboxylic acid and a monoamine are acyclically condensed.

[0056] Examples of the sorbitol-based thixotropic agent include dibenzylidene-D-sorbitol, bis(4-methylbenzylidene)-D-sorbitol, (D-)sorbitol, monobenzylidene-(D-)sorbitol, and mono(4-methylbenzylidene)-(D-)sorbitol, and the like.

[0057] For the thixotropic agent, one type may be used alone, or two or more types may be mixed and used.

[0058] The thixotropic agent contained in the flux according to the present embodiment is preferably at least one type selected from the group consisting of an ester-based thixotropic agent and an amide-based thixotropic agent, more preferably contains at least an amide-based thixotropic agent, and is still more preferably a combination of an ester-based thixotropic agent and an amide-based thixotropic agent.

[0059] As the ester-based thixotropic agent, a hydrogenated castor oil is preferable.

[0060] As the amide-based thixotropic agent, polyamide is preferable.

[0061] The content of the thixotropic agent in the flux according to the present embodiment is preferably 2% by mass or more and 20% by mass or less, more preferably 5% by mass or more and 15% by mass or less, and still more preferably 5% by mass or more and 10% by mass or less with respect to the total mass (100% by mass) of the flux.

<Thiol Compound>

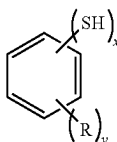
[0062] In the flux according to the present embodiment, a thiol compound containing a compound (Tp) having a benzenethiol skeleton is used.

[0063] The “benzenethiol skeleton” refers to a structure in which one or more hydrogen atoms on a benzene ring are substituted with a mercapto group (—SH).

<<Compound (Tp)>>

[0064] Suitable examples of the compound (Tp) include a thiol compound represented by General Formula (Tp-0).

[Chemical Formula 1]



(Tp-0)

[0065] [In the formula, R is a substituent. x is an integer of 1 or more and represents the number of mercapto groups (—SH). y is an integer of 0 or more and represents the number of substituents (R). Provided that $1 \leq x+y \leq 6$.]

[0066] In Formula (Tp-0), examples of the substituent in R include an amino group (—NH_2), a halogen atom, an alkyl group, an alkoxy group, a halogenated alkyl group, a hydroxy group, and the like.

[0067] Examples of the halogen atoms include a fluorine atom, a chlorine atom, a bromine atom, and an iodine atom.

[0068] The alkyl group may be linear or branched, and an alkyl group having 1 to 6 carbon atoms is preferable.

[0069] As the alkoxy group, an alkoxy group having 1 to 6 carbon atoms is preferable.

[0070] Examples of the halogenated alkyl group include a group in which some or all of hydrogen atoms of an alkyl group are substituted with halogen atoms, the alkyl group may be linear or branched and is preferably an alkyl group having 1 to 6 carbon atoms, and examples of the halogen atom include a fluorine atom, a chlorine atom, a bromine atom, and an iodine atom.

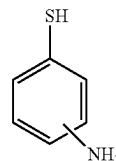
[0071] Among these, the substituent in R is preferably an amino group or a hydroxy group, and particularly preferably an amino group, since the effect of suppressing a change in viscosity of the solder paste with time can be easily enhanced.

[0072] In Formula (Tp-0), x is an integer of 1 or more, preferably an integer of 1 to 3, more preferably 1 or 2, and particularly preferably 1.

[0073] y is an integer of 0 or more, preferably an integer of 0 to 3, more preferably an integer of 0 to 2, and particularly preferably 1.

[0074] Preferred examples of the compound (Tp) include aminobenzenethiol represented by Chemical Formula (Tp-10).

[Chemical Formula 2]



(Tp-10)

[0075] In Chemical Formula (Tp-10), a bonding position of the amino group to the mercapto group on the benzene ring is may be any of an ortho position (2-), a meta position (3-), or a para position (4-).

[0076] For the compound (Tp), one type may be used alone, or two or more types may be mixed and used.

[0077] As the compound (Tp) contained in the flux according to the present embodiment, the thiol compound represented by General Formula (Tp-0) is preferable, and from the viewpoint of easily enhancing the effect of suppressing a change in viscosity of the solder paste with time, aminobenzenethiol (x is 1 or more, y is 1 or more) or benzenethiol (x is 1 or more, $y=0$) is more preferable.

[0078] Among these, from the viewpoint of further enhancing the effect of suppressing the change in viscosity of the solder paste with time, a thiol compound selected from the group consisting of 2-aminobenzenethiol ($x=y=1$), 4-aminobenzenethiol ($x=y=1$), 3-aminobenzenethiol ($x=y=1$), and benzenethiol ($x=1$, $y=0$) is preferable, a thiol compound selected from the group consisting of 2-aminobenzenethiol ($x=y=1$), 4-aminobenzenethiol ($x=y=1$), and 3-aminobenzenethiol ($x=y=1$) is more preferable, a thiol compound selected from the group consisting of 2-aminobenzenethiol ($x=y=1$) and 4-aminobenzenethiol ($x=y=1$) is still more preferable, and it is particularly preferable to use 2-aminobenzenethiol ($x=y=1$) and 4-aminobenzenethiol ($x=y=1$) in combination.

[0079] In a case where 2-aminobenzenethiol ($x=y=1$) and 4-aminobenzenethiol ($x=y=1$) are used in combination, a mixing ratio (mass ratio) thereof, 2-aminobenzenethiol/4-aminobenzenethiol, is preferably 1/9 to 9/1, more preferably 3/7 to 7/3, and still more preferably 4/6 to 6/4.

[0080] The total content of the compound (Tp) in the flux according to the present embodiment is preferably 0.005% by mass or more and 0.7% by mass or less, more preferably 0.01% by mass or more and 0.5% by mass or less, and still more preferably 0.02% by mass or more and 0.3% by mass or less with respect to the total mass (100% by mass) of the flux.

[0081] In a case where the total content of the compound (Tp) is equal to or more than the lower limit value of the above-described preferred range, the effect of suppressing a change in viscosity of the solder paste with time is more easily enhanced, and in a case where the total content of the compound (Tp) is equal to or less than the upper limit value of the above-described preferred range, void generation during soldering is easily suppressed.

[0082] A thiol compound other than the above-described compound (Tp) may be used in combination with the thiol compound.

[0083] Examples of the thiol compound other than the compound (Tp) include 2-(dibutylamino)-4,6-dimercapto-1,3,5-triazine, 2-mercaptobenzo[thiazole], tert-dodecanethiol, 2-ethylhexyl 3-mercaptopropionate, tridecyl 3-mercaptopropionate, and the like.

<Activator>

[0084] Examples of the activator include a halogen-based activator, an organic acid, an amine, and the like.

<<Halogen-Based Activator>>

[0085] Example of the halogen-based activator include an amine hydrohalic acid salt, and organic halogen compounds other than the amine hydrohalic acid salt.

Amine Hydrohalide Salt:

[0086] The amine hydrohalide salt is a compound obtained by reacting an amine with a hydrogen halide. Examples of the amine here include azoles, guanidines, alkylamine compounds, and amino alcohol compounds, and include amines exemplified in the description of Amine described later. Examples of the hydrogen halide include each hydride of iodine, bromine, chlorine, and fluorine.

[0087] Examples of the amine hydrohalide salt include an amine hydroiodide, an amine hydrobromide, an amine hydrochloride, and an amine hydrofluoride.

[0088] Examples of the amine hydroiodide include heteroalicyclic amine hydroiodides such as 2-pipecoline hydroiodide (2-pipecoline-HI) and piperidine-HI; chain-like amine hydroiodides such as monoethylamine-HI, triethylamine-HI, 1-pentanamine-HI, 2-ethylhexylamine-HI, and diallylamine-HI; alicyclic amine hydroiodides such as cyclohexylamine-HI; aromatic amine hydroiodides such as aniline-HI; and guanidine hydroiodides such as 1,3-diphenylguanidine-HI.

[0089] Examples of the amine hydrobromide include 2-pipecoline hydrobromide (2-pipecoline-HBr), piperidine-HBr, diphenylguanidine-HBr, cyclohexylamine-HBr, hexadecylamine-HBr, stearylamine-HBr, ethylamine-HBr, 2-ethylhexylamine-HBr, pyridine-HBr, isopropylamine-HBr, diethylamine-HBr, dimethylamine-HBr, rosinamine-HBr, hydrazine hydrate-HBr, trinonylamine-HBr, diethylaniline-HBr, 2-diethylaminoethanol-HBr, diallylamine-HBr, triethylamine-HBr, aniline-HBr, dimethylcyclohexylamine-HBr, rosinamine-HBr, 2-phenylimidazole-HBr, 4-benzylpyridine-HBr, hydrazine monohydrobromide, hydrazine dihydrobromide, ethylenediamine dihydrobromide, and the like.

[0090] Examples of the amine hydrochloride include 1,3-diphenylguanidine hydrochloride (1,3-diphenylguanidine-HCl), ethylamine-HCl, stearylamine-HCl, diethylaniline-HCl, diethanolamine-HCl, dimethylamine-HCl, 2-ethylhexylamine-HCl, isopropylamine-HCl, cyclohexylamine-HCl, 1,3-diphenylguanidine-HCl, dimethylbenzylamine-HCl, dimethylcyclohexylamine-HCl, 2-diethylaminoethanol-HCl, diallylamine-HCl, diethylamine-HCl, triethylamine-HCl, butylamine-HCl, hexylamine-HCl, n-octylamine-HCl, dodecylamine-HCl, L-glutamic acid-HCl, N-methylmorpholine-HCl, betaine-HCl, pyridine-HCl, hydrazine monohydrochloride, hydrazine dihydrochloride, ammonium chloride, and the like.

