

**METHOD FOR BRAZING BY SOLDER REFLOW ELECTRONIC
COMPONENTS USING PRE-DEPOSITS OF SOLDER ALLOY AND
BRAZING DEVICE THEREFOR**

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The present invention relates to a process for the reflow soldering of electronic components to a substrate (for example a printed-circuit board) and it
10 also relates to a soldering apparatus for the implementation of such a process.

The two methods most commonly used for carrying out a soldering operation are "wave soldering" and "reflow soldering".

15 In the first case, that is to say wave soldering, the soldering consists in bringing the boards carrying the electronic components to be soldered into contact with one or more waves of liquid solder alloy which are obtained by making a solder bath
20 contained in a tank circulate by means of a nozzle. Generally speaking, the substrates are prefluxed in an upstream zone, using a flux spray or a flux foam, and are then preheated so as to activate the fluxes deposited beforehand, so as to clean the surfaces to be
25 soldered, for the removal of oxides, organic contaminants, etc.

In the second, "reflow", soldering technique, a certain amount of solder alloy is used at points of connection to the components on the circuit, for
30 example by screen-printing a solder paste, containing a mixture of a metal alloy and a flux, on the printed circuit before the components to be soldered are deposited thereon.

Another recent technology consists in that the
35 solder alloy was predeposited one or more times on the substrate at points of connection to the components, the predeposited spots(s) being reflowed ("reflow"), this generally being followed by an operation of planarizing the surface of the previously reflowed

predeposited spots (formation of "bumps" - reference may be made to the industrially available SIPADTM or OPTIPADTM processes), or even by the fact that the solder alloy was predeposited, in the case of certain components, on terminations on the actual components.

It is only then that the operation of positioning the components on the substrate is carried out.

The substrate provided with the components is then inserted into a reflow oven so as to provide the quantity of heat necessary for allowing the metal alloy to reflow and allowing the fluxing element contained in the paste or predeposited material to be activated.

As in the case of wave soldering, this technique requires the use of a flux so as to clean the surfaces to be soldered. The use of these fluxes has a certain number of drawbacks, especially because of their cost and of the residues that they leave on the boards, this tending to cause problems of reliability of the electronic boards thus designed. It is therefore necessary, with these techniques, to provide an additional step for cleaning the boards after soldering, which step usually employs chlorinated solvents whose use tends to be greatly limited by regulations currently in force. Furthermore, this additional cleaning step tends to increase the cost of manufacturing the circuits significantly.

Moreover, there is a strong tendency in the microelectronics industry to move towards miniaturization and to an extremely high level of integration on the circuits (number of inputs/outputs on the components) with, in particular, the appearance of new types of components having a very high number of connections and complex geometries for connecting to the circuit, such as the components called, in this field, BGA or Flip Chip.

It is known, for example, that the performance of BGA components is extremely attractive for the industry, but these components also have a certain

number of drawbacks due especially to the fact that the solder connections and joints are not along the sides of the component (in the form of the conventional leads) but are located under the component, making it
5 very difficult both to clean and to make any repairs to).

Reference will be made, regarding these new components and new solder deposition technologies, to the various articles in the journal "Advanced
10 Packaging", July/August 1997.

Documents EP-658,391 and EP-747,159 in the name of the Applicant had proposed processes and plants for the dry fluxing, before soldering or tinning, using gas mixtures containing excited or unstable chemical
15 species and being substantially free of electrically charged species.

Studies completed by the Applicant have shown that these processes could be further improved in the case of reflow soldering, particular in order to allow
20 the reflow conditions for the new generations of components to be improved.

The subject of the invention is especially to provide a response to the technical problems mentioned above.

25 The subject of the invention is therefore a process for the reflow soldering of electronic components to a substrate, during which:

- a certain amount of solder alloy is used,
- the components are placed at points of
30 connection to the substrate and

- an actual operation of soldering the components is carried out using the said solder alloy, by heat treatment of the substrate ,

characterized by the combined implementation of
35 the following steps:

- the said solder alloy is used according to one or more of the following methods:

- i) the solder alloy was predeposited one or more times on the substrate at the or some of the

points of connection to the components, the predeposited spots then having undergone a reflow operation;

5 j) the solder alloy was predeposited one or more times at points/terminations on the actual components, the predeposited spots then having undergone a reflow operation;

- prior to the step of depositing the components, some curable adhesive is deposited at
10 points of bonding to the substrate and the said adhesive is then cured so as to bond the components to the substrate at the points of bonding;

- prior to the soldering operation, a dry-fluxing operation is carried out, in which this
15 substrate is fluxed by bringing it into contact with a fluxing atmosphere at a pressure close to atmospheric pressure, the said fluxing atmosphere containing excited or unstable species and being substantially free of electrically charged species.

