

**METHOD FOR BRAZING BY SOLDER REFLOW ELECTRONIC
COMPONENTS AND BRAZING DEVICE THEREFOR**

5 The present invention relates to a process for the reflow soldering of electronic components to a substrate such as a printed-circuit board, and it also relates to a soldering apparatus for the implementation of such a process.

10 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 contained in a tank circulate by means of a nozzle.

20 Generally speaking, the boards 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 soldered, for the removal of oxides, organic contaminants, etc.

25 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 example by screen-printing a solder paste, containing a mixture of a metal alloy and a flux, on the printed
30 circuit before the components to be soldered are deposited thereon.

35 Another recent technology consists in that the 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 SIPAD™ or

OPTIPAD™ processes), or even by the fact that the solder alloy was predeposited, in the case of certain components, on terminations on the actual components.

5 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
10 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
15 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
20 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
25 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
30 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.

35 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 but are located under the component, making it very difficult both to clean and to make any repairs to).

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

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

Studies completed by the Applicant have shown
15 that these processes needed to be further improved in the case of reflow soldering, not only to improve the conditions for soldering special components but also to improve the general fluxing conditions so as to avoid having to carry out the upstream operation of cleaning
20 the substrates.

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

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

- a certain amount of solder alloy is used,
- the components are placed at points of connection to the substrate and
- an actual operation of soldering the
30 components is carried out using the said solder alloy, by heat treatment of the substrate,

and is characterized in that the substrate undergoes the said heat treatment in order for the soldering of the components to be carried out using the
35 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
5 action of the discharge.

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

- 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;

- the solder alloy is used by screen-printing a solder paste on the substrate at points of connection
15 to the components;

- the solder alloy is used in that the solder alloy was predeposited on the substrate one or more times at the or some of the points of connection to the components, the predeposited spot(s) then having
20 undergone a reflow operation, followed advantageously by an operation of planarizing their surface;

- the solder alloy is used in that the solder alloy was predeposited one or more times at points/terminations on the actual components, the
25 predeposited spot(s) then having undergone a reflow operation;

- prior to the step of depositing adhesive at the points of bonding to the substrate, or thereafter, or else after the components have been deposited on the
30 substrate, an operation of prefluxing the substrate is carried out by treating the latter, at a pressure close to atmospheric pressure, by means of a fluxing atmosphere containing excited or unstable chemical species and being substantially free of electrically
35 charged species;

- the substrate-fluxing atmosphere is obtained by passing an initial fluxing gas through an electrical discharge, the initial fluxing gas advantageously comprising a reducing gas mixture containing hydrogen;

- 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;

- 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;

- 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;

- the process furthermore includes a step of cooling the substrate, after the said treatment, by passing the latter through a cooling atmosphere, containing an inert gas.

The subject of the invention is also an apparatus for the reflow soldering of electronic components to a substrate, for example a printed-circuit board, for the implementation of a process as defined above, characterized in that it comprises a member for conveying the substrates carrying, on at least one of their face [sic], the components to be soldered at points of connection, at which points a solder alloy is used, 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 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, at a pressure close to atmospheric pressure, for carrying out a heat

treatment of the substrate, for the purpose of carrying out the actual soldering of the components.

Advantageously, the apparatus includes, inserted along the conveyor, upstream of the first means, or between the first means and the second means, 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 for fluxing the substrate in the gas phase.

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 industry, and also of course 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.

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 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 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; and

5 - 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 soldering apparatus suitable for the implementation of the process according to the invention. This apparatus
10 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 and 18, at least one of which is driven.

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

20 The electronic components are placed at points of connection at which solder paste, for example a tin and lead alloy, is applied. Moreover, spots of a curable adhesive which is suitable for the envisaged use have been deposited at suitable points of bonding
25 to the board (for example on polymer surfaces of the printed circuit board, between two points of connection), ensuring that the components are held in place during their soldering.

30 The belt 12 ensures that the printed-circuit boards 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 28 for heat treatment, at which the actual soldering of the
35 components 22 is carried out.

Finally, the belt 12 ensures that, downstream of the second heat-treatment station 28, the boards 20 are transferred to a cooling station 30 where the boards are placed in a nitrogen-type atmosphere.

As may be seen in this Figure 1, the second, heat-treatment station 28 may be regarded as being merged with a fluxing station 26, both stations being made up by a module 32 for forming a treatment and
5 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 board 20, the module 32 for forming excited or
10 unstable species being turned towards this face. However, 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 board 20, the
15 apparatus may comprise two modules 32 for forming excited or unstable chemical species, each being placed facing one of the large faces of the board 20.

The function of the module 32 is to make an initial treatment gas, advantageously comprising a
20 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
25 treatment gas which contains the excited or unstable gaseous species and which is substantially free of electrically charged species (remote-plasma situation).

As will have been understood on reading the foregoing, depending on the circuits to be soldered and
30 depending on the solder alloy in question, the temperature of the species leaving the discharge will generally be directly sufficient ($> 190^{\circ}\text{C}$). However, in certain special cases (certain metal eutectics, for example), it may be envisaged to slightly preheat the
35 initial gas before it enters the discharge.

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

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
5 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 which has been exaggerated in Figure 2 for the sake of clarity.

10 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 volume 44 in which a coolant circulates.

The block 36 has two diametrically opposed
15 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 flow of treatment atmosphere containing the excited or unstable gaseous species but being substantially free
20 of electrically charged species.