[0091] Examples of the amine hydrofluoride include 1,3-diphenylguanidine hydrofluoride (1,3-diphenylguanidine-HF), diethylamine-HF, 2-ethylhexylamine HF, cyclohexylamine-HF, ethylamine-HF, rosinamine-HF, and the like. Organic Halogen Compound Other than Amine Hydrohalide Salt:

[0092] Examples of the organic halogen compound other than the amine hydrohalide salt include halogenated aliphatic compounds having a halogenated aliphatic hydrocarbon group.

[0093] The halogenated aliphatic hydrocarbon group refers to one in which a part or all of hydrogen atoms constituting the aliphatic hydrocarbon group are substituted with halogen atoms.

[0094] Examples of the halogenated aliphatic compound include halogenated aliphatic alcohols and halogenated heterocyclic compounds.

[0095] Examples of the halogenated aliphatic alcohols include 1-bromo-2-propanol, 3-bromo-1-propanol, 3-bromo-1,2-propanediol, 1-bromo-2-butanol, 1,3-dibromo-2-propanol, 2,3-dibromo-1-propanol, 1,4-dibromo-2-butanol, trans-2,3-dibromo-2-butene-1,4-diol, and the like.

[0096] Examples of the halogenated heterocyclic compound include a compound represented by General Formula (3).



[0097] R^5 represents an m-valent heterocyclic group. R^6 represents a halogenated aliphatic hydrocarbon group.

[0098] Examples of heterocyclic rings of the m-valent heterocyclic group as R^5 include a ring structure in which a part of carbon atoms constituting an aliphatic hydrocarbon ring or an aromatic hydrocarbon ring is substituted with a heteroatom. Examples of the heteroatom in this heterocyclic ring include an oxygen atom, a sulfur atom, a nitrogen atom, and the like. This heterocyclic ring is preferably a 3- to 10-membered ring, and more preferably a 5- to 7-membered ring. Examples of this heterocyclic ring include an isocyanurate ring.

[0099] The halogenated aliphatic hydrocarbon group as R^6 preferably has 1 to 10 carbon atoms, more preferably 2 to 6 carbon atoms, and further preferably 3 to 5 carbon atoms. In addition, R^6 is preferably a brominated aliphatic hydrocarbon group or a chlorinated aliphatic hydrocarbon group, more preferably a brominated aliphatic hydrocarbon group, and further preferably a brominated saturated aliphatic hydrocarbon group.

[0100] Specific examples of the halogenated heterocyclic compounds include tris-(2,3-dibromopropyl)isocyanurate, and the like.

[0101] In addition, examples of the organic halogen compounds other than the amine hydrohalide salts include halogenated carboxyl compounds and include carboxyl iodide compounds such as 2-iodobenzoic acid, 3-iodobenzoic acid, 2-iodopropionic acid, 5-iodosalicylic acid, 5-iodoanthranilic acid; carboxyl chloride compounds such as 2-chlorobenzoic acid and 3-chloropropionic acid; and brominated carboxyl compounds such as 2,3-dibromopropionic acid, 2,3-dibromosuccinic acid, and 2-bromobenzoic acid.

[0102] Alternatively, as the halogen-based activator, for example, a salt obtained by reacting an amine with tetrafluoroboric acid (HBF_4), and a complex obtained by reacting an amine with boron trifluoride (BF_3) can also be used. Examples of the complex include boron trifluoride piperidine and the like.

[0103] For the halogen-based activator, one type may be used alone, or two or more types may be mixed and used.

[0104] As the halogen-based activator contained in the flux according to the present embodiment, from the viewpoint of the effect of suppressing the void generation during

soldering, an amine hydrohalide salt is preferably used, among these, an amine hydroiodide is more preferably used, at least one selected from the group consisting of a heteroalicyclic amine hydroiodide and a guanidine hydroiodide is still more preferably used, a heteroalicyclic amine hydroiodide is particularly preferably used, and at least one selected from the group consisting of 2-pipecoline HI and piperidine HI is most preferably used.

[0105] In a case where the flux according to the present embodiment contains an amine hydroiodide in addition to the above-described compound (Tp), the mixing ratio (mass ratio) of the compound (Tp) to the amine hydroiodide, compound (Tp)/amine hydroiodide is preferably more than 50/50 and 90/10 or less, more preferably 60/40 or more and 80/20 or less, and still more preferably 67/33 or more and 75/25 or less.

[0106] The total content of the halogen-based activator in the flux according to the present embodiment is preferably 0.01% by mass or more and 5% by mass or less, more preferably 0.5% by mass or more and 4% by mass or less, and still more preferably 1% by mass or more and 2% by mass or less with respect to the total mass (100% by mass) of the flux.

[0107] In a case where the total content of the halogen-based activator is equal to or more than the lower limit value of the above-described preferred range, the void generation during soldering is easily suppressed, and in a case where the total content of the halogen-based activator is equal to or less than the upper limit value of the above-described preferred range, the effect of suppressing the change in viscosity of the solder paste with time is easily enhanced.

<<Organic Acid>>

[0108] Examples of the organic acid include a monocarboxylic acid, a dicarboxylic acid, a tricarboxylic acid, a cyanuric acid, a dimer acid, a trimer acid, and the like.

[0109] Examples of the monocarboxylic acid include aliphatic monocarboxylic acids such as glycolic acid, thioglycolic acid, propionic acid, 2,2-bis(hydroxymethyl)propionic acid, 2,2-bis(hydroxymethyl)butanoic acid, lauric acid, palmitic acid, stearic acid, oleic acid, linoleic acid, linolenic acid, 12-hydroxystearic acid, and glycine; and aromatic monocarboxylic acids such as benzoic acid, 3-hydroxybenzoic acid, 2,3-dihydroxybenzoic acid, salicylic acid, picolinic acid, p-anisic acid, m-anisic acid, o-anisic acid, parahydroxyphenylacetic acid, and 2-quinoline carboxylic acid.

[0110] Examples of the dicarboxylic acid include aliphatic dicarboxylic acids such as oxalic acid, malonic acid, succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, dodecanedioic acid, eicosanedioic acid, 2,4-diethylglutaric acid, fumaric acid, maleic acid, diglycolic acid, dithiodiglycolic acid, tartaric acid, malic acid, and 1,3-cyclohexanedicarboxylic acid; and aromatic dicarboxylic acids such as phthalic acid, isophthalic acid, terephthalic acid, phenylsuccinic acid, dipicolinic acid, and dibutylanilinediglycolic acid.

[0111] Examples of the tricarboxylic acid include citric acid and the like.

[0112] Examples of the cyanuric acid include tris(2-carboxyethyl) isocyanurate and the like.

[0113] Examples of the dimer acid and the trimer acid include dimer acid which is the reaction product of oleic acid and linoleic acid, trimer acid which is the reaction product

of oleic acid and linoleic acid, dimer acid which is the reaction product of acrylic acid, trimer acid which is the reaction product of acrylic acid, dimer acid which is the reaction product of methacrylic acid, trimer acid which is the reaction product of methacrylic acid, dimer acid which is the reaction product of acrylic acid and methacrylic acid, trimer acid which is the reaction product of acrylic acid and methacrylic acid, dimer acid which is the reaction product of oleic acid, trimer acid which is the reaction product of oleic acid, dimer acid which is the reaction product of linoleic acid, trimer acid which is the reaction product of linoleic acid, dimer acid which is the reaction product of linolenic acid, trimer acid which is the reaction product of linolenic acid, dimer acid which is the reaction product of acrylic acid and oleic acid, trimer acid which is the reaction product of acrylic acid and oleic acid, dimer acid which is the reaction product of acrylic acid and linoleic acid, trimer acid which is the reaction product of acrylic acid and linoleic acid, dimer acid which is the reaction product of acrylic acid and linolenic acid, trimer acid which is the reaction product of acrylic acid and linolenic acid, dimer acid which is the reaction product of methacrylic acid and oleic acid, trimer acid which is the reaction product of methacrylic acid and oleic acid, dimer acid which is the reaction product of methacrylic acid and linoleic acid, trimer acid which is the reaction product of methacrylic acid and linoleic acid, dimer acid which is the reaction product of methacrylic acid and linolenic acid, trimer acid which is the reaction product of methacrylic acid and linolenic acid, dimer acid which is the reaction product of oleic acid and linolenic acid, trimer acid which is the reaction product of oleic acid and linolenic acid, dimer acid which is the reaction product of linoleic acid and linolenic acid, trimer acid which is the reaction product of linoleic acid and linolenic acid, hydrogenated dimer acid which is the hydrogenated product obtained by adding a hydrogen to each of the above-mentioned dimer acids, hydrogenated trimer acid which is the hydrogenated product obtained by adding a hydrogen to each of the above-mentioned trimer acid, and the like.

[0114] For example, dimer acid, which is the reaction product of oleic acid and linoleic acid, is a dimer having 36 carbon atoms. In addition, trimer acid, which is the reaction product of oleic acid and linoleic acid, is a trimer having 54 carbon atoms.

[0115] For the organic acid, one type may be used alone, or two or more types may be mixed and used.

[0116] As the organic acid contained in the flux according to the present embodiment, at least one selected from the group consisting of a monocarboxylic acid, a dicarboxylic acid, and a dimer acid is preferably used, at least one selected from the group consisting of a dicarboxylic acid and a dimer acid is more preferably used, at least one selected from the group consisting of an aliphatic dicarboxylic acid and a dimer acid is still more preferably used, and from the viewpoint of suppressing the generation of solder balls, at least an aliphatic dicarboxylic acid is particularly preferably used.