20 The process according to the invention may furthermore include one or more of the following steps:

- the fluxing atmosphere is obtained by passing an initial fluxing gas through an electrical discharge;

- the initial fluxing gas comprises a reducing
25 gas mixture containing hydrogen;

- the fluxing atmosphere is obtained at a gas outlet of a device for forming excited or unstable species, in which device the initial fluxing gas has been transformed;

30 - the said operation of fluxing the substrate is carried out prior to depositing adhesive, or thereafter;

- the said operation of fluxing the substrate is carried out after the components have been deposited
35 on the substrate;

- the process continues with the said heat treatment of the substrate in order to carry out the said soldering of the components using the said solder alloy, by bringing the substrate into contact with a

treatment atmosphere, at a pressure close to atmospheric pressure, the said treatment atmosphere containing excited or unstable chemical species and being substantially free of electrically charged species, the atmosphere being obtained by passing an initial treatment gas through an electrical discharge and the heat treatment of the substrate being obtained by means of the chemical species thus heated under the action of the discharge;

10 - the initial treatment gas comprises a reducing gas mixture containing hydrogen;

 - the treatment atmosphere is obtained at a gas outlet of a device for forming excited or unstable species, in which device the initial treatment gas has been transformed;

15 - the steps of placing the components and of soldering are carried out on both large faces of the substrate, the said fluxing operation being carried out by means of two devices for forming excited or unstable chemical species, each device being opposite one of the faces of the substrate;

20 - the steps of placing the components and of soldering are carried out on both large faces of the substrate, the said treatment operation being carried out by means of two devices for forming excited or unstable chemical species, each device being opposite one of the faces of the substrate;

25 - the process furthermore includes a step of cooling the substrate, after the soldering, by passing the substrate through a cooling atmosphere, containing an inert gas;

30 - the alloy predeposition underwent, after reflow, an operation of planarizing its surface.

35 The subject of the invention is also an apparatus for the reflow soldering of electronic components to a support using a solder alloy, for the implementation of the process described above, characterized in that it comprises a member for conveying substrates carrying, on at least one of their

face [sic], the components to be soldered at points of connection to the substrate, the conveying member transferring the substrates past first means allowing the spots of adhesive present at points of bonding to the substrate to be cured, and past second means comprising at least one device for forming a fluxing atmosphere containing excited or unstable chemical species and being substantially free of electrically charged species, which fluxing atmosphere can be used, at a pressure close to atmospheric pressure, in order for the substrate to undergo dry fluxing.

According to one of the embodiments of the invention, the second means are located upstream of the first means.

According to another of the embodiments of the invention, the second means are located downstream of the first means.

Advantageously, the apparatus includes, along the conveying member, downstream of the first and second means, at least one device for forming a treatment atmosphere containing excited or unstable chemical species and being substantially free of electrically charged species, the temperature of which treatment atmosphere makes it usable for carrying out a heat treatment of the substrate, for the purpose of carrying out the actual soldering of the components.

The expression "pressure close to atmospheric pressure" should be understood to mean, according to the invention, a pressure lying advantageously within the range $[0.1 \times 10^5 \text{ Pa}, 3 \times 10^5 \text{ Pa}]$.

As will have been understood on reading the foregoing, the "substrate" to which the components according to the invention are soldered may vary greatly in nature, depending on the various substrates used in the electronics industry, and the same applies just as well of course to the electronic components to be soldered. By way of illustration, the substrates may be of the printed-circuit type (whatever their surface state or finish) or else, for example, metallized

ceramic substrates such as hybrid circuits, or even the bottoms of packages to which circuits have to be soldered in an overall encapsulation process.

5 Likewise, the components involved could be extremely varied, ranging from conventional passive or active electronic components to components which are more complex and difficult to handle, whether they are encapsulated or bare-chip components (BGA, MCM, Flip Chips, etc.). The "components" according to the
10 invention may also consist of circuits that have to be soldered to another substrate or to the bottom of a package before encapsulation.

Further characteristics and advantages will emerge from the following description, given solely by
15 way of example and with reference to the appended drawings in which:

- Figure 1 is a diagrammatic view of a soldering apparatus for the implementation of the process according to the invention;

20 - Figure 2 is a diagrammatic sectional view of an example of a module for forming excited or unstable chemical species used in the make-up of the apparatus in Figure 1.

