

[DESCRIPTION]

[Title of Invention]

SOLDERING FLUX, SOLDER PASTE AND METHOD FOR MANUFACTURING
SOLDERING FLUX

[Technical Field]

[0001]

The present invention relates to a soldering flux used during soldering, solder paste in which the soldering flux is used and a method for manufacturing a soldering flux.

[Background Art]

[0002]

Generally, for example, when electronic components and the like are mounted on a circuit board, the electronic components and the circuit board are soldered using a reflow soldering method or the like in which the above solder paste is used.

The solder paste is configured by, for example, mixing solder powder and a soldering flux as described in Patent Literatures 1 and 2.

In the past, a viscosity or thixotropy index (TI value) of the solder paste were adjusted depending on use. Meanwhile, the TI value refers to a value computed from a viscosity in a case in which a shear velocity is low and a viscosity in a case in which the shear velocity is high.

[0003]

Here, in a case in which electronic components are mounted using solder paste, the electronic components are mounted in the following order. First, the solder paste is printed on a surface of a circuit board on which the electronic components are to be mounted using a stencil mask or the like, and bumps are formed through reflowing. After that, the electronic components are put on the formed bumps, and a heating treatment is carried out. Thereby, the electronic components and the circuit board are soldered.

In recent years, electronic components have been mounted in a highly integrated manner, and, accordingly, fine pitch printing in which solder paste is printed at minute intervals is carried out.

[Citation List]

[Patent Literature]

[0004]

[Patent Literature 1] Japanese Unexamined Patent Application Publication No. 07-075894

[Patent Literature 2] Japanese Unexamined Patent Application Publication No. 2011-136365

[Summary of Invention]

[Technical Problem]

[0005]

Meanwhile, in order to precisely carry out the fine pitch printing of solder paste, the viscosity and TI value of the solder paste are preferably set to be low in order to improve a filling property in a stencil mask or the like.

Here, in order to decrease the viscosity and TI value of the solder paste, a content of a resin component in a soldering flux is decreased. However, when the content of the resin component in the soldering flux was decreased, solder powder and the soldering flux were easily separated, which created a problem of storage stability of the solder paste degrading.

[0006]

In addition, in a case in which the fine pitch printing was carried out using solder paste having a low viscosity and a low TI value, a slump was easily caused after printing, shape retention after printing became insufficient, and there was a concern that adjacent bumps might come into contact with each other.

Based on the above facts, in the solder paste for the fine pitch printing of the related art, it was necessary to set, for example, the viscosity to 200 Pa·s or more and the TI value to 0.6 or more. Therefore, it

was not possible to ensure a filling property in a stencil mask or the like and to stably print solder paste.

[0007]

In addition, in a case in which the fine pitching printing is carried out, as the solder powder, it is necessary to use, for example, fine powder having an average particle diameter of 12 μm or less. Since fine solder powder has a large specific surface area and is easily oxidized, there is a tendency of an amount of an oxide increasing. In order to remove the oxide, it is necessary to add a strong activator to the soldering flux. However, in a case in which a strong activator was used, there was a problem of storage stability of the solder paste degrading.

[0008]

The invention has been made in consideration of the above circumstances, and an object of the invention is to provide a soldering flux which is excellent in terms of shape retention and storage stability of paste after printing and can ensure a filling property even when a viscosity and a TI value are set to be low, solder paste and a method for manufacturing a soldering flux.

[Solution to Problem]

[0009]

In order to solve the above problems and achieve the

above object, the soldering flux of the invention is a soldering flux including rosin, a thixotropic agent, an activator, an antioxidant and a solvent, in which rosin ester is included as the rosin, a content of the rosin ester is set in a range of 20 mass% to 50 mass% with respect to the entire flux, and one or two or more selected from polyamides, cured castor oil, derivatives thereof and hydrocarbon-based waxes are included as the thixotropic agent.

[0010]

In the soldering flux of the invention, rosin ester is included as the rosin, and the content of the rosin ester is set in a range of 20 mass% to 50 mass% with respect to the entire flux. When a relatively large amount of rosin ester which is a resin component is included, it is possible to suppress separation of the soldering flux and the solder powder, and it becomes possible to ensure shape stability after printing. In addition, the rosin ester can suppress an increase in the viscosity and TI value of the paste even at a large content.