[0117] As the aliphatic dicarboxylic acid, at least one selected from the group consisting of oxalic acid, malonic acid, succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, and sebacic acid is preferable, at least one selected from the group consisting of succinic acid, glutaric acid, adipic acid, pimelic acid, and suberic acid is more preferable, at least one selected from the group con-

sisting of glutaric acid, adipic acid, and pimelic acid is still more preferable, and adipic acid is particularly preferable.

[0118] The total content of the organic acid in the flux according to the present embodiment is preferably 1% by mass to 25% by mass, more preferably 2% by mass to 20% by mass, and still more preferably 3% by mass to 20% by mass with respect to the total mass (100% by mass) of the flux.

[0119] The content of the dicarboxylic acid is preferably 1% by mass or more and 10% by mass or less, more preferably 1% by mass or more and 5% by mass or less, and still more preferably 2% by mass or more and 5% by mass or less with respect to the total mass (100% by mass) of the flux.

[0120] The content of the dimer acid (including a hydrogenated dimer acid) is preferably 2.5% by mass to 20% by mass, more preferably 5% by mass to 15% by mass, and still more preferably 7.5% by mass to 12.5% by mass with respect to the total mass (100% by mass) of the flux.

<<Amine>>

[0121] Examples of the amine include azoles, guanidines, alkylamine compounds, amino alcohol compounds, and the like.

[0122] Examples of the azoles include imidazole compounds such as 2-methylimidazole, 2-ethylimidazole, 2-undecylimidazole, 2-heptadecylimidazole, 1,2-dimethylimidazole, 2-ethyl-4-methylimidazole, 2-phenylimidazole, 2-phenyl-4-methylimidazole, 1-benzyl-2-methylimidazole, 1-benzyl-2-phenylimidazole, 1-cyanoethyl-2-methylimidazole, 1-cyanoethyl-2-undecylimidazole, 1-cyanoethyl-2-ethyl-4-methylimidazole, 1-cyanoethyl-2-phenylimidazole, 1-cyanoethyl-2-undecylimidazolium trimellitate, 1-cyanoethyl-2-phenylimidazolium trimellitate, 2,4-diamino-6-[2'-methylimidazolyl-(1')]-ethyl-s-triazine, 2,4-diamino-6-[2'-undecylimidazolyl-(1')]-ethyl-s-triazine, 2,4-diamino-6-[2'-ethyl-4'-methylimidazolyl-(1')]-ethyl-s-triazine, a 2,4-diamino-6-[2'-methylimidazolyl-(1')]-ethyl-s-triazine isocyanuric acid adduct, a 2-phenylimidazole isocyanuric acid adduct, 2-phenyl-4,5-dihydroxymethylimidazole, 2-phenyl-4-methyl-5-hydroxymethylimidazole, 2,3-dihydro-1H-pyrrolo[1,2-a]benzimidazole, 1-dodecyl-2-methyl-3-benzylimidazolium chloride, 2-methylimidazolone, 2-phenylimidazolone, 2,4-diamino-6-vinyl-s-triazine, a 2,4-diamino-6-vinyl-s-triazine isocyanuric acid adduct, 2,4-diamino-6-methacryloyloxyethyl-s-triazine, an epoxy-imidazole adduct, 2-methylbenzimidazole, 2-octylbenzimidazole, 2-pentylbenzimidazole, 2-(1-ethylpentyl)benzimidazole, 2-nonylbenzimidazole, 2-(4-thiazolyl)benzimidazole, and benzimidazole; triazole compounds such as 1,2,4-triazole, 2-(2'-hydroxy-5'-methylphenyl)benzotriazole, 2-(2'-hydroxy-3'-tert-butyl-5'-methylphenyl)-5-chlorobenzotriazole, 2-(2'-hydroxy-3',5'-di-tert-amylphenyl)benzotriazole, 2-(2'-hydroxy-5'-tert-octylphenyl)benzotriazole, 2,2'-methylenebis[6-(2H-benzotriazol-2-yl)-4-tert-octylphenol], 6-(2-benzotriazolyl)-4-tert-octyl-6'-tert-butyl-4'-methyl-2,2'-methylenebisphenol, 1,2,3-benzotriazole, 1-[N,N-bis(2-ethylhexyl)aminomethyl]benzotriazole, carboxybenzotriazole, 1-[N,N-bis(2-ethylhexyl)aminomethyl]methylbenzotriazole, 2,2'-[[[methyl-1H-benzotriazol-1-yl)methyl]imino]bisethanol, 1-(1',2'-dicarboxyethyl)benzotriazole, 1-(2,3-dicarboxypropyl)benzotriazole, 1-[(2-ethylhexylamino)methyl]benzotriazole, 2,6-bis[(1H-benzotriazol-1-yl)methyl]-4-methylphe-

nol, 5-methylbenzotriazole, and 3-(N-salicyloyl)amino-1,2,4-triazole; 5-phenyltetrazole; and the like.

[0123] Examples of the guanidines include 1,3-diphenylguanidine, 1,3-di-o-tolylguanidine, 1-o-tolylbiguanide, 1,3-di-o-cumenylguanidine, 1,3-di-o-cumenyl-2-propionylguanidine, and the like.

[0124] Examples of the alkylamine compounds include ethylamine, triethylamine, ethylenediamine, triethylenetetramine, cyclohexylamine, hexadecylamine, stearylamine, and the like.

[0125] Examples of the amino alcohol compound include N,N,N',N'-tetrakis(2-hydroxypropyl)ethylenediamine and the like.

[0126] For the amine, one type may be used alone, or two or more types may be mixed and used.

[0127] As the amine contained in the flux according to the present embodiment, at least one selected from the group consisting of azoles and guanidines is preferably used, and at least one selected from the group consisting of triazole compounds and guanidines is more preferably used.

[0128] In the flux according to the present embodiment, from the viewpoint of suppressing the generation of solder balls, the activator still more preferably includes a triazole compound.

[0129] The total content of the amines in the flux according to the present embodiment is preferably 0.5% by mass to 5% by mass, more preferably 1% by mass to 4.5% by mass, and still more preferably 2% by mass to 4% by mass with respect to the total mass (100% by mass) of the flux.

[0130] The content of the triazole compound is preferably more than 0% by mass and 0.99% by mass or less and more preferably 0.1% by mass or more and 0.5% by mass or less with respect to the total mass (100% by mass) of the flux.

[0131] The content of the guanidines is preferably 1% by mass or more and 5% by mass or less and more preferably 2% by mass or more and 4% by mass or less with respect to the total mass (100% by mass) of the flux.

[0132] In addition, in the flux according to the present embodiment, from the viewpoint of suppressing the generation of solder balls, it is also preferable to use an aliphatic dicarboxylic acid and a triazole compound in combination as the activator. In a case where the aliphatic dicarboxylic acid and the triazole compound are used in combination, a mixing ratio (mass ratio) of the aliphatic dicarboxylic acid to the triazole compound, aliphatic dicarboxylic acid/triazole compound is preferably aliphatic dicarboxylic acid/triazole compound=90/10 or more and 95/5 or less.

<Other Components>

[0133] The flux according to the present embodiment may contain other components as necessary, in addition to the rosin, the solvent, the thixotropic agent, the thiol compound, and the activator.

[0134] Examples of the other components include resin components other than rosin, sulfur-containing compounds other than thiol compounds, surfactants, antioxidants, metal inactivating agents, silane coupling agents, and the like.

[0135] Examples of the resin components other than rosin include a terpene resin, a modified terpene resin, a terpene phenol resin, a modified terpene phenol resin, a styrene resin, a modified styrene resin, a xylene resin, a modified xylene resin, an acrylic resin, a polyethylene resin, an acrylic-polyethylene copolymer resin, and an epoxy resin.

[0136] Examples of the modified terpene resin include an aromatic modified terpene resin, a hydrogenated terpene resin, and a hydrogenated aromatic modified terpene resin. Examples of the modified terpene phenol resin include a hydrogenated terpene phenol resin. Examples of the modified styrene resin include a styrene acrylic resin and a styrene maleic acid resin. Examples of the modified xylene resin include a phenol-modified xylene resin, an alkylphenol-modified xylene resin, a phenol-modified resol-type xylene resin, a polyol-modified xylene resin, and a polyoxyethylene-added xylene resin. Examples of the acrylic-polyethylene copolymer resin include an ethylene acrylic acid copolymer and the like.

[0137] Examples of the sulfur-containing compound other than the thiol compound include tetraethylthiuram disulfide, diisopropylxanthogen disulfide, dihexyl sulfide, diphenyl disulfide, 3-(2-benzothiazolylthio)propionic acid, and the like.

[0138] Examples of the surfactant include a nonionic surfactant, a weak cationic surfactant, and the like.

[0139] Examples of the nonionic surfactants include polyethylene glycol, a polyethylene glycol-polypropylene glycol copolymer, an aliphatic alcohol polyoxyethylene adduct, an aromatic alcohol polyoxyethylene adduct, and a polyhydric alcohol polyoxyethylene adduct.

[0140] Examples of the weak cationic surfactants include diamine-terminated polyethylene glycol, a diamine-terminated polyethylene glycol-polypropylene glycol copolymer, an aliphatic amine polyoxyethylene adduct, an aromatic amine polyoxyethylene adduct, and a polyvalent amine polyoxyethylene adduct.