Figure 1 shows a general view of a reflow
25 soldering apparatus suitable for the implementation of the process according to the invention.

This apparatus comprises a conveying member 10 having a belt 12, shown in dotted lines, placed in an enclosure 14 and extending between two guide rollers 16
30 and 18, at least one of which is driven.

As may be seen in this figure, a set of printed-circuit substrates, such as 20, is placed on the belt 12, on at least one of the large faces of which substrates a set of electronic components, such
35 as 22, that have to be soldered is placed.

The electronic components are placed at points of connection at which spots of solder, for example a tin and lead alloy, have been predeposited, the spots having been planarized after their reflow. Moreover,

spots of a curable adhesive which is suitable for the envisaged use have been deposited at suitable points of bonding to the substrate (for example on polymer surfaces of a printed circuit, between two points of connection), ensuring that the components are held in place during their subsequent soldering.

The belt 12 ensures that the printed-circuit substrates 20 carrying the components 22 are transferred past a first station 24 allowing the adhesive deposited to be cured by heat transfer (for example by radiation), and then through a second station 26 for dry-fluxing the substrate.

Finally, the belt 12 ensures that, downstream of the second station 26, the substrates 20 are transferred to a cooling station 30 where the substrates are placed in a nitrogen-type atmosphere.

As may be seen in this Figure 1, the second fluxing station 26 may be regarded as being merged with a treatment station 28, both stations being made up by a module 32 for forming a treatment and fluxing gas comprising excited or unstable chemical species and being substantially free of electrically charged species.

In this Figure 1, it has been assumed that the components 22 are placed on one of the large faces of the substrate 20, the module 32 for forming excited or unstable species being turned towards this face.

As will be clearly apparent to those skilled in the art, if the components 22 are placed on both mutually opposed large faces of each substrate 20, the apparatus may comprise two modules 32 for forming excited or unstable chemical species, each being placed facing one of the faces of the substrate 20.

The function of the module 32 is to make an initial fluxing gas, advantageously comprising a reducing gas mixture, for example based on nitrogen and hydrogen, to which has been added, if required, water vapour, through an electrical discharge, inside which discharge the initial gas is transformed so as to

generate, at the gas outlet of the module, the fluxing atmosphere which contains the excited or unstable gaseous species and which is substantially free of electrically charged species (remote-plasma situation).

5 Figure 2 shows a sectional view of one example of a module 32 capable of generating such chemical species.

10 This figure shows that the module 32 comprises a first tubular electrode 34, formed for example by an internal face of a metal block 36, and in which is placed, concentrically, an assembly formed by a tube made of dielectric material 38, for example ceramic, on the internal face of which is deposited, by metallization, a second electrode 40, the thickness of
15 which has been exaggerated in Figure 2 for the sake of clarity.

 The dielectric tube 38 and the second electrode 40, together with the first electrode 34, define a tubular gas passage 42 and, on the inside, an internal
20 volume 44 in which a coolant circulates.

 The block 36 has two diametrically opposed longitudinal slots 46 and 48 forming, respectively, the inlet for the initial treatment gas to be transformed (excited) in the passage 42, and the outlet for the
25 flow of treatment or fluxing atmosphere containing the excited or unstable gaseous species but being substantially free of electrically charged species.

 The slots 46 and 48 extend over the entire axial length of the cavity 42.

30 The block 36 furthermore includes, advantageously, around the periphery of the first electrode 34, a plurality of ducts, such as 50, for the flow of a refrigerant, for example water.

 Figure 2 also shows that the gas inlet slit 46
35 communicates with a homogenization chamber 52 formed in a casing 54 attached to the block 36 and having a pipe 56 for feeding the initial gas.

 The module is completed by a high-voltage high-frequency electrical generator 58 designed to

generate a discharge in the gas mixture flowing in the gas passage 42 so as to excite, by ionization, the gas molecules of which it is composed and thus to generate excited or unstable chemical species, particularly $H^{\cdot}$ or $H_2^{\cdot}$ radicals, which deoxidize and decontaminate the surface of the printed-circuit substrates 20 (Figure 1).

The process for soldering electronic components to a substrate according to the invention is then carried out here in the following way.

It will be assumed in the following that substrates 20 are used on which solder alloy has been predeposited, reflowed and then planarized at points of connection to the components.

