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Air assisted liquid dispensing apparatus and method for increasing contact area between the liquid and a substrate
Pneumatisch unterstütze Austragvorrichtung und Verfahren zur Erhöhung des Kontaktbereichs zwischen einer Flüssigkeit und einem Substrat
Dispositif assisté par air pour délivrer un liquide et procédé pour augmenter la surface de contact entre un liquide et un substrat

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Proprietor: NORDSON CORPORATION
Westlake, Ohio 44145-1119 (US)

Inventors:
- Donges, William E.
  Wellington, OH 44090 (US)
- Smith, James C.
  Amherst, OH 44001 (US)

Representative: Eisenführ, Speiser & Partner Patentanwälte Rechtsanwälte
Postfach 10 80 78
28060 Bremen (DE)

References cited:
- US-A- 4 957 783
- US-A- 4 970 985

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Description

Field of the Invention

[0001] The present invention generally relates to a method for dispensing liquid and, more specifically, to a method for dispensing droplets of liquid onto a substrate.

Background of the Invention

[0002] Electrical components are generally secured to a circuit board or other substrate by means of a soldering Operation. Although there are a number of common soldering processes to secure components to the substrate, a conventional soldering process may be comprised of three separate steps. These steps include (1) applying flux to the substrate, (2) preheating the substrate, and (3) soldering various components to the substrate. In some, situations, such as reflow and surface mounting processes, preheating is unnecessary. As same examples, the invention pertains to component securement in applications utilizing circuit boards, micropalates, interposer boards, controlled collapse chip collections, VGA and other Computer chips.

[0003] Soldering flux is a chemical compound which promotes the wetting of a metal surface by molten solder. The flux removes oxides or other surface films from the base metal surface. The flux also protects the surface from reoxidation during soldering and alters the surface tension of the molten solder and the base material. Substrates, such as printed circuit boards, must be cleaned with flux to effectively prepare the board for soldering and to properly wet the electrical components to be secured to the circuit board.

[0004] During the soldering Operation it may be necessary to dispense minute amounts or droplets of solder flux onto discrete portions of the substrate. Various types of dispensers have been used for this purpose, such as syringe style contact dispensers and valve-operated, noncontact dispensers. In addition to solder flux, other liquids may also be applied to the substrate. These liquids may include adhesives, solder paste, solder mask, grease, oil encapsulants, potting compounds, inks and silicones.

[0005] Because of surface tension effects, liquid exiting a valveoperated, noncontact dispenser typically forms a substantially sphericallyshaped, airborne droplet before reaching the substrate. The droplet therefore contacts the substrate in a specific, generally circular surface area. Depending upon the viscosity and surface tension characteristics of the droplet material, the droplet may maintain a substantially semi-spherical shape above the surface contact area. For instance, if the droplet material has a high viscosity or high surface tension, the droplet will generally maintain a semi-spherical shape above the surface of the substrate and the surface contact area will be relatively small. For conventional fluxes, the height of the droplet may generally equal the diameter of the droplet. If, however, the droplet material has relatively low viscosity or low surface tension, the spherical shape flattens out onto the surface and the surface contact area is greater. In essence, high viscosity droplets or those with high surface tension do not spread out over the surface like low viscosity droplets or those with low surface tension.

[0006] During the manufacture of electronic devices, it is desirable to use the smallest effective amount of flux possible while still covering the greatest amount of surface area with the flux. In many soldering operations, the flux is best applied to a substrate in the form of a series of droplets an discrete areas of the substrate. It is preferable that the single droplet of flux flatten out and form a thin layer over a [larger area of the substrate. A relatively thin layer of solder flux has several advantages relative to a thicker layer of flux. For example, a thin layer of solder flux yields more reliable solder connections between the electrical components and, for example, a printed circuit an the substrate, especially where "no clean" fluxes are used. A thin layer formed from a single droplet of flux also uses less flux than several taller droplets of flux used to cover the same area. Also, a single droplet of flux that spreads out to form a thin layer increases manufacturing throughput because applying a single flattened droplet is quicker than covering the saure surface area with several taller droplets.

[0007] Since solder flux generally has high surface tension, it does not flatten appreciably upon contact with the substrate. Instead, the noncontact dispensing operation leaves a relatively tall droplet with a substantially semi-spherical shape and a small contact area. As a result, it is difficult to produce a thin layer of solder flux using conventional noncontact dispensers and conventional solder flux.

[0008] Therefore, it would be desirable to provide a noncontact droplet dispenser which is able to both dispense a droplet of viscous liquid, such as solder flux, and flatten or spread out the droplet onto a substrate to increase its surface contact area.

Summary of the invention

[0009] The present invention achieves the object by means of the method claimed in claim 1 in that the method provides for dispensing droplets of viscous liquid, such as solder flux, onto the surface of a substrate and thereafter flatten or spread out the droplet with at least one burst of pressurized air.

[0010] Dispensers for dispensing liquid and air have been known for various purposes. US-A-5,114,752 for instance discloses apparatus and method for depositing liquid material onto a workpiece in the form of a bead having a desired conformation. Liquid material and gas jets are dispensed together and dependent upon one another to maintain substantial uniformity of the conformation of the bead. In addition, the flow rate of the gas jets may be controlled such as to selectively alter the confor-
In the present invention, a dispenser for nonconductive adhesive is provided. The dispenser comprises a valve stem to dispense the droplets from the liquid dispensing nozzle body. The valve stem is operatively connected to the liquid dispenser to selectively engage and disengage the valve stem relative to the valve seat. The control device is further operatively connected to the supply of pressurized air to selectively generate bursts of pressurized air for discharge by the air discharge orifice. The control device is operatively connected to pneumatically, hydraulically, or electrically actuated solenoid valves associated with the liquid and pressurized air supplies to accurately control the emitted flow of liquid and bursts of pressurized air from the liquid discharge passageway and air discharge orifice, respectively. The air control device preferably operates in a predetermined time relationship relative to the discharge of the one or more dispensed droplets that will be flattened with the air. For example, the predetermined time relationship may be established between the solenoid valve that operates the discharge of pressurized air and the solenoid valve that controls the discharge of liquid material. It will be appreciated that the liquid and air control device and the components used in such a control device may take many different configurations.

The present invention also contemplates a method for increasing the contact area between a droplet of liquid, such as solder flux, and a substrate, such printed circuit board. The method generally involves dispensing at least one droplet of