[0141] Examples of surfactants other than the above-mentioned examples include polyoxyalkylene acetylene glycol, polyoxyalkylene glyceryl ethers, polyoxyalkylene alkyl ethers, polyoxyalkylene esters, polyoxyalkylene alkylamines, and polyoxyalkylene alkylamides.

[0142] Since the flux according to the present embodiment described above contains the specific thiol compound (Tp), a change in viscosity of the solder paste with time can be further suppressed in a case of being used in the solder paste. From the viewpoint of easily enhancing such effect, among the specific thiol compounds (Tp), a thiol compound selected from the group consisting of aminobenzenethiol and benzenethiol is preferably used, and among these, aminobenzenethiol is more preferably used. Among the aminobenzenethiols, in a case where at least one of 2-aminobenzenethiol or 4-aminobenzenethiol is used, the effect of suppressing the change in viscosity of the solder paste with time is more easily obtained as compared with a case where 3-aminobenzenethiol is used. The reason for this is not clear, but it is presumed that the change in viscosity of the solder paste with time occurs because of the formation of a complex between the metal of the solder alloy and the acid in the flux system. The aminobenzenethiol forms a protective layer by being adsorbed on the metal surface, and suppresses the formation of a complex between the metal and the acid. In aminobenzenethiol, the electron density of the mercapto group sulfur atom is increased by the electron-donating property of $-\text{NH}_2$ on the benzene ring. Therefore, it is presumed that the aminobenzenethiol is more likely to promote the adsorption to the anion defect portion on the surface of the solder alloy, thereby easily obtaining such effect. In addition, it is considered that since 2-aminobenzenethiol and 4-aminobenzenethiol have a higher ratio of an

increase in the electron density of the mercapto group sulfur atom because of the electron-donating property of $-\text{NH}_2$ on the benzene ring than 3-aminobenzenethiol, the effect of suppressing the change in viscosity of the solder paste with time is more easily obtained.

[0143] In the flux according to the present embodiment, by further containing preferably an amine hydroiodide in addition to the specific thiol compound, a change in viscosity of the solder paste containing the flux with time is more easily suppressed, and the generation of voids during soldering is suppressed.

(Solder Paste)

[0144] A solder paste of the present embodiment contains a solder alloy powder and the above-mentioned flux.

[0145] The solder alloy powder may be constituted of an Sn-only solder powder; a powder of an Sn—Ag-based, Sn—Cu-based, Sn—Ag—Cu-based, Sn—Bi-based, or Sn—In-based solder alloy; or a powder of solder alloys in which Sb, Bi, In, Cu, Zn, As, Ag, Cd, Fe, Ni, Co, Au, Ge, P, or the like has been added to the above solder alloys.

[0146] In addition, the solder alloy powder may be constituted of a powder of an Sn—Pb-based solder alloy, or a powder of solder alloys in which Sb, Bi, In, Cu, Zn, As, Ag, Cd, Fe, Ni, Co, Au, Ge, P, or the like has been added to the Sn—Pb-based solder alloy.

[0147] The solder alloy powder is preferably a Pb-free solder.

[0148] As the solder alloy powder, for example, a solder alloy powder having a melting temperature of 150° C. to 250° C. can be used.

[0149] The content of the flux in the solder paste is preferably 5% to 30% by mass and more preferably 5% to 15% by mass with respect to the total mass of the solder paste.

[0150] In the solder paste according to the present embodiment described above, since a flux containing a specific thiol compound is adopted, a change in viscosity with time is unlikely to occur.

[0151] In addition, in a case where the solder paste according to the present embodiment contains a flux in which an amine hydroiodide is further used in combination, a change in viscosity with time is less likely to occur, and the generation of voids during soldering is also suppressed.

(Thickening Inhibitor for Soldering Flux)

[0152] The thickening inhibitor of the soldering flux according to the present embodiment is a flux material suitable for suppressing an increase in viscosity of a solder paste containing a solder alloy powder and a soldering flux.

[0153] Such thickening inhibitor includes a thiol compound having a benzenethiol skeleton in which one or more hydrogen atoms on a benzene ring are substituted with a mercapto group ($-\text{SH}$).

[0154] The thiol compound having a benzenethiol skeleton referred to here is the same as the above-described <<Compound (Tp)>>. Among these, from the viewpoint of further enhancing the effect of suppressing an increase in viscosity of the solder paste with time, as the thiol compound having a benzenethiol skeleton, at least one selected from the group consisting of 2-aminobenzenethiol ($x=y=1$), 4-aminobenzenethiol ($x=y=1$), 3-aminobenzenethiol ($x=y=1$), and benzenethiol ($x=1$, $y=0$) is preferable.

[0155] A thiol compound other than the thiol compound having a benzenethiol skeleton may be used in combination with such thickening inhibitor.

[0156] Examples of the thiol compound other than the thiol compound having a benzenethiol skeleton include 2-(dibutylamino)-4,6-dimercapto-1,3,5-triazine, 2-mercaptobenzothiazole, tert-dodecanethiol, 2-ethylhexyl 3-mercaptopropionate, tridecyl 3-mercaptopropionate, and the like.

[0157] The content of the thiol compound having a benzenethiol skeleton in such thickening inhibitor may be 50% by mass or more, may be 80% by mass or more, may be 90% by mass or more, or may be 100% by mass.

[0158] The thickening inhibitor of the soldering flux according to the present embodiment can be used in the same manner as the <thiol compound> constituting the above-described (flux) in the application of the soldering flux. The thickening inhibitor according to the present embodiment can be typically used as a formulation component of a soldering flux in an embodiment in which a solder paste containing a soldering flux and a solder alloy powder is printed on a board, a component is mounted on the printed portion, and a joined body is produced by a method of heating (reflow).

[0159] According to the thickening inhibitor of the soldering flux according to the present embodiment, it is possible to provide a flux that is unlikely to cause an increase in viscosity of the solder paste with time.

EXAMPLES

[0160] Hereinafter, the present invention will be described with reference to Examples, but the present invention is not limited to the following Examples.

Preparation of Flux

EXAMPLES 1 TO 91 AND COMPARATIVE EXAMPLES 1 TO 10

[0161] As shown in Tables 1 to 13, the formulation components were mixed to formulate each flux of Examples and Comparative Examples. The formulation components used are shown below.

Rosin:

[0162] An acrylic acid-modified hydrogenated rosin and a hydrogenated rosin were used as the rosin.

Solvent:

[0163] Diethylene glycol mono-2-ethylhexyl ether (boiling point of 272° C.) was used as a solvent (S1) having a boiling point of 250° C. or higher.

[0164] 1,4-butanediol (boiling point of 228° C.) was used as a solvent (S2) having a boiling point of higher than 220° C. and lower than 250° C.

[0165] The following solvent (S31) having a boiling point of 190° C. or higher and 220° C. or lower and a solvent (S32) having a boiling point of 160° C. or higher and lower than 190° C. were used as the solvent (S3) having a boiling point of 220° C. or lower.

[0166] Solvent (S31) having boiling point of 190° C. or higher and 220° C. or lower:

[0167] 1,3-Butanediol (boiling point of 203° C.), 1,2-butanediol (boiling point of 194° C.), 2-methyl-2,4-pentanediol (hexylene glycol) (boiling point of 198° C.), eth-

ylene glycol monohexyl ether (hexyl glycol) (boiling point of 208° C.), and α -terpineol (boiling point of 218° C.)

[0168] Solvent (S32) having boiling point of 160° C. or higher and lower than 190° C.:

[0169] 2,3-Butanediol (boiling point of 183° C.)

Thixotropic Agent:

[0170] Polyamide and hydrogenated castor oil were used as the thixotropic agent.

Sulfur-Containing Compound:

[0171] The thiol compound (Tp) having a benzenethiol skeleton, the thiol compound other than the compound (Tp), and the other sulfur-containing compounds, which were shown below, were used as the sulfur-containing compound.

Thiol Compound (Tp) Having Benzenethiol Skeleton:

[0172] Benzenethiol, 3-aminobenzenethiol, 2-aminobenzenethiol, and 4-aminobenzenethiol.

Thiol Compound Other than Compound (Tp):

[0173] 2-(Dibutylamino)-4,6-dimercapto-1,3,5-triazine, 2-mercaptobenzothiazole, tert-dodecanethiol, 2-ethylhexyl 3-mercaptopropionate, and tridecyl 3-mercaptopropionate.

Other Sulfur-Containing Compounds:

[0174] Tetraethylthiuram disulfide, diisopropylxanthogen disulfide, dihexyl sulfide, diphenyl disulfide, and 3-(2-benzothiazolylthio)propionic acid.

Activator:

[0175] The following amine hydroiodide, amine hydrobromide, amine hydrochloride, organic acid, and amine were used as the activator.

[0176] 2-Pipecoline-HI, piperidine-HI, and 1,3-diphenylguanidine-HI were used as the amine hydroiodide.

[0177] 2-Pipecoline-HI was produced by adding 30 g of a total amount of 2-pipecoline and hydrogen iodide in an equimolar ratio to 70 g of isopropyl alcohol (IPA), mixing these, then allowing the mixture to stand at room temperature (25° C.) for 5 minutes to precipitate, and drying the precipitate (yield of about 100%).

[0178] Piperidine-HI was produced by the same method as the method for producing 2-pipecoline-HI, except that 2-pipecoline was changed to piperidine (yield of about 100%).

[0179] As other amine hydroiodides, a ready-made product was used.

[0180] 2-Pipecoline-HBr, piperidine-HBr, and 1,3-diphenylguanidine-HBr were used as the amine hydrobromide.