According to the invention, as described above, spots of adhesive are deposited at points of bonding to the substrate so as to ensure that the components are held in place during the soldering.

Next, the components are placed on the points of connection and then the substrates thus prepared are placed on the conveying member, particularly on the belt 12.

The latter then transfers the boards from the loading station to the first station 24 for curing the adhesive, and the circuit is thus preheated.

During the next phase, the substrates are transferred to a module 32 for forming excited or unstable chemical species, which module was described above with reference to Figure 2 and where the substrates, on the one hand, undergo a fluxing operation due to the action of the chemical species delivered by the module 32 and, on the other hand, due to the action of the heat transmitted to these excited species by the effect of the discharge, the components are soldered to the substrate.

The process continues with a cooling step, due to the action of a flow of nitrogen delivered to the cooling station 30.

In the illustrative example described with reference to Figure 1, it has been assumed that the first step of curing heat treatment and of preheating of the substrate is carried out by means of a specific station 24.

However, it would be possible, as a variant, to carry out this prior heating by means of the heated gas output by a module 32 for producing excited chemical species.

Moreover, it will be possible to provide a step of fluxing the substrates by means of excited or unstable chemical species delivered by a module identical to the module 32, placed before the coating of the points of bonding by means of adhesive.

Finally, and according to an embodiment that has not been shown, it would also be possible, still within the scope of the present invention, to carry out the fluxing of the substrates and the soldering heat treatment not by means of one and the same module 32 but by means of two successive separate modules 32.

It should be understood that the invention that has just been described, using a dry-fluxing step prior to the actual soldering makes it possible to considerably improve the quality of the soldered joints thus obtained, while avoiding a subsequent cleaning step using a chlorinated solvent.

It may be seen in fact that the invention that has just been described makes it possible to carry out reflow soldering without a flux and without a conventional solder paste, thus making it possible with much greater assurance to avoid a subsequent circuit-cleaning operation, and therefore *a fortiori* the use of chlorinated solvents:

- the solder alloy, necessary for forming the solder joints, is supplied by predeposited spots at points of connection to the substrate and/or at points/terminations on the actual components, all this without the presence of a chemical flux (predeposited spots/reflow/preferably planarized);

- since the flux is therefore not able here to fulfil as usual its function of holding the components in place, prior to the step of depositing the components, curable adhesive is deposited at points of bonding to the substrate and this adhesive is then cured so as to bond the components to the substrate at the points of bonding;

- an operation of dry-fluxing the substrate is carried out (before or after depositing adhesive, or even after depositing the components on the substrate) by bringing this substrate into contact, at a pressure close to atmospheric pressure, with a fluxing atmosphere comprising excited or unstable species but being substantially free of electrically charged species;

- advantageously, the actual reflow heat treatment is carried out using hot and active species (cleaning, deoxidation, etc.) such as those obtained as output from a discharge, making it possible to avoid any oxidation phenomenon during the soldering and therefore not only to substantially improve the wetting performance but also, again at this stage, to mitigate the lack of flux upstream of the line.

It may therefore be seen that the combination of the steps of the invention provides an effective response to the problem posed and therefore makes it possible for it to be adapted to the inexorable trend in microelectronics which desires to go towards ever more integration, while maintaining high reliability but avoiding the cleaning steps that the international protocols relating to the environment strictly regulate - objectives which it may be imagined appear to be very difficult to reconcile.

Although the present invention has been described in relation to particular embodiments, it is not limited in any way thereby but is, on the contrary, capable of modifications and variants which will be apparent to those skilled in the art in the context of the claims below.

Thus, although the invention has been most particularly exemplified in the foregoing by positioning, in the path of the substrates, a module for forming the treatment or fluxing atmosphere (or
5 even one module per face), it is possible, of course, to envisage the presence of several modules in series and/or in parallel, making it possible to obtain the required effect, but it is also possible to envisage (depending on the case of each user site) the fact of
10 placing, opposite one or each face of the substrate, only one module (whether for treatment or for fluxing), by carrying out successive passes, past the module, in order to obtain the desired effect.

