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Method and apparatus for dispensing solder



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5 **Technical Field**

This invention relates to solder die-bonding technology in the manufacture of semiconductor devices. In particular, it relates to a method for dispensing solder to
10 a point on a substrate to be soldered so that clogging of the dispensing apparatus is assuaged. Devices and apparatus employing such method are also disclosed.

15 **Background Art**

In the manufacture of semiconductor devices, components are soldered or die-bonded onto a substrate. The solder dispensed may either be heated to become molten
20 inside the dispensing apparatus before being dispensed onto the point on the substrate to be soldered, or is in solid form inside the dispensing apparatus and only melts upon coming into contact with a heated substrate. Our invention relates to the latter category of dispensing solder but can
25 be used also in combination with an apparatus for molten solder.

The dispensing of either pre-heated molten solder from a reservoir of liquid solder of the first category or solid
30 solder to be melted upon contact with external heat of the second category requires a capillary-like feeding outlet. This solder feed capillary (12) of the dispensing tool (10) may be further provided with a dispensing cavity (14)

attachment, add-on or extension of the feeding outlet (16) so that the extension is in close contact with the substrate (15), thus creating a sealed or liquid-proof cavity for the solder (18) wire to melt and flow out
5 through the outlet (16), and to take the form or shape as confined within the cavity (14) as shown in FIGURE 1 (Prior Art). In the preferred embodiment, the feeding outlet (16) and the dispensing cavity (14) are joint together to form one piece, into which the insert (30) is placed.

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For soft solder die attach, oxidation and the presence of thin oxide films on, and other impurities in the solder pose a critical problem for the dispensing of the solder through a capillary-shaped feeding system particularly in
15 high volume and continuous operation. As the solder is dispensed into the cavity (14) and melted, the thin layer of oxide film and other impurities (hereinafter collectively referred to as "contaminants") will be separated from the "pure" solder liquid phase to become the
20 solid phase comprising the contaminants which float atop the molten solder.

Most of the solid contaminants will be dispensed out of the outlet (16) along with the liquid solder onto the
25 substrate's surface. However, some of the contaminants will be pressed against the outlet (16) as the liquid solder fills up the cavity space (14), thus eventually finding their way into the solder feed capillary (12) thus clogging it and bringing further dispensing of the solder
30 to a halt. The dispensing apparatus may then have to be taken out for cleaning and unclogging, the solder wire (18) reinserted into the capillary (12) and the production process restarted again.

Depending on the solder alloy compositions and grades, the need to stop the soldering machine's operation in order to remove the clogging may arise frequently, i.e. several
5 times during a production shift, thus causing work stoppages and reducing the total output of units per hour (UPH). Besides reducing the total output, these stoppages have a detrimental effect on the quality of the assembled product. During a stoppage the exposure of the products
10 under assembly to high temperature (typically around 50°C above the liquidus temperature of solder) will be increased and may result in a softening of the substrate material and an increased phase growth between the bonded die and substrate. Both these effects can lead to a rejection of
15 the assembled product, thus reducing the assembly machine's yield.

The use of certain materials for fabricating the dispensing capillary and tool, which may reduce the clogging, has been
20 tried. The most commonly used materials for dispensing tools are titanium alloys, due to their high strength (low wear rate) and due to the fact that titanium is non-wetting for lead-tin based alloys. However, actual application shows that although titanium may be non-wetting for the
25 pure solder, the contaminants are still sticking to the surface, thus causing a clogging of the titanium tool. Another previously used material for the dispensing tool is graphite, but this has the disadvantage of having a very high wear rate due to the softness of the material, thus
30 rendering it unsuitable for a high volume production environment.

Still referring to Fig. 1, another problem with a conventional solder dispenser cavity tool (for the dispensing of solder patterns) is that the volume which is to be pumped into the cavity space (14) to ensure complete solder coverage of the designated point on the substrate is fixed. It would therefore be advantageous if the volume may be changed quickly without having to change the solder dispensing tool. Such capability would be useful for manufacturing work-study or research purposes.

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Objects of the Invention

It is therefore an object of the present invention to provide the solder wire dispensing apparatus with means to effectively protect the dispensing capillary from building up material inside, thus preventing unscheduled stops of the dispensing system during production, which would result in a lowered net UPH and the possible rejection of otherwise good devices.

Another object is to provide for alternative target volumes of solder to the apparatus by changing the position of the insert inside the dispensing tool, thus creating smaller or larger cavities, without the need for substituting the entire dispensing tool.

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Summary of the Invention

In accordance with the above objects, the present invention provides for a method for dispensing solder in contact with a substrate to be soldered wherein the dispensing pathway

is lined with a material suitable for assuaging the clogging of said pathway. Specifically, the solder is in the form of solder wire and is fed to and dispensed from a dispensing device. However, the insert is also suitable for
5 the handling of liquid solder.