[0181] 1,3-Diphenylguanidine-HCl was used as the amine hydrochloride.

[0182] As the amine hydrobromide and the amine hydrochloride described above, ready-made products were used.

Organic Acid:

[0183] A hydrogenated dimer acid, adipic acid, benzoic acid, and phenylsuccinic acid were used as the organic acid.

Amine:

[0184] 1,3-Di-o-tolylguanidine and 3-(N-salicyloyl) amino-1,2,4-triazole were used as the amine.

Other Components:

[0185] An ethylene acrylic acid copolymer was used as the acrylic resin.

[0186] 2,2'-Methylenebis[6-(1-methylcyclohexyl)-p-cresol] was used as the antioxidant.

<Preparation of Solder Paste>

[0187] Each of the fluxes of each of the examples and the following solder alloy powders were mixed to blend solder pastes. In all the prepared solder pastes, the content of the flux was 11.5% by mass and the content of the solder alloy powder was 88.5% by mass, with respect to the total amount of the solder paste.

Solder Alloy Powder:

[0188] As the solder alloy powder, a powder consisting of a solder alloy in which Ag was 3% by mass, Cu was 0.5% by mass, and the remainder was Sn, was used. A solidus temperature of the solder alloy was 217° C., and a liquidus temperature was 220° C.

[0189] The size of the solder alloy powder was such that it satisfied the symbol 5 (particle size distribution) of the powder size classification (Table 2) in JIS Z 3284-1: 2004.

<Evaluation>

[0190] Using the solder paste prepared as described above, each of [change in viscosity of solder paste with time] and [effect of suppressing void generation] was evaluated according to the test methods described below.

[Change in Viscosity of Solder Paste with Time]

(1) Test Method

[0191] Regarding the solder paste immediately after the preparation, the measurement of the viscosity was continued under the conditions of a rotation speed of 10 rpm, a temperature of 25° C., and 24 hours in the atmosphere using a viscometer (manufactured by Malcom Ltd., PCU-205). Then, a viscosity change rate after 24 hours was determined from the viscosity at the start point of the measurement and the viscosity after 24 hours in the solder paste, and the viscosity change of the solder paste with time was evaluated according to the following evaluation criteria. The evaluation results are shown in Tables 1 to 13.

(2) Evaluation Criteria

[0192] 1 Point: the viscosity change rate after 24 hours was less than 10%.

[0193] 2 Points: the viscosity change rate after 24 hours was 10% or more and less than 20%.

[0194] 3 Points: the viscosity change rate after 24 hours was 20% or more and less than 30%.

[0195] 4 Points: the viscosity change rate after 24 hours was 30% or more and less than 40%.

[0196] 5 Points: the viscosity change rate after 24 hours was 40% or more and less than 50%.

[0197] 6 Points: the viscosity change rate after 24 hours was 50% or more.

[Effect of Suppressing Void Generation]

(1) Test Method

[0198] Using a metal mask (mask thickness of 0.12 mm), the solder paste of each example was printed on a Cu—OSP-treated board (board size of 105 mm×105 mm).

[0199] Next, a QFN (one side length of 8 mm, one side length of the lower electrode of 5.80 mm, and pad dimensions of 5.80 mm×5.80 mm) was mounted on the board on which the solder paste had been printed.

[0200] Next, reflow was performed to solder the components.

[0201] The reflow profile at that time is shown in FIG. 1.

[0202] In the reflow profile, preheating was performed by holding the temperature at 150° C. to 175° C. for 85 seconds, and the temperature was held at 220° C. or higher for 40 seconds, and the peak temperature was 242° C.

[0203] A void area was measured by irradiating the joined body of the board and the QFN with X-rays from a vertical direction of the board, and analyzing the transmitted X-rays. An XD 7600NT Diamond X-ray inspection system (manufactured by Nordson Corporation) was used for the measurement of the void area.

[0204] For the measurement of the void area, it was assumed that the void was present in a case where the X-rays passed through at least one void. As the voids, those having a diameter of 0.1 μm or more were detected.

[0205] Next, the proportion of the total area of the voids to the total area of the lower electrode (area ratio of 100%) was calculated to obtain a void area ratio (%). The average value of the void area ratios in the five joined bodies was obtained, and the effect of suppressing void generation during soldering was evaluated according to the following evaluation criteria. The evaluation results are shown in Tables 5 to 13.

(2) Evaluation Criteria

[0206] 1 Point: the void area ratio was less than 10%.

[0207] 2 Points: the void area ratio was 10% or more and less than 15%.

[0208] 3 Points: the void area ratio was 15% or more and less than 20%.

[0209] 4 Points: the void area ratio was 20% or more and less than 30%.

[0210] 5 Points: the void area ratio was 30% or more.

TABLE 1

Flux material	Name of formulation component	Example 1	Example 2	Example 3	Example 4	Example 5
Rosin	Acrylic acid-modified hydrogenated rosin Hydrogenated rosin	33	33	33	33	33

TABLE 1-continued

Solvent	Solvent (S1)	Diethylene glycol mono-2-ethylhexyl ether	30.695	30.68	30.4	30.1	30.0
	Solvent (S2)	1,4-Butanediol					
	Solvent (S31)	1,3-Butanediol	10	10	10	10	10
	Solvent (S32)	2,3-Butanediol					
	Thixotropic agent	Polyamide	4	4	4	4	4
		Hydrogenated castor oil	3	3	3	3	3
Sulfur-containing compound	Thiol compound (Tp)	2-Aminobenzenethiol	0.005	0.02	0.3	0.6	0.7
		4-Aminobenzenethiol					
		3-Aminobenzenethiol					
		Benzenethiol					
Activator	Organic acid	Hydrogenated dimer acid	10	10	10	10	10
		Adipic acid	3	3	3	3	3
		Benzoic acid	0.1	0.1	0.1	0.1	0.1
		Phenylsuccinic acid					
	Amine	1,3-Di-o-tolylguanidine	3	3	3	3	3
		3-(N-Salicyloyl)amino-1,2,4-triazole	0.2	0.2	0.2	0.2	0.2
Other	Acrylic resin	Ethylene acrylic acid copolymer					
	Antioxidant	2,2'-Methylenebis[6-(1-methylcyclohexyl)-p-cresol]	3	3	3	3	3
Total			100.000	100.000	100.000	100.000	100.000
Evaluation		Change in viscosity of solder paste with time	3	2	2	1	1

Flux material	Name of formulation component	Example 6	Example 7	Example 8	Example 9	Example 10
Rosin	Acrylic acid-modified hydrogenated rosin	33	33	33	33	33
	Hydrogenated rosin					
Solvent	Solvent (S1)	30.695	30.68	30.4	30.1	30.0
	Solvent (S2)					
	Solvent (S31)	10	10	10	10	10
	Solvent (S32)					
	Thixotropic agent	4	4	4	4	4
		3	3	3	3	3
Sulfur-containing compound	Thiol compound (Tp)	0.005	0.02	0.3	0.6	0.7
Activator	Organic acid	10	10	10	10	10
		3	3	3	3	3
		0.1	0.1	0.1	0.1	0.1
	Amine	3	3	3	3	3
		0.2	0.2	0.2	0.2	0.2
Other	Acrylic resin					
	Antioxidant	3	3	3	3	3
Total		100.000	100.000	100.000	100.000	100.000
Evaluation	Change in viscosity of solder paste with time	3	2	2	1	1

TABLE 2

Flux material	Name of formulation component	Example 11	Example 12	Example 13	Example 14	Example 15	Example 16	Example 17	Example 18
Rosin	Acrylic acid-modified hydrogenated rosin	33	33	33	33	33	33	33	33
	Hydrogenated rosin								
Solvent	Solvent (S1)	30.68	30.4	30.1	30.0	30.68	30.4	30.1	30.0
	Solvent (S2)								
	Solvent (S31)	10	10	10	10	10	10	10	10
	Solvent (S32)								

TABLE 2-continued

Flux material	Name of formulation component	Example 11	Example 12	Example 13	Example 14	Example 15	Example 16	Example 17	Example 18
Thixotropic agent	Polyamide	4	4	4	4	4	4	4	4
	Hydrogenated castor oil	3	3	3	3	3	3	3	3
Sulfur-containing compound (Tp)	Thiol compound								
	2-Aminobenzenethiol								
Activator	Organic acid								
	4-Aminobenzenethiol								
	3-Aminobenzenethiol	0.02	0.3	0.6	0.7				
	Benzenethiol					0.02	0.3	0.6	0.7
	Hydrogenated dimer acid	10	10	10	10	10	10	10	10
	Adipic acid	3	3	3	3	3	3	3	3
	Benzoic acid	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Phenylsuccinic acid								
	Amine								
	1,3-Di-o-tolylguanidine	3	3	3	3	3	3	3	3
Other	Acrylic resin	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	3-(N-Salicyloyl)amino-1,2,4-triazole								
	Antioxidant								
	Ethylene acrylic acid copolymer								
	2,2'-Methylenebis[6-(1-methylcyclohexyl)-p-cresol]	3	3	3	3	3	3	3	3
Evaluation	Total	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
	Change in viscosity of solder paste with time	3	3	2	2	3	3	3	3