In addition, since one or two or more selected from polyamides, cured castor oil, derivatives thereof and hydrocarbon-based waxes are included as the thixotropic agent, it is possible to optimize the viscosity and the TI

value, and it becomes possible to ensure shape stability after printing.

Therefore, it becomes possible to configure the solder paste which has a low viscosity and a low TI value, is excellent in terms of a filling property, and is excellent in terms of shape retention after printing and storage stability.

[0011]

Meanwhile, in a case in which the content of the rosin ester is less than 20 mass% with respect to the entire flux, when a large amount of rosin which is a resin component is included, the viscosity increases, and there is a concern that it may become impossible to ensure an optimum filling property. On the other hand, in a case in which the content of the rosin ester exceeds 50 mass% with respect to the entire flux, activity of the soldering flux is not sufficient, and there is a concern that the flux may be poorly fused.

Based on the above facts, in the invention, the content of the rosin ester may be set in a range of 20 mass% to 50 mass% with respect to the entire flux.

[0012]

Here, in the soldering flux of the invention, one or two or more selected from salicylic acid, 2,3-dibromosuccinic acid and triethanolamine are preferably

included as the activator.

In a case in which fine solder powder is used, since the specific surface area of the solder powder becomes large, the solder powder comes to include much oxide. Therefore, when one or two or more selected from salicylic acid, 2,3-dibromosuccinic acid and triethanolamine are included as the activator included in the soldering flux, it is possible to sufficiently remove the oxide, and it becomes possible to favorably carry out soldering.

[0013]

In addition, in the soldering flux of the invention, butylated hydroxytoluene is preferably included as the antioxidant.

A preferable example of butylated hydroxytoluene is dibutyl hydroxyl toluene. Dibutyl hydroxyl toluene has an action of efficiently suppressing oxidation of the solder powder by being adsorbed on surfaces of the solder powder. Therefore, when dibutyl hydroxyl toluene is used as the antioxidant, even in a case in which fine solder powder is used, it is possible to suppress surface oxidation of the solder powder, and it becomes possible to favorably carry out soldering.

[0014]

The solder paste of the invention includes the solder powder and the soldering flux described above, and

the content of the solder powder is set to 70 mass% to 95 mass%.

Since the solder paste having the above configuration includes the soldering flux described above, the viscosity and the TI value are low, a filling property is excellent, shape retention and storage stability after printing are excellent, the fine pitch printing can be favorably carried out, and it is possible to satisfy highly integrated mounting of electronic components.

[0015]

Here, in the solder paste of the invention, a viscosity η_{10} at 25°C and 10 rpm is preferably set in a range of 100 Pa·s to 150 Pa·s, and a TI value computed from a viscosity η_3 at 25°C and 3 rpm, a shear velocity D_3 ($=1.8 \text{ sec}^{-1}$), a viscosity η_{30} at 25°C and 30 rpm and a shear velocity D_{30} ($=18 \text{ sec}^{-1}$) using
$$TI = \log(\eta_3 / \eta_{30}) / \log(D_{30} / D_3) = \log(\eta_3 / \eta_{30}) / \log(18 / 1.8)$$
 is preferably set in a range of 0.25 to 0.5.

In this case, since the viscosity and the TI value are suppressed to be low, a filling property improves, and it becomes possible to favorably carry out the fine pitch printing.

[0016]

In a case in which the viscosity η_{10} at 25°C and 10 rpm is less than 100 Pa·s, there is a concern that shape

stability after printing may deteriorate. On the other hand, in a case in which the viscosity η_{10} exceeds 150 Pa·s, there is a concern that poor filling may occur during paste printing.

Based on the above facts, in the invention, the viscosity η_{10} at 25°C and 10 rpm is set in a range of 100 Pa·s to 150 Pa·s.