In one aspect of the invention, the lining is a coating applied unto the pathway. In another aspect, the lining is a removable insert tightly fitting into the pathway. This
10 is the preferred embodiment of the invention.

Preferably, the lining material is chosen from any one or combination of carbon-graphite, graphite; ceramics; cermets, including carbides of tungsten, titanium and
15 cemented carbides.

The invention also provides for a device for dispensing solid solder in contact with a substrate to be soldered wherein the dispensing pathway is lined in accordance with
20 the above method. Preferably, fastening means are provided for transfixing said device to fasten the insert therein.

Preferably still, the insert lines the pathway through which the solder flows. Specifically, the insert comprises
25 a stem portion and a capillary running within and lengthwise of the stem portion through which the solder is transported. The other end of the insert forms one part of the dispensing cavity.

30 Preferably, the insert comprises a head portion integral with one end of the stem portion.

Brief Description of the Drawings

The aforesaid objects and advantages of the method and apparatus may be better understood by referring to the following drawings and the accompanying description of the
5 representative or exemplary embodiments in which:

- FIGURE 1 (Prior Art) as described above, shows the conventional solder wire dispenser tool with
10 die attach enclosing a cavity confining solder flow between its cavity (14) and the substrate's surface (15);
- FIGURES 2 show a dispenser tool according to the present invention with the insert in place; FIGs. 2A,
15 2B, 2C and 2D respectively show the side elevational, bottom, cross-sectional and side perspective views of the dispenser tool ;
- FIGURE 3 shows a cross-sectional view of the dispenser tool without the insert;
- 20 FIGURE 4 shows the insert in isolation;
- FIGURE 5 shows the insert being provided with fastening means to fasten itself to the dispenser tool; and
- FIGURE 6 shows a dispenser tool according to the coating
25 embodiment of the invention.

Detailed Description of Embodiments

30 The method of the present invention in general entails replacing parts or the entire dispensing pathway either with one of the two embodiments, i.e. a protective coating or with a removable insert. FIGURES 2, 3 and 4 shall be

referred to and described collectively hereinafter in respect of the insert embodiment of the invention.

FIGURES 2A - 2D respectively show a wire solder dispenser tool (20) whose solder feeding pathway (22) has been adapted to receive a removable insert (30) designed to assuage the clogging of the pathway (22). The dispenser tool (20) may be provided with a dispensing cavity (14). In operation, the molten solder flows into the confines of the cavity and fills up the space between the dispenser tool cavity (14) and the substrate's surface (15).

FIGURE 3 shows the dispenser tool (20) without the insert (30). The insert, shown in isolation in FIGURE 4, comprises in essence a tubular stem portion (32), wherein is provided a capillary (34) running lengthwise therewithin through which the solder wire (not shown) is transported.

Preferably, the insert (30) substantially covers or lines the length of the dispensing pathway (26) of the dispenser tool (20) through which the solder flows. In this manner, the substantial length of the pathway (26) that is potentially exposed to the liquid solder may be protected. Accordingly, without the insert, the long hours of dispensing cause the feeding capillary to be filled with contaminants which then cause the equipment to stop. Using a graphite (or similar) insert, the material build up inside the capillary is reduced significantly, elimination all unscheduled stops and allowing for a preventive cleaning during scheduled stops. The dispenser tool (20) can thus be used to dispense solder wire continuously. When taking the key factors, namely machine stoppage due to dispenser clogging, dispenser tool machining cost and cost

for the insert, into consideration, the concept of a replaceable insert (in case of wear out), which is then a consumable, becomes economically viable due to the very low cost for replacing the insert (30) when it is worn out.

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Preferably, an integral head portion (36) is provided at the top end of the insert (30). The head portion (36) may be provided for the purpose of ease of gripping with fingers so that the insert may be slotted into the pathway
10 of the dispenser tool (20) by hand. The enlarged head portion (36) may also serve to limit the length of insertion into the pathway of the dispenser tool (20). As shown in FIGURE 5, fastening means (for example, screw and thread means, bayonet pins and the like which may be done
15 and undone with the hand or fingers without requiring any tools) may be provided to fasten the insert into the dispenser tool's pathway.

An alternative means of fastening the insert (30) in the
20 pathway (26) is to provide a pin or screw means (not shown) that transfixes the dispenser tool housing to reach and restrain the outer wall of the insert stem in a perpendicular manner. Such perpendicular screw fastening means may be provided with a head portion with features to
25 ease finger grip such as a hexagonal shape bolt head and/or knurling on the sides of the head. With such handy features, the unfastening and replacement of the insert may be carried out with the hand without the assistance of any tools.

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Other conventional features, such as chamfering (38) around the edge of the intake end of the insert to ease the feed of solder wire thereinto, may be provided.