TABLE 3

Flux material	Name of formulation component	Example 19	Example 20	Example 21	Example 22	Example 23	Example 24
Rosin	Acrylic acid-modified hydrogenated rosin	33	33	33	33	33	33
	Hydrogenated rosin						
Solvent	Solvent (S1)	30.696	30.695	30.68	30.40	30.10	30.00
	Diethylene glycol mono-2-ethylhexyl ether						
	Solvent (S2)						
	1,4-Butanediol						
	Solvent (S31)	10	10	10	10	10	10
	1,3-Butanediol						
	Solvent (S32)						
	2,3-Butanediol						
Thixotropic agent	Polyamide	4	4	4	4	4	4
	Hydrogenated castor oil	3	3	3	3	3	3
Sulfur-containing compound (Tp)	Thiol compound						
	2-Aminobenzenethiol	0.002	0.0025	0.01	0.15	0.30	0.35
	4-Aminobenzenethiol	0.002	0.0025	0.01	0.15	0.30	0.35
	3-Aminobenzenethiol						
Activator	Organic acid						
	Benzenethiol						
	Hydrogenated dimer acid	10	10	10	10	10	10
	Adipic acid	3	3	3	3	3	3
	Benzoic acid	0.1	0.1	0.1	0.1	0.1	0.1
	Phenylsuccinic acid						
	Amine						
	1,3-Di-o-tolylguanidine	3	3	3	3	3	3
Other	Acrylic resin	0.2	0.2	0.2	0.2	0.2	0.2
	3-(N-Salicyloyl)amino-1,2,4-triazole						
	Antioxidant						
	Ethylene acrylic acid copolymer						
	2,2'-Methylenebis[6-(1-methylcyclohexyl)-p-cresol]	3	3	3	3	3	3
Evaluation	Total	100,000	100,000	100,000	100,000	100,000	100,000
	Change in viscosity of solder paste with time	3	2	1	1	1	1

TABLE 4

Flux material	Name of formulation component	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4	Comparative Example 5
Rosin	Acrylic acid-modified hydrogenated rosin	33	33	33	33	33
	Hydrogenated rosin					
Solvent	Solvent (S1)	30.4	30.4	30.4	30.4	30.4
	Diethylene glycol mono-2-ethylhexyl ether					

TABLE 4-continued

	Solvent (S2)	1,4-Butanediol					
	Solvent (S31)	1,3-Butanediol	10	10	10	10	10
	Solvent (S32)	2,3-Butanediol					
	Thixotropic agent	Polyamide	4	4	4	4	4
		Hydrogenated castor oil	3	3	3	3	3
Sulfur-containing compound	Thiol compound other than compound (Tp)	2-(Dibutylamino)-4,6-dimercapto-1,3,5-triazine	0.3				
		2-Mercaptobenzothiazole		0.3			
		tert-Dodecanethiol			0.3		
		2-Ethylhexyl 3-mercaptopropionate				0.3	
		Tridecyl 3-mercaptopropionate					0.3
	Other sulfur-containing compounds	Tetraethylthiuram disulfide					
		Diisopropylxanthogen disulfide					
		Diethyl sulfide					
		Diphenyl disulfide					
		3-(2-Benzothiazolylthio)propionic acid					
Activator	Organic acid	Hydrogenated dimer acid	10	10	10	10	10
		Adipic acid	3	3	3	3	3
		Benzoic acid	0.1	0.1	0.1	0.1	0.1
		Phenylsuccinic acid					
	Amine	1,3-Di-o-tolylguanidine	3	3	3	3	3
		3-(N-Salicyloyl)amino-1,2,4-triazole	0.2	0.2	0.2	0.2	0.2
Other	Acrylic resin	Ethylene acrylic acid copolymer					
	Antioxidant	2,2'-Methylenebis[6-(1-methylcyclohexyl)-p-cresol]	3	3	3	3	3
Total			100.000	100.000	100.000	100.000	100.000
Evaluation	Change in viscosity of solder paste with time		4	4	4	4	4

Flux material	Name of formulation component	Comparative Example 6	Comparative Example 7	Comparative Example 8	Comparative Example 9	Comparative Example 10
	Rosin	33	33	33	33	33
Solvent	Solvent (S1)	30.4	30.4	30.4	30.4	30.4
	Solvent (S2)					
	Solvent (S31)	10	10	10	10	10
	Solvent (S32)					
	Thixotropic agent	4	4	4	4	4
		3	3	3	3	3
Sulfur-containing compound	Thiol compound other than compound (Tp)					
		0.3				
	Other sulfur-containing compounds		0.3			
				0.3		
					0.3	
						0.3
Activator	Organic acid	10	10	10	10	10
		3	3	3	3	3
		0.1	0.1	0.1	0.1	0.1
	Amine	3	3	3	3	3
		0.2	0.2	0.2	0.2	0.2

TABLE 4-continued

Other	Acrylic resin Antioxidant	Ethylene acrylic acid copolymer 2,2'-Methylenebis[6-(1-methylcyclohexyl)-p-cresol]	3	3	3	3	3
Evaluation	Total Change in viscosity of solder paste with time		100.000 4	100.000 4	100.000 4	100.000 4	100.000 4

[0211] From the results shown in Tables 1 to 4, it can be confirmed that the flux of Examples containing the specific thiol compound (Tp) has a lower viscosity change rate after 24 hours and a more suppressed change in viscosity of the solder paste with time, as compared with the flux of Comparative Examples containing a sulfur-containing compound that does not correspond to the compound (Tp) (comparison between Examples 3, 8, 12, and 16 and Comparative Examples 1 to 10).

[0212] In a case where the specific thiol compound (Tp) is made into a solder paste, it can be confirmed that the effect of suppressing a change in viscosity of the solder paste with

time is high in the following order (Examples 3, 8, 12, 16, and 22).

Benzenethiol

[0213] <3-aminobenzenethiol

[0214] <2-aminobenzenethiol and 4-aminobenzenethiol

[0215] <combined use of 2-aminobenzenethiol and 4-aminobenzenethiol

[0216] It is recognized that a higher effect is exhibited with a smaller formulation amount by the combined use of 2-aminobenzenethiol and 4-aminobenzenethiol (Examples 4, 9, and 21).

TABLE 5

Flux material	Name of formulation component	Example 3	Example 8	Example 22	Example 25	Example 26	Example 27	Example 28
Rosin	Acrylic acid-modified hydrogenated rosin Hydrogenated rosin	33	33	33	33	33	33	33
Solvent	Solvent (S1) Diethylene glycol mono-2-ethylhexyl ether	30.4	30.4	30.40	30.3	30.3	30.30	30.30
	Solvent (S2) 1,4-Butanediol							
	Solvent (S31) 1,3-Butanediol	10	10	10	10	10	10	10
	Solvent (S32) 2,3-Butanediol							
Thixotropic agent	Polyamide	4	4	4	4	4	4	4
	Hydrogenated castor oil	3	3	3	3	3	3	3
Sulfur-containing compound	Thiol compound (Tp)	0.3		0.15	0.3		0.15	0.15
	4-Aminobenzenethiol		0.3	0.15		0.3	0.15	0.15
	3-Aminobenzenethiol							
	Benzenethiol							
Activator	Amine hydroiodide				0.1	0.1	0.1	
	Piperidine•HI							0.1
	Organic acid							
	Hydrogenated dimer acid	10	10	10	10	10	10	10
	Adipic acid	3	3	3	3	3	3	3
	Benzoic acid	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Phenylsuccinic acid							
	Amine							
	1,3-Di-o-tolylguanidine	3	3	3	3	3	3	3
	3-(N-Salicyloyl)amino-1,2,4-triazole	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Other	Acrylic resin Antioxidant	Ethylene acrylic acid copolymer 2,2'-Methylenebis[6-(1-methylcyclohexyl)-p-cresol]	3	3	3	3	3	3
Evaluation	Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000
	Change in viscosity of solder paste with time	2	2	1	2	2	1	1
	Effect of suppressing void generation	4	4	4	1	1	1	1

[0217] From the results shown in Table 5, it can be confirmed that in a case where the amine hydroiodide is further contained, a change in viscosity with time in a case of being made into a solder paste is less likely to occur, and the generation of voids during soldering is also suppressed.

TABLE 6

Flux material	Name of formulation component	Example 29	Example 30	Example 31	Example 32	Example 33
Rosin	Acrylic acid-modified hydrogenated rosin	20	20	20	20	20
Solvent	Solvent (S1)	55	60	45	50	55
	Solvent (S2)					
	Solvent (S31)					
	Solvent (S32)					
Thixotropic agent	Diethylene glycol mono-2-ethylhexyl ether					
	1,4-Butanediol					
	1,3-Butanediol					
	2,3-Butanediol					
	Polyamide	10	10	10	10	10
	Hydrogenated castor oil	5				
Sulfur-containing compound	Thiol compound (Tp)	0.1	0.1	0.1	0.1	0.1
	4-Aminobenzenethiol	0.1	0.1	0.1	0.1	0.1
	3-Aminobenzenethiol					
Activator	Amine hydroiodide	0.1	0.1	0.1	0.1	0.1
	Organic acid					
	2-Pipecoline•HI					
	Piperidine•HI					
	Hydrogenated dimer acid			15	10	5
	Adipic acid	3.5	3.5	3.5	3.5	3.5
	Benzoic acid					
	Phenylsuccinic acid					
	Amine	3	3	3	3	3
	1,3-Di-o-tolylguanidine	0.2	0.2	0.2	0.2	0.2
	3-(N-Salicyloyl)amino-1,2,4-triazole					
Other	Acrylic resin					
	Antioxidant	3	3	3	3	3
	Ethylene acrylic acid copolymer					
	2,2'-Methylenebis[6-(1-methylcyclohexyl)-p-cresol]					
	Total	100.000	100.000	100.000	100.000	100.000
Evaluation	Change in viscosity of solder paste with time	1	1	1	1	1
	Effect of suppressing void generation	2	2	2	2	2