[0017]

In addition, in a case in which the TI value computed from the viscosity η_3 , the shear velocity D_3 ($=1.8 \text{ sec}^{-1}$) at 25°C and 3 rpm, the viscosity η_{30} and the shear velocity D_{30} ($=18 \text{ sec}^{-1}$) at 25°C and 30 rpm using $TI = \log(\eta_3/\eta_{30})/\log(D_{30}/D_3) = \log(\eta_3/\eta_{30})/\log(18/1.8)$ is less than 0.25, a stencil mask becomes easily clogged during printing, and there is a concern that printing may become poor. In addition, there is a concern that the soldering flux and the solder powder may be easily separated. On the other hand, in a case in which the TI value exceeds 0.5, there is a concern that poor filling may occur during paste printing.

Based on the above facts, in the invention, the TI value is set in a range of 0.25 to 0.5.

[0018]

A method for manufacturing a soldering flux of the invention is a method for manufacturing a soldering flux

in which the above soldering flux is manufactured, and includes a solvent-heating step in which a solvent is heated; a rosin-adding step in which rosin is added to the solvent and stirred; a thixotropic agent-adding step in which the solvent to which the rosin has been added is cooled, a thixotropic agent is added and stirred; and an activator and antioxidant-adding step in which the solvent to which the thixotropic agent has been added is further cooled, and an activator and an antioxidant are added, in which, in the thixotropic agent-adding step, a stirring velocity during the addition of the thixotropic agent is set to be higher than a stirring velocity in the rosin-adding step, and the thixotropic agent is dispersed.

[0019]

In the method for manufacturing a soldering flux having the above configuration, since the stirring velocity during the addition of the thixotropic agent is set to be higher than the stirring velocity in the rosin-adding step, and the thixotropic agent is sufficiently dispersed in the thixotropic agent-adding step, it is possible to improve shape retention after printing.

In addition, since the activator and the antioxidant are added after the solvent has been cooled, it is possible to suppress thermal decomposition of the activator and the antioxidant, and it is possible to

improve an oxide-removing performance on solder powder surfaces and the storage stability of the solder paste. Therefore, even in a case in which fine powder is used as the solder powder, it is possible to ensure favorable wettability and the storage stability of the solder paste.

Furthermore, since the rosin, the thixotropic agent, the activator, the antioxidant and the solvent are mixed in a step of one-time heating and one-time cooling, it is possible to reduce energy costs spent in manufacturing the soldering flux.

[Advantageous Effects of Invention]

[0020]

According to the invention, it is possible to provide a soldering flux which is excellent in terms of shape retention and storage stability of paste after printing and can ensure a filling property even when a viscosity and a TI value are set to be low, solder paste and a method for manufacturing a soldering flux.

[Brief Description of Drawing]

[0021]

Fig. 1 is a flow chart illustrating a method for manufacturing a soldering flux which is an embodiment of the invention.

[Description of Embodiments]

[0022]

Hereinafter, a soldering flux and solder paste which are embodiments of the invention will be described.

The soldering flux and the solder paste which are the embodiments of the invention are used when electronic components are mounted on surfaces of circuit boards. More specifically, the soldering flux and the solder paste are used when, for example, area array bumps having pitches of 150 μm or less are formed.

[0023]

First, the soldering flux which is the embodiment will be described. The soldering flux contains rosin, a thixotropic agent, an activator, an antioxidant and a solvent. Also, a surfactant may be added in addition to what has been listed above.

A composition of the soldering flux which is the embodiment is 30 mass% to 70 mass% of the rosin, 1 mass% to 10 mass% of the thixotropic agent, 2 mass% to 7 mass% of the activator and 0.1 mass% to 2.0 mass% of the antioxidant with a remainder being the solvent.

[0024]

Rosin ester is included as the rosin which is a resin component, and a content of the rosin ester is set in a range of 20 mass% to 50 mass% with respect to the

entire soldering flux.

Meanwhile, the soldering flux which is the embodiment contains two kinds of rosin, hydrogenated rosin and rosin ester, as the rosin. It is possible to use polymerized rosin, a rosin-denatured phenol resin, a rosin-denatured maleic acid resin or acrylic rosin.

[0025]

One or two or more selected from polyamides, cured castor oil, derivatives thereof (amide-denatured castor oil and hydrogenated castor oil) and hydrocarbon-based waxes (Vaseline, paraffin waxes and the like) are included as the thixotropic agent.

Meanwhile, in the soldering flux which is the embodiment, a polyamide and a paraffin wax are used as the thixotropic agents.