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

The block 36 furthermore includes, advantageously, around the periphery of the first
25 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 communicates with a homogenization chamber 52 formed in a casing 54 attached to the block 36 and having a pipe
30 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
35 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 external surface of the printed-circuit boards 20 (Figure 1).

The process for soldering electronic components to a printed-circuit board is carried out here in the following way.

It will be assumed in the following that boards
5 20 are used on which solder paste has been screen
printed at points of connection to the components. It
would also be conceivable to use a solder alloy that
was predeposited one or more times on the board at
points of connection to the components, and underwent
10 prior reflow followed, in general, by an operation of
planarizing the surface of the predeposited spots thus
obtained (industrially available processes well known
to those skilled in the microelectronics art). The
components could also be components which themselves
15 have points/terminations at which a solder alloy has
been predeposited.

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

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

25 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 boards are
transferred to a module 32 for forming excited or
30 unstable chemical species, which module was described
above with reference to Figure 3 and where the boards,
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 and at the same time, due to
35 the action of the heat transmitted to these excited
species by the effect of the discharge, the components
are soldered to the board.

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

5 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 board is carried out by means of a specific station 24.

10 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.

15 Moreover, it would be possible to provide a step of prefluxing the boards 20 by means of excited or unstable chemical species delivered by a module identical to the module 32, before the coating of the points of bonding by means of adhesive.

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

25 It should be understood that the invention that has just been described, using a reflow/heat-treatment step using the excited or unstable chemical species and substantially which is [sic] free of electrically charged species, these being heated by the action of a discharge, makes it possible to considerably improve the quality of the soldered joints thus obtained, while
30 avoiding a subsequent cleaning step using a chlorinated solvent:

- the actual reflow heat treatment is carried out using active species (cleaning, deoxidation, etc.) making it possible to avoid any oxidation phenomenon
35 and therefore to substantially improve the wetting performance;

- it may be imagined, moreover, that by using lightly fluxed solder pastes (low activity/small amounts of residues on the substrate after soldering),

or better still using systems for predepositing solder alloy without a flux at suitable points on the substrate or at terminations on the components, the process according to the invention makes it possible to
5 combine completely satisfactory soldering performance while avoiding having to carry out the subsequent operation of cleaning the substrates.

Although the present invention has been described in relation to particular embodiments, it is
10 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
15 particularly exemplified in the foregoing by positioning, in the path of the substrates, a module for forming the treatment or fluxing atmosphere (or even one module per face), it is possible, of course, to envisage the presence of several modules in series
20 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 placing, opposite one or each face of the substrate, only one module (whether for treatment or for fluxing),
25 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 operation of soldering the components (22)
is carried out using the said solder alloy by heat
treatment of the substrate (20),

characterized in that the substrate undergoes
the said heat treatment in order for the said soldering
15 of the components to be carried out 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
20 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
25 action of the discharge.

2. Process according to Claim 1,
characterized in that, prior to the step of depositing
the components, some curable adhesive is deposited at
points of bonding to the substrate (20) and the said
30 adhesive is then cured so as to bond the components to
the substrate at the points of bonding.

3. Process according to Claim 1 or 2,
characterized in that the said solder alloy is used
according to one or more of the following methods:

35 i) by screen-printing a solder paste on the
substrate (20) at points of connection to the
components;

j) 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 k) 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.

4. Process according to Claim 3, characterized in that the said predeposited spot(s) 10 then underwent an operation of planarizing its surface.

5. Process according to one of the preceding claims, characterized in that prior to the step of depositing adhesive at the points of bonding to the substrate, or thereafter, an operation of fluxing 15 the substrate (20) is carried out by treating the latter, at a pressure close to atmospheric pressure, by means of a fluxing atmosphere containing excited or unstable chemical species and being substantially free of electrically charged species.

20 6. Process according to one of Claims 1 to 4, characterized in that, after the step of depositing the components on the substrate, an operation of fluxing the substrate (20) is carried out by treating the latter, at a pressure close to atmospheric 25 pressure, by means of a fluxing atmosphere containing excited or unstable chemical species and being substantially free of electrically charged species.

7. Process according to Claim 5 or 6, characterized in that the fluxing atmosphere is 30 obtained by passing an initial fluxing gas through an electrical discharge.

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

35 9. Process according to any one of the preceding claims, characterized in that the initial treatment gas comprises a reducing gas mixture containing hydrogen.



10. Process according to any one of the preceding claims, characterized in that the treatment atmosphere is obtained at a gas outlet of a device for forming excited or unstable species, in which device
5 the initial treatment gas has been transformed.

11. Process according to any one of Claims 5 to 8, 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
10 initial fluxing gas has been transformed.

12. Process according to Claim 10, 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 heat-
15 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.

13. Process according to any one of the preceding claims, 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.

14. Apparatus for the reflow soldering of
25 electronic components (22) to a substrate (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
30 faces, the components (22) to be soldered at points of connection, 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
35 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



- 16 -

pressure close to atmospheric pressure, a heat treatment of the substrate, for the purpose of carrying out the actual soldering of the components.

15. Apparatus according to Claim 14,
5 characterized in that includes, inserted along the conveying member, upstream of the first means or between the first means and the second means, at least one device (28) for forming a fluxing atmosphere containing excited or unstable chemical species and
10 being substantially free of electrically charged species, which fluxing atmosphere can be used for fluxing the substrate (20) in the gas phase.