Flux material	Name of formulation component	Example 34	Example 35	Example 36	Example 37	Example 38
Rosin	Acrylic acid-modified hydrogenated rosin	25	25	25	25	25
Solvent	Solvent (S1)	50	55	40	45	50
	Solvent (S2)					
	Solvent (S31)					
	Solvent (S32)					
Thixotropic agent	Diethylene glycol mono-2-ethylhexyl ether					
	1,4-Butanediol					
	1,3-Butanediol					
	2,3-Butanediol					
	Polyamide	8	8	8	8	8
	Hydrogenated castor oil	7	2	2	2	2
Sulfur-containing compound	Thiol compound (Tp)	0.1	0.1	0.1	0.1	0.1
	4-Aminobenzenethiol	0.1	0.1	0.1	0.1	0.1
	3-Aminobenzenethiol					
Activator	Amine hydroiodide	0.1	0.1	0.1	0.1	0.1
	Organic acid					
	2-Pipecoline•HI					
	Piperidine•HI					
	Hydrogenated dimer acid			15	10	5
	Adipic acid	3.5	3.5	3.5	3.5	3.5
	Benzoic acid					
	Phenylsuccinic acid					
	Amine	3	3	3	3	3
	1,3-Di-o-tolylguanidine	0.2	0.2	0.2	0.2	0.2
	3-(N-Salicyloyl)amino-1,2,4-triazole					
Other	Acrylic resin					
	Antioxidant	3	3	3	3	3
	Ethylene acrylic acid copolymer					
	2,2'-Methylenebis[6-(1-methylcyclohexyl)-p-cresol]					
	Total	100.000	100.000	100.000	100.000	100.000
Evaluation	Change in viscosity of solder paste with time	1	1	1	1	1
	Effect of suppressing void generation	2	2	2	2	2

TABLE 7

Flux material	Name of formulation component	Example 39	Example 40	Example 41	Example 42	Example 43	Example 44
Rosin	Acrylic acid-modified hydrogenated rosin	30	30	30	30	30	33
Solvent	Solvent (S1)	45	50	35	40	45	30.4
	Solvent (S2)						
	Solvent (S31)						10
	Solvent (S32)						
Thixotropic agent	Polyamide	6	6	6	6	6	4
	Hydrogenated castor oil	9	4	4	4	4	3
Sulfur-containing compound	Thiol	0.1	0.1	0.1	0.1	0.1	0.1
	compound (Tp)	0.1	0.1	0.1	0.1	0.1	0.1
Activator	Amine hydroiodide	0.1	0.1	0.1	0.1	0.1	0.1
	Organic acid						
	Hydrogenated dimer acid			15	10	5	10
	Adipic acid	3.5	3.5	3.5	3.5	3.5	3
	Benzoic acid						0.1
	Phenylsuccinic acid						
	Amine	3	3	3	3	3	3
	1,3-Di-o-tolylguanidine	0.2	0.2	0.2	0.2	0.2	0.2
	3-(N-Salicyloyl)amino-1,2,4-triazole						
Other	Acrylic resin						
	Antioxidant	3	3	3	3	3	3
	2,2'-Methylenebis[6-(1-methylcyclohexyl)-p-cresol]						
	Total	100.000	100.000	100.000	100.000	100.000	100.000
Evaluation	Change in viscosity of solder paste with time	1	1	1	1	1	1
	Effect of suppressing void generation	2	2	2	2	2	1

Flux material	Name of formulation component	Example 45	Example 46	Example 47	Example 48	Example 49
Rosin	Acrylic acid-modified hydrogenated rosin	33	33	33	23	23
	Hydrogenated rosin				10	
Solvent	Solvent (S1)	29.6	30.4	29.6	30.4	30.4
	Solvent (S2)					
	Solvent (S31)	10	10	10	10	10
	Solvent (S32)					
Thixotropic agent	Polyamide	4	4	4	4	4
	Hydrogenated castor oil	3	3	3	3	3
Sulfur-containing compound	Thiol	0.1	0.1	0.1	0.1	0.1
	compound (Tp)	0.1	0.1	0.1	0.1	0.1
Activator	Amine hydroiodide	0.1	0.1	0.1	0.1	0.1
	Organic acid					
	Hydrogenated dimer acid	10	10	10	10	10
	Adipic acid	3	3	3	3	3
	Benzoic acid	0.9			0.1	0.1
	Phenylsuccinic acid		0.1	0.9		
	Amine	3	3	3	3	3
	1,3-Di-o-tolylguanidine	0.2	0.2	0.2	0.2	0.2
	3-(N-Salicyloyl)amino-1,2,4-triazole					
Other	Acrylic resin					10
	Antioxidant	3	3	3	3	3
	2,2'-Methylenebis[6-(1-methylcyclohexyl)-p-cresol]					
	Total	100.000	100.000	100.000	100.000	100.000
Evaluation	Change in viscosity of solder paste with time	1	1	1	1	1
	Effect of suppressing void generation	1	1	1	1	1

TABLE 9

Flux material	Name of formulation component	Example 61	Example 62	Example 63	Example 64	Example 65	Example 66
Rosin	Acrylic acid-modified hydrogenated rosin	45	45	45	45	50	50
Solvent	Solvent (S1) Hydrogenated rosin Diethylene glycol mono-2-ethylhexyl ether	30	35	40	30	30	35
	Solvent (S2) 1,4-Butanediol						
	Solvent (S31) 1,3-Butanediol						
	Solvent (S32) 2,3-Butanediol						
Thixotropic agent	Polyamide	3	3	3	3	3	3
	Hydrogenated castor oil	12	7	2	7	7	2
Sulfur-containing compound	Thiol compound (Tp) 2-Aminobenzenethiol 4-Aminobenzenethiol 3-Aminobenzenethiol Benzenethiol	0.1 0.1	0.1 0.1	0.1 0.1	0.1 0.1	0.1 0.1	0.1 0.1
Activator	Amine hydroiodide Organic acid 2-Pipecoline•HI Piperidine•HI Hydrogenated dimer acid Adipic acid Benzoic acid Phenylsuccinic acid	0.1	0.1	0.1	0.1	0.1	0.1
		3.5	3.5	3.5	5 3.5	3.5	3.5
	Amine 1,3-Di-o-tolylguanidine 3-(N-Salicyloyl)amino-1,2,4-triazole	3 0.2	3 0.2	3 0.2	3 0.2	3 0.2	3 0.2
Other	Acrylic resin Antioxidant Ethylene acrylic acid copolymer 2,2'-Methylenebis[6-(1-methylcyclohexyl)-p-cresol]	3	3	3	3	3	3
	Total	100.000	100.000	100.000	100.000	100.000	100.000
Evaluation	Change in viscosity of solder paste with time	1	1	1	1	1	1
	Effect of suppressing void generation	2	2	2	2	2	2

[0218] From the results shown in Tables 6 to 9, it can be confirmed that in a case of using the fluxes of Examples 29 to 66, which have both a specific thiol compound (Tp) and

an amine hydroiodide, the viscosity change of the solder paste with time is less likely to occur, and the generation of voids during soldering is also suppressed.

TABLE 10

Flux material	Name of formulation component	Example 67	Example 68	Example 69	Example 70
Rosin	Acrylic acid-modified hydrogenated rosin	33	33	33	33
Solvent	Solvent (S1) Hydrogenated rosin Diethylene glycol mono-2-ethylhexyl ether	30.39	30.3	29.5	28.9
	Solvent (S2) 1,4-Butanediol				
	Solvent (S31) 1,3-Butanediol	10	10	10	10
	Solvent (S32) 2,3-Butanediol				
Thixotropic agent	Polyamide	4	4	4	4
	Hydrogenated castor oil	3	3	3	3
Sulfur-containing compound	Thiol compound (Tp) 2-Aminobenzenethiol 4-Aminobenzenethiol 3-Aminobenzenethiol Benzenethiol	0.15 0.15	0.15 0.15	0.15 0.15	0.15 0.15
Activator	Amine hydroiodide Organic acid 2-Pipecoline•HI Piperidine•HI 1,3-Diphenylguanidine•HI Hydrogenated dimer acid Adipic acid Benzoic acid Phenylsuccinic acid	0.01	0.1	0.9	1.5
		10	10	10	10
		3	3	3	3
		0.1	0.1	0.1	0.1
	Amine 1,3-Di-o-tolylguanidine 3-(N-Salicyloyl)amino-1,2,4-triazole	3 0.2	3 0.2	3 0.2	3 0.2
Other	Acrylic resin Antioxidant Ethylene acrylic acid copolymer 2,2'-Methylenebis[6-(1-methylcyclohexyl)-p-cresol]	3	3	3	3
	Total	100.000	100.000	100.000	100.000