[0026]

As the activator, it is possible to use lactic acid, stearic acid, anthranilic acid, oxalic acid, butyric acid, citric acid, glutaric acid, adipic acid, salicylic acid, succinic acid, 2,3-dibromosuccinic acid, diethyl phosphoric acid, triethyl phosphoric acid, dimethyl hydrochloride, pyridine hydrobromide, anilinium chloride, 2-ethylimidazole, diethanolamine, triethanolamine and the like.

In the soldering flux which is the embodiment, one

or two selected from salicylic acid and 2,3-dibromosuccinic acid are included as the activator.

[0027]

As the antioxidant, it is possible to use butyl hydroxyanisole, dibutyl hydroxyl toluene, glycine, hydroquinone and the like.

In the soldering flux which is the embodiment, dibutyl hydroxyl toluene is included as the antioxidant.

[0028]

As the solvent, it is possible to use glycol-based solvents (ethylene glycol; diethylene glycol; dipropylene glycol; triethylene glycol; hexylene glycol; 1,5-pentanediol, propylene glycol monomethyl ether, methyl carbitol, butyl carbitol, triethylene glycol monomethyl ether, triethylene glycol dimethyl ether, tetraethylene glycol dimethyl ether, diethylene glycol monomethyl ether, diethylene glycol monohexyl ether, ethylene glycol monophenyl ether, diethylene glycol monophenyl ether, diethylene glycol-2-ethylhexyl ether, ethylene glycol monobutyl ether and diethylene glycol monobutyl ether), alcohol-based solvents (isopropyl alcohol and 2-butoxyethanol) and the like.

In the soldering flux which is the embodiment, diethylene glycol monobutyl ether is used as the solvent.

[0029]

Meanwhile, a surfactant may be added depending on use. As the surfactant, for example, levulinic acid can be used. An addition amount of the surfactant is preferably 0.1 mass% to 2.0 mass%.

[0030]

Next, the solder paste which is the embodiment will be described.

The solder paste which is the embodiment includes solder powder and the soldering flux which is the embodiment, in which a content of the solder powder is set to 70 mass% to 95 mass%.

In the solder paste which is the embodiment, a Sn-Ag-Cu alloy that is made into fine powder having an average particle diameter of 12 μm or less is used as the solder powder.

[0031]

In the solder paste which is the embodiment, a viscosity η_{10} at 25°C and 10 rpm is set in a range of 100 Pa·s to 150 Pa·s.

Furthermore, in the solder paste which is the embodiment, a TI value computed from a viscosity η_3 , a shear velocity D_3 ($=1.8 \text{ sec}^{-1}$) at 25°C and 3 rpm, a viscosity η_{30} and a shear velocity D_{30} ($=18 \text{ sec}^{-1}$) at 25°C and 30 rpm using
$$\text{TI} = \log(\eta_3/\eta_{30}) / \log(D_{30}/D_3) = \log(\eta_3/\eta_{30}) / \log(18/1.8)$$
 is set in

a range of 0.25 to 0.5.

Here, in the embodiment, the viscosities η_{10} , η_3 and η_{30} of the solder paste are measured using a spiral viscometer manufactured by Malcom Company Limited.

[0032]

Next, the method for manufacturing a soldering flux which is the embodiment will be described with reference to Fig. 1.

The solvent is put into a container having a thermometer and a stirrer, and heated (solvent-heating step S01). Rosin is added to the heated solvent (rosin-adding step S02).

In the solvent-heating step S01, a heating temperature is preferably adjusted depending on the kind and addition amount of the solvent and the kind and addition amount of the rosin. In the embodiment, the heating temperature is set in a range of 70°C to 200°C.

In addition, in the rosin-adding step S02, the solvent and the rosin are stirred at a low speed so as to be uniformly mixed.

Meanwhile, when the rosin is added to the solvent, and heated under stirring, the solvent-heating step S01 and the rosin-adding step S02 may be carried out at the same time.

[0033]

When the rosin is uniformly dispersed in the solvent, a solution is cooled to an addition temperature of the thixotropic agent under stirring at a low speed, and the thixotropic agent is added (thixotropic agent-adding step S03).