CLAIMS



1. Process for the reflow soldering of
5 electronic components (22) to a substrate (20), during
which:

- a certain amount of solder alloy is used,
- the components (22) are placed at points of
connection to the substrate and

10 - an actual operation of soldering the
components (22) is carried out using the said solder
alloy, by heat treatment of the substrate (20),

characterized by the combined implementation of
the following steps:

15 - the said solder alloy is used according to
one or more of the following methods:

i) the solder alloy was predeposited one
or more times on the substrate at the or some of the
points of connection to the components, the
20 predeposited spots then having undergone a reflow
operation;

j) the solder alloy was predeposited one
or more times at points/terminations on the actual
components, the predeposited spots then having
25 undergone a reflow operation;

- prior to the step of depositing the
components, some curable adhesive is deposited at
points of bonding to the substrate (20) and the said
adhesive is then cured so as to bond the components to
30 the substrate at the points of bonding;

- prior to the soldering operation, a dry-
fluxing operation is carried out, in which this
substrate is fluxed by bringing it into contact with a
fluxing atmosphere at a pressure close to atmospheric
35 pressure, the said fluxing atmosphere containing
excited or unstable species and being substantially
free of electrically charged species.



2. Process according to Claim 1, characterized in that the fluxing atmosphere is obtained by passing an initial fluxing gas through an electrical discharge.

3. Process according to Claim 2, characterized in that the initial fluxing gas comprises a reducing gas mixture containing hydrogen.

4. Process according to either of Claims 2 and 3, characterized in that the fluxing atmosphere is obtained at a gas outlet of a device for forming excited or unstable species, in which device the initial fluxing gas has been transformed.

5. Process according to one of the preceding claims, characterized in that the said operation of fluxing the substrate (20) is carried out prior to depositing adhesive, or thereafter.

6. Process according to one of Claims 1 to 4, characterized in that the said operation of fluxing the substrate (20) is carried out after the components have been deposited on the substrate.

7. Process according to one of the preceding claims, characterized in that this continues with the said heat treatment of the substrate in order to carry out the said soldering of the components using the said solder alloy, by bringing the substrate into contact with a treatment atmosphere, at a pressure close to atmospheric pressure, the said treatment atmosphere containing excited or unstable chemical species and being substantially free of electrically charged species, the atmosphere being obtained by passing an initial treatment gas through an electrical discharge and the heat treatment of the substrate being obtained by means of the chemical species thus heated under the action of the discharge.

8. Process according to Claim 7, characterized in that the initial treatment gas comprises a reducing gas mixture containing hydrogen.

9. Process according to Claim 7 or 8, characterized in that the treatment atmosphere is obtained at a gas outlet of a device for forming



excited or unstable species, in which device the initial treatment gas has been transformed.

10. Process according to Claim 4, characterized in that the steps of placing the components and of soldering are carried out on both large faces of the substrate (20), the said fluxing operation being carried out by means of two devices (32) for forming excited or unstable chemical species, each device being opposite one of the faces of the substrate.

11. Process according to Claim 9, characterized in that the steps of placing the components and of soldering are carried out on both large faces of the substrate (20), the said treatment operation being carried out by means of two devices (32) for forming excited or unstable chemical species, each device being opposite one of the faces of the substrate.

12. Process according to any one of Claims 1 to 11, characterized in that it furthermore includes a step of cooling the substrate, after the soldering, by passing the substrate through a cooling atmosphere containing an inert gas.

13. Process according to one of the preceding claims, characterized in that the predeposition underwent, before the components were deposited, an operation of planarizing its surface.

14. Apparatus for the reflow soldering of electronic components (22) to a support (20) using a solder alloy, for the implementation of the process according to any one of Claims 1 to 13, characterized in that it comprises a member (10) for conveying substrates (20) carrying, on at least one of their face [sic], the components (22) to be soldered at points of connection to the substrate, the conveying member (10) transferring the substrates past first means (24) allowing the spots of adhesive present at points of bonding to the substrate (20) to be cured, and past second means comprising at least one device (28) for forming a fluxing atmosphere containing excited or

unstable chemical species and being substantially free of electrically charged species, which fluxing atmosphere can be used, at a pressure close to atmospheric pressure, in order for the substrate to
5 undergo dry fluxing.

15. Apparatus according to Claim 14, characterized in that the second means are located upstream of the first means.

16. Apparatus according to Claim 14,
10 characterized in that the second means are located downstream of the first means.

17. Apparatus according to one of Claims 14 to 16, characterized in that it includes, along the conveying member, downstream of the first and second
15 means, at least one device (28) for forming a treatment atmosphere containing excited or unstable chemical species and being substantially free of electrically charged species, the temperature of which treatment atmosphere makes it usable for carrying out, at a
20 pressure close to atmospheric pressure, a heat treatment of the substrate, for the purpose of carrying out the actual soldering of the components.