TABLE 10-continued

	Evaluation	Change in viscosity of solder paste with time	1	1	1	2	
		Effect of suppressing void generation	2	1	1	1	
	Flux material	Name of formulation component	Example 71	Example 72	Example 73	Example 74	
	Rosin	Acrylic acid-modified hydrogenated rosin	33	33	33	33	
Solvent	Solvent (S1)	Hydrogenated rosin Diethylene glycol mono-2-ethylhexyl ether	30.39	30.3	29.5	28.9	
	Solvent (S2)	1,4-Butanediol					
	Solvent (S31)	1,3-Butanediol	10	10	10	10	
	Solvent (S32)	2,3-Butanediol					
Thixotropic agent		Polyamide	4	4	4	4	
		Hydrogenated castor oil	3	3	3	3	
	Sulfur-containing compound	Thiol compound (Tp)	2-Aminobenzenethiol	0.15	0.15	0.15	0.15
			4-Aminobenzenethiol	0.15	0.15	0.15	0.15
		3-Aminobenzenethiol					
Activator		Benzenethiol					
	Amine hydroiodide	2-Pipecoline•HI					
		Piperidine•HI	0.01	0.1	0.9	1.5	
	Organic acid		1,3-Diphenylguanidine•HI				
		Hydrogenated dimer acid	10	10	10	10	
		Adipic acid	3	3	3	3	
		Benzoic acid	0.1	0.1	0.1	0.1	
Amine		Phenylsuccinic acid					
		1,3-Di-o-tolylguanidine	3	3	3	3	
		3-(N-Salicyloyl)amino-1,2,4-triazole	0.2	0.2	0.2	0.2	
	Other	Acrylic resin	Ethylene acrylic acid copolymer				
Antioxidant		2,2'-Methylenebis[6-(1-methylcyclohexyl)-p-cresol]	3	3	3	3	
		Total	100,000	100,000	100,000	100,000	
	Evaluation	Change in viscosity of solder paste with time	1	1	1	2	
		Effect of suppressing void generation	2	1	1	1	

TABLE 11

[illegible]

TABLE 11-continued

Flux material	Name of formulation component	Example 75	Example 76	Example 77	Example 78	Example 79	Example 80
Other	Amine	1,3-Di-o-tolylguanidine 3-(N-Salicyloyl)amino- 1,2,4-triazole	3 0.2	3 0.2	3 0.2	3 0.2	3 0.2
	Acrylic resin	Ethylene acrylic acid copolymer	3	3	3	3	3
	Antioxidant	2,2'-Methylenebis[6-(1-methylcyclohexyl)-p-cresol]					
Evaluation	Total		100.000	100.000	100.000	100.000	100.000
	Change in viscosity of solder paste with time		1	1	1	3	1
	Effect of suppressing void generation		2	2	1	1	2

TABLE 12

Flux material	Name of formulation component	Example 81	Example 82	Example 83	Example 84	Example 85	Example 86
Solvent	Rosin	Acrylic acid-modified hydrogenated rosin	33	33	33	33	33
	Solvent (S1)	Hydrogenated rosin	30.3	30.3	30.3	30.3	30.3
	Solvent (S2)	Diethylene glycol mono-2-ethylhexyl ether					
Solvent (S31)	1,4-Butanediol					10	
	1,3-Butanediol						
	1,2-Butanediol	10					
Solvent (S32)	2-Methyl-2,4-pentanediol (hexylene glycol)		10				
	Ethylene glycol monoethyl ether (hexyl glycol)			10			
	α -Terpineol				10		
Thixotropic agent	2,3-Butanediol						10
	Polyamide	4	4	4	4	4	4
	Hydrogenated castor oil	3	3	3	3	3	3
Sulfur-containing compound (Tp)	Thiol	2-Aminobenzenethiol	0.15	0.15	0.15	0.15	0.15
		4-Aminobenzenethiol	0.15	0.15	0.15	0.15	0.15
		3-Aminobenzenethiol					
Activator	Amine hydroiodide	Benzenethiol	0.1	0.1	0.1	0.1	0.1
		2-Pipecoline•HI					
		Piperidine•HI					
Organic acid	1,3-Diphenylguanidine•HI						
	Hydrogenated dimer acid	10	10	10	10	10	10
	Adipic acid	3	3	3	3	3	3
Amine	Benzoic acid	0.1	0.1	0.1	0.1	0.1	0.1
	Phenylsuccinic acid						
	1,3-Di-o-tolylguanidine	3	3	3	3	3	3
Other	Acrylic resin	3-(N-Salicyloyl)amino- 1,2,4-triazole	0.2	0.2	0.2	0.2	0.2
	Antioxidant	Ethylene acrylic acid copolymer	3	3	3	3	3
		2,2'-Methylenebis[6-(1-methylcyclohexyl)-p-cresol]					
Evaluation	Total		100.000	100.000	100.000	100.000	100.000
	Change in viscosity of solder paste with time		1	1	1	1	3
	Effect of suppressing void generation		1	1	1	5	1

TABLE 13

Flux material	Name of formulation component	Example 87	Example 88	Example 89	Example 90	Example 91
Solvent	Rosin	Acrylic acid-modified hydrogenated rosin	33	33	33	33
	Solvent (S1)	Hydrogenated rosin	30.3	30.3	30.3	30.3
		Diethylene glycol mono-2-ethylhexyl ether				

TABLE 13-continued

Flux material	Name of formulation component	Example 87	Example 88	Example 89	Example 90	Example 91
	Solvent (S2)					
	Solvent (S31)	10	10	10	10	10
	Solvent (S32)					
Thixotropic agent	Polyamide	4	4	4	4	4
	Hydrogenated castor oil	3	3	3	3	3
Sulfur-containing compound	2-Aminobenzenethiol	0.15	0.15	0.15	0.15	0.15
compound (Tp)	4-Aminobenzenethiol	0.15	0.15	0.15	0.15	0.15
	3-Aminobenzenethiol					
	Benzenethiol					
Activator	Amine hydroiodide					
	2-Pipeccholine•HI					
	Piperidine•HI	0.1				
	1,3-Diphenylguanidine•HI		0.1			
	Amine hydrobromide			0.1		
	2-Pipeccholine•HBr					
	Piperidine•HBr				0.1	
	1,3-Diphenylguanidine•HBr					0.1
	Amine hydrochloride					
	1,3-Diphenylguanidine•HCl					
	Organic acid					
	Hydrogenated dimer acid	10	10	10	10	10
	Adipic acid	3	3	3	3	3
	Benzoic acid	0.1	0.1	0.1	0.1	0.1
	Phenylsuccinic acid					
	Amine					
	1,3-Di-o-tolylguanidine	3	3	3	3	3
	3-(N-Salicyloyl)amino-1,2,4-triazole	0.2	0.2	0.2	0.2	0.2
Other	Acrylic resin					
	Antioxidant					
	Ethylene acrylic acid copolymer					
	2,2'-Methylenebis[6-(1-methylecyclohexyl)-p-cresol]	3	3	3	3	3
	Total	100,000	100,000	100,000	100,000	100,000
Evaluation	Change in viscosity of solder paste with time	1	1	1	1	1
	Effect of suppressing void generation	3	5	5	5	5

[0219] From the results shown in Tables 10 to 13, from the comparison between Examples 68, and 81 to 84 and Example 86, it can be seen that in a case where the solvent (S1) and the solvent (S31) are combined in the solvent (S3) having a boiling point of 220° C. or lower, the viscosity change rate after 24 hours is lower and the viscosity change of the solder paste with time is easily suppressed as compared with a case where the solvent (S1) and the solvent (S32) are combined.

[0220] From the comparison between Examples 68, 81 to 84, and 86 and Example 85, it can be seen that in a case where the solvent (S1) and the solvent (S3) are combined, the generation of voids during soldering is easily suppressed in a case of being made into a solder paste as compared with a case where the solvent (S1) and the solvent (S2) are combined.

[0221] From the comparison between Examples 68, and 76 to 78 and Example 79, it can be seen that the change in viscosity of the solder paste with time can be suppressed by controlling the ratio of the solvent (S1) to the solvent (S31).

[0222] Regarding the amine hydrohalide salt, it can be confirmed that in a case of being made into a solder paste, the effect of suppressing the generation of voids during soldering is high in the following order (Examples 68, 72, and 87; Examples 88 to 91).

Amine Hydrochloride and Amine Hydrobromide<Guanidine Hydroiodide<Heteroalicyclic Amine Hydroiodide

[0223] Regarding the amine hydroiodide, it can be seen that in a case of being made into a solder paste, the effect of

suppressing the generation of voids during soldering is most excellent in a case of using 2-pipeccholine HI and piperidine HI (heteroalicyclic amine hydroiodide) (Examples 68, 72, and 87).

[0224] Hereinabove, preferable examples of the present invention have been described above, but the present invention is not limited to these examples. Additions, omissions, substitutions, and other modifications can be made without departing from the scope of the present invention. The present invention is not limited by the description above, but is limited only by the appended claims.

1. A flux comprising:

rosin;
a solvent;
a thixotropic agent;
a thiol compound; and
an activator,

wherein the thiol compound includes a compound (Tp) having a benzenethiol skeleton in which one or more hydrogen atoms on a benzene ring are substituted with a mercapto group (—SH), and
a content of the compound (Tp) is 0.005% to 0.7% by mass with respect to a total mass of the flux.

2. The flux according to claim 1,

wherein the compound (Tp) is at least one thiol compound selected from the group consisting of 2-aminobenzenethiol, 4-aminobenzenethiol, 3-aminobenzenethiol, and benzenethiol.

3. The flux according to claim 1,

wherein the activator includes an amine hydroiodide.

4. The flux according to claim 1,
wherein the solvent has both a solvent (S1) having a
boiling point of 250° C. or higher and a solvent (S3)
having a boiling point of 220° C. or lower.
5. The flux according to claim 4,
wherein the solvent (S3) is a solvent (S31) having a
boiling point of 190° C. or higher and 220° C. or lower.
6. The flux according to claim 5,
wherein a ratio of the solvent (S1) to the solvent (S31) is
55/45 or more and 95/5 or less in a mass ratio repre-
sented by solvent (S1)/solvent (S31).
7. A solder paste comprising:
a solder alloy powder; and
the flux according to claim 1.

* * * * *