In the thixotropic agent-adding step S03, the addition temperature is preferably adjusted depending on the kind of thixotropic agent. In the embodiment, the addition temperature of the thixotropic agent is set in a range of 30°C to 80°C.

In the thixotropic agent-adding step S03, the solution is stirred at a high speed so that the thixotropic agent is reliably dispersed. A stirring speed in the thixotropic agent-adding step S03 is preferably set to be twice or more the stirring speed in the rosin-adding step S02. In addition, a stirring time is preferably set to 10 minutes or more.

Meanwhile, in the thixotropic agent-adding step S03, it is preferable that the solution be stirred at a high speed, and then further stirred at a low speed for 10 minutes or more in a state in which the addition temperature of the thixotropic agent is held.

[0034]

Next, the solution is cooled to an addition temperature of the activator and the antioxidant under

stirring at a low speed, and the activator and the antioxidant are added (activator and antioxidant-adding step S04).

In the activator and antioxidant-adding step S04, an addition temperature is preferably adjusted depending on the kind and addition amount of the activator and the kind and addition amount of the antioxidant. In the embodiment, the addition temperature of the activator and the antioxidant is set in a range of 25°C to 70°C.

[0035]

After it is confirmed that the entire solution becomes uniform, the solution is cooled to room temperature.

[0036]

The soldering flux which is the embodiment is manufactured using the above steps.

The soldering paste which is the embodiment is manufactured by mixing the solder powder and the soldering flux.

In addition, when the solder paste which is the embodiment is printed on a surface of a circuit board on which electronic components are to be mounted using fine pitch printing in which a stencil mask is used, area array bumps having pitches of 150 μm or less are formed, and the electronic components are mounted on the circuit board.

[0037]

According to the soldering flux and the solder paste which are the embodiments having the above configurations, since rosin ester is included as the rosin which is a resin component, and the content of the rosin ester is set in a range of 20 mass% to 50 mass% with respect to the entire flux, it is possible to suppress separation of the soldering flux and the solder powder, and it becomes possible to ensure shape stability after printing. In addition, the rosin ester can suppress an increase in the viscosity and TI value even at a large content so that a filling property in a stencil mask or the like improves and it becomes possible to precisely print the paste.

[0038]

According to the soldering flux and the solder paste which are the embodiments, since one or two or more selected from polyamides, cured castor oil, derivatives thereof and hydrocarbon-based waxes are included as the thixotropic agent, it is possible to optimize the viscosity and the TI value of the solder paste, and it becomes possible to ensure shape stability after printing.

Therefore, it is possible to provide the solder paste which has a low viscosity and a low TI value, is excellent in terms of a filling property, and is excellent in terms of shape retention after coating.

[0039]

According to the soldering flux and the solder paste which are the embodiments, since one or two or more selected from salicylic acid, 2,3-dibromosuccinic acid and triethanolamine are included as the activator, even when fine solder powder is used, it is possible to sufficiently suppress surface oxidation of the solder powder.

According to the soldering flux and the solder paste which are the embodiments, since dibutyl hydroxyl toluene is included as the antioxidant, it is possible to efficiently suppress oxidation of the solder powder, and to sufficiently suppress surface oxidation of the solder powder even when fine solder powder is used.

[0040]

According to the solder paste which is the embodiment, since the solder powder and the above soldering flux are included, and the content of the solder powder is set to 70 mass% to 95 mass%, the viscosity and the TI value are low, a filling property is excellent, shape retention and storage stability after coating are excellent, the fine pitch printing can be favorably carried out, and it is possible to satisfy highly integrated mounting of electronic components.

[0041]

According to the solder paste which is the

embodiment, since the viscosity η_{10} at 25°C and 10 rpm is set in a range of 100 Pa·s to 150 Pa·s, and the TI value computed from the viscosity η_3 , the shear velocity D_3 ($=1.8 \text{ sec}^{-1}$) at 25°C and 3 rpm, the viscosity η_{30} and the shear velocity D_{30} ($=18 \text{ sec}^{-1}$) at 25°C and 30 rpm using $TI = \log(\eta_3/\eta_{30})/\log(D_{30}/D_3) = \log(\eta_3/\eta_{30})/\log(18/1.8)$ is set in a range of 0.25 to 0.5, a filling property improves, and it becomes possible to favorably carry out the fine pitch printing.

[0042]

According to the method for manufacturing a soldering flux which is the embodiment, since the solvent-heating step in which the solvent is heated, the rosin-adding step in which the rosin is added to the solvent and stirred, the thixotropic agent-adding step in which the solvent to which the rosin has been added is cooled, the thixotropic agent is added and stirred and the activator and antioxidant-adding step in which the solvent to which the thixotropic agent has been added is further cooled, and the activator and the antioxidant are added are included, and, in the thixotropic agent-adding step, a stirring velocity during the addition of the thixotropic agent is set to be higher than a stirring velocity in the rosin-adding step, and the thixotropic agent is dispersed, the thixotropic agent is sufficiently dispersed, and it is

possible to improve shape retention after printing.

[0043]

In addition, since the activator and the antioxidant are added after the solvent has been cooled, it is possible to suppress thermal decomposition of the activator and the antioxidant, and it is possible to improve an oxide-removing performance on surfaces of the solder powder in the solder paste and the storage stability of the solder paste. Therefore, even in a case in which fine powder is used as the solder powder, it is possible to ensure favorable wettability and the storage stability of the solder paste.

Furthermore, since the rosin, the thixotropic agent, the activator, the antioxidant and the solvent are mixed in a step of one-time heating and one-time cooling, it is possible to reduce energy costs spent in manufacturing the soldering flux.

[0044]

Thus far, the embodiments of the invention have been described, but the invention is not limited thereto, and can be appropriately modified within the scope of technical ideas of the invention.

For example, raw materials and blending amounts of the soldering flux and the solder paste are not limited to what has been described in the embodiments, and other

solvents, solder powder and the like may be used.

[Examples]

[0045]

Hereinafter, the results of confirmatory experiments carried out to confirm the effects of the invention will be described.

A soldering flux having a composition described in Table 1 was produced in an order illustrated in Fig. 1.

A solvent and rosin were added to a container having a thermometer and a rotary stirrer, and heated to 120°C under stirring. At this time, a stirring speed (rotation speed) was set to 100 rpm.

In a state in which a solution was cooled and held at 60°C, a thixotropic agent was added. At this time, the solution was stirred at a stirring speed (rotation speed) of 300 rpm for 10 minutes or more, and then stirred at 150 rpm for 10 minutes or more.

Next, after the solution was cooled to 50°C or lower, an activator and an antioxidant were added, and stirred until the entire solution becomes uniform.

[0047]

The obtained soldering flux and solder powder were mixed, thereby producing solder paste described in Table 2.

In addition, a viscosity (a viscosity η_{10} at 25°C and 10 rpm) and a TI value (a TI value computed from a viscosity η_3 at 25°C and 3 rpm, a shear velocity D_3 ($=1.8 \text{ sec}^{-1}$), a viscosity η_{30} at 25°C and 30 rpm and a shear velocity D_{30} ($=18 \text{ sec}^{-1}$) using $\text{TI} = \log(\eta_3/\eta_{30})/\log(D_{30}/D_3) = \log(\eta_3/\eta_{30})/\log(18/1.8)$) of the obtained solder paste were measured using a spiral viscometer (PCU-205 manufactured by Malcom Company Limited). The measurement results are described in Table 2.

[0048]

[Table 2]

		Invention Example 11	Invention Example 12	Invention Example 13	Invention Example 14	Invention Example 15	Comparative Example 11	Comparative Example 12
Solder powder	Composition	SAC305	SAC305	SAC305	SAC305	SAC305	SAC305	SAC305
	Particle diameter	2 μm to 12 μm	5 μm to 15 μm	2 μm to 12 μm	5 μm to 15 μm	2 μm to 12 μm	2 μm to 12 μm	2 μm to 12 μm
	Content (mass%)	89.5	89.0	89.5	89.0	89.5	89.5	89.5
Flux		Invention Example 1	Invention Example 2	Invention Example 3	Invention Example 4	Invention Example 5	Comparative Example 1	Comparative Example 2
Viscosity (Pa·s)		113	107	136	140	122	187	130
TI value		0.28	0.32	0.45	0.35	0.42	0.31	0.45

[0049]

Next, solder ball tests were carried out on the obtained solder paste. In addition, storage stability, printability, shape retention after printing and shape retention after a thermal treatment were evaluated in the following manner.

[0050]

(Solder ball test)

Tests and evaluations were carried out based on IPC-TM-650 No. 2.4.43 Solder paste-solder ball test.

Using a stencil mask having a diameter of 6.5 mm, a thickness of 0.2 mm and three or more openings, solder paste to be evaluated was printed on an aluminum substrate using a spatula. The aluminum substrate on which the solder paste had been printed was heated on a hot plate at $242^{\circ}\text{C} \pm 3^{\circ}\text{C}$ for 20 seconds so as to carry out a reflow treatment.

Obtained solder balls were observed, solder balls displaying no micro balls observed around the main ball were evaluated to be "preferred", solder balls with few micro balls surrounding the main ball were evaluated to be "acceptable", solder balls with many micro balls in clusters were evaluated to be "unacceptable: cluster", and solder balls with many micro balls surrounding the main ball were evaluated to be "unacceptable". Meanwhile,

"preferred" and "acceptable" are considered as Pass. The evaluation results are described in Table 3.

[0051]

(Storage stability)

The obtained paste was stored at 4°C in the atmosphere, and separation status of the flux and the solder powder in the paste after 3 months was evaluated. Paste in which separation was observed was evaluated as "Yes", and paste in which separation was not observed was evaluated as "No". The evaluation results are described in Table 3.

In addition, similarly, the paste was stored at 4°C in the atmosphere, and a viscosity (the viscosity η_{10} at 25°C and 10 rpm) of the paste after 3 months was measured. The measured viscosity was compared with a viscosity measured 3 months before, paste having a change amount of the viscosity of ± 20 Pa·s and a viscosity in a range of 100 Pa·s to 150 Pa·s was evaluated as "allowable", and paste having a viscosity outside the above range was evaluated as "unallowable". The evaluation results are described in Table 3.

[0052]

(Printability/ shape retention after printing)

The solder paste was printed using a Hitachi cream solder printer NP-04MB manufactured by Hitachi, Ltd. At

this time, three stencil masks (thickness 35 μm) having pitches of 150 μm (mask opening diameter 115 μm), 180 μm (mask opening diameter 130 μm) and 200 μm (mask opening diameter 140 μm) were used.

The occurrence of clogging at the mask opening portion was checked. In addition, the shapes of the printed paste in the respective masks were observed using a microscope and evaluated. Masks which were sufficiently filled with the paste and had no contact between adjacent bumps observed were evaluated as "favorable", and masks which were insufficiently filled with the paste or had contact between adjacent bumps observed were evaluated as "unallowable". The evaluation results are described in Table 3.

[0053]

(Shape retention after thermal treatment)

A reflow treatment (in a nitrogen atmosphere, a peak temperature of 250°C, 3 minutes) was carried out on the printed solder paste, and the occurrence of contact between adjacent bumps (bridging) was evaluated. The evaluation results are described in Table 3.

[0054]

[Table 3]

	Invention Example 11 Acceptable	Invention Example 12 Preferred	Invention Example 13 Preferred	Invention Example 14 Preferred	Invention Example 15 Acceptable	Comparative Example 11 Preferred	Comparative Example 12 Unacceptable
Solder ball test							
Storage stability (separation of powder)	No	No	No	No	No	No	No
Storage stability (change in viscosity over time)	Favorable	Favorable	Favorable	Favorable	Favorable	Unallowable	Favorable
Printability (clogging)	No	No	No	No	No	No	No
Shape retention after printing	150 μ m pitch	Favorable	Favorable	Favorable	Favorable	Unallowable	Favorable
	180 μ m pitch	Favorable	Favorable	Favorable	Favorable	Favorable	Favorable
	200 μ m pitch	Favorable	Favorable	Favorable	Favorable	Favorable	Favorable
Shape retention after thermal treatment (occurrence of bridging)	No	No	No	No	No	No	No

[0055]

In solder paste of Comparative Example 11 in which a soldering flux of Comparative Example 1 having a content of a rosin ester below the range of the invention was used, the viscosity η_{10} at 25°C and 10 rpm was as relatively high as 187 Pa·s. In addition, the shape retention after printing at a pitch of 150 μm was insufficient. Furthermore, a change in the viscosity over time was observed after 3 months of storage, and it was confirmed that the storage stability deteriorated.

[0056]

In solder paste of Comparative Example 12 in which a soldering flux of Comparative Example 2 having a content of the rosin ester above the range of the invention was used, as a result of the solder ball test, the solder balls were fully surrounded by much non-agglomerated powder, and evaluated as "unacceptable".

[0057]

In contrast to what has been described above, in soldering fluxes of Invention Examples 1 to 5 and solder paste of Invention Examples 11 to 15, separation of the flux and the solder powder was not observed even after 3 months of storage, the viscosity only slightly changed over time, and the storage stability was excellent. In addition, in solder paste of Invention Examples 11 to 15,

the viscosities η_{10} at 25°C and 10 rpm were set in a range of 100 Pa·s to 150 Pa·s, TI values computed using $TI = \log(\eta_3/\eta_{30})/\log(18/1.8)$ were set in a range of 0.25 to 0.5, and printability, shape stability after printing and shape stability after the thermal treatment were excellent. In addition, the results of the solder ball tests were also favorable.

[0058]

As a result of the above confirmatory experiments, it was confirmed that, according to the invention, it is possible to provide a soldering flux and solder paste which are excellent in terms of shape retention after printing and storage stability and can ensure a filling property.

[Industrial Applicability]

[0059]

Electronic circuits can be assembled more effectively and efficiently by providing a soldering flux and a solder paste with suitable properties and a higher stability.

[Reference Signs List]

[0060]

S01: Solvent-heating step

S02: Rosin-adding step

S03: Thixotropic agent-adding step

S04: Activator and antioxidant-adding step

CLAIMS

[Claim 1]

A soldering flux comprising:

rosin;

a thixotropic agent;

an activator;

an antioxidant; and

a solvent,

wherein rosin ester is included as the rosin, a content of the rosin ester is set in a range of 20 mass% to 50 mass% with respect to the entire flux, and

one or two or more selected from polyamides, cured castor oil, derivatives thereof and hydrocarbon-based waxes are included as the thixotropic agent.

[Claim 2]

The soldering flux according to Claim 1,

wherein one or two or more selected from salicylic acid, 2,3-dibromosuccinic acid and triethanolamine are included as the activator.

[Claim 3]

The soldering flux according to Claim 1 or 2,

wherein butylated hydroxytoluene is included as the antioxidant.

[Claim 4]

Solder paste comprising:

solder powder; and
the soldering flux according to any one of Claims 1 to 3,
wherein a content of the solder powder is set to 70 mass% to 95 mass%.

[Claim 5]

The solder paste according to Claim 4,
wherein a viscosity η_{10} at 25°C and 10 rpm is set in a range of 100 Pa·s to 150 Pa·s, and
a TI value computed from a viscosity η_3 , a shear velocity D_3 ($=1.8 \text{ sec}^{-1}$) at 25°C and 3 rpm, a viscosity η_{30} and a shear velocity D_{30} ($=18 \text{ sec}^{-1}$) at 25°C and 30 rpm using $TI = \log(\eta_3/\eta_{30})/\log(D_{30}/D_3) = \log(\eta_3/\eta_{30})/\log(18/1.8)$ is set in a range of 0.25 to 0.5.

[Claim 6]

A method for manufacturing a soldering flux in which the soldering flux according to any one of Claims 1 to 3 is manufactured, comprising:

a solvent-heating step in which a solvent is heated;
a rosin-adding step in which rosin is added to the solvent and stirred;

a thixotropic agent-adding step in which the solvent to which the rosin has been added is cooled, a thixotropic agent is added and stirred; and

an activator and antioxidant-adding step in which

the solvent to which the thixotropic agent has been added is further cooled, and an activator and an antioxidant are added,

wherein, in the thixotropic agent-adding step, a stirring velocity during the addition of the thixotropic agent is set to be higher than a stirring velocity in the rosin-adding step, and the thixotropic agent is dispersed.