Materials

5 While the dispenser tool (20) may conventionally be made from titanium, chosen for its minimal affinity with the solder alloy and its low wear rate, the insert may be made from a different material including graphite, carbon-graphite, ceramics and cermets. To distinguish from
10 graphite, carbon-graphite may be defined as combinations of amorphous carbon, graphite and an impregnant to improve strength.

Apart from the ease of machining or tooling to precise
15 dimensions, graphite and carbon-graphite materials are preferred as carbon can behave as a metal or a non-metal due to its valency. It may be hard in its cubic structure and may be slippery or provides lubrication for sliding systems in its hexagonal graphite structure.

20 Other materials, which may be used, include tungsten carbide.

25 Coating

In another aspect of the invention, the insert for the solder dispensing pathway may be provided with a protective coating lining the length of the solder flow pathway or
30 capillary of the dispenser tool.

The capillary of the dispenser tool may be coated with a layer of material suitable for minimising friction and

adhesion of solder material and contaminants due to contact with the liquid solder. The material should also be non-reactive to the solder alloy and contaminants therefrom. Apart from graphite as suggested in the insert embodiment
5 above, other durable non-stick or lubricating coatings may be used, for example, silicon, silicon-nitride and boron nitride boron nitride coating.

Upon the wearing-off of the coating, the dispenser tool may
10 be replaced with another and the worn-off dispenser tool be recoated again. In this manner, the dispenser tool can be reused again after recoating. The coating (50) may even be extended to cover or line the soldering cavity (52) as shown in FIGURE 6. It is suggested that the thickness of
15 the coating be in the order of about 2-10 μm .

It will be apparent to a skilled person that there is number of alternative ways of achieving the various features of the present invention. For example, the insert
20 may be fastened in a number of conventional ways apart from the screw means described above. It will also be obvious to a person skilled in the art that the various methods of the present invention and its various specific embodiments and configurations of the apparatus and components thereof
25 may be varied or modified without departing from the above-described method or working principle. These and other embodiments not described specifically herein are not to be considered as departures from the present invention and shall be considered as falling within the letter and spirit
30 of the following claims.

CLAIMS

1. A method for dispensing solder into contact with a
5 substrate to be soldered wherein the dispensing pathway of
the dispenser tool or tip that can potentially come in
contact with liquid solder is lined with a material
suitable for assuaging the clogging of said pathway.
- 10 2. A method according to Claim 1 wherein the lining is a
removable insert covering said pathway completely.
3. A method according to Claim 1 wherein the lining is a
coating covering said pathway.
- 15 4. A method according to Claim 1 wherein the solder is in
the form of wire solder which is transported through a
dispensing tool or tip which is in direct contact with the
substrate's surface during the dispensing process.
- 20 5. A method according to Claim 1 wherein the lining
material is chosen from any one or combination of:
 - carbon-graphite, graphite;
 - ceramics;
 - 25 - cermets, including carbides of tungsten, titanium
and cemented carbides.
6. A device for dispensing solder into contact with a
substrate to be soldered wherein the dispensing pathway is
30 lined with a material suitable for assuaging the clogging
of said pathway.
7. A device according to Claim 6 wherein the insert

lining the pathway is removable.

8. A device according to Claim 6 wherein the pathway is covered by a coating.

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9. A device according to Claim 6 wherein the lining material is chosen from any one or combination of:

- carbon-graphite, graphite;
- ceramics;
- 10 - cermets including carbides of tungsten, titanium and cemented carbides.

10. A device according to Claim 8 wherein fastening means is provided transfixing said device to reach and fasten the
15 insert therein.

11. An insert for reinforcing a dispensing pathway of a device for dispensing solder into contact with a substrate to be soldered, wherein said insert lines the pathway
20 through which the solder flows.

12. An insert according to Claim 11 comprising

- a stem portion; and
- a capillary running within and lengthwise of the

25 stem portion through which the solder flows.

13. An insert according to Claim 12 further comprising a head portion integral with one end of the stem portion.

30 14. An insert according to Claim 12 wherein the head portion is provided with any one or combination of

- means for ease of grip with fingers;
- means for limiting the insertion into the pathway

of the solder dispensing device; and

- means for fastening the insert within the pathway of the solder dispensing device.

5 15. An insert according to Claim 12 which material is chosen from any one or combination of:

- carbon-graphite, graphite;

- ceramics;

- cermets including carbides of tungsten, titanium and

10 cemented carbides.

16. An apparatus for soldering electronics components onto a substrate employing a method according to any one of Claims 1 to 5.

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17. An apparatus according to Claim 16 comprising a solder dispensing device according to any one of Claims 6 to 10.

18. An apparatus according to Claim 16 comprising

20 an insert according to any one of Claims 11 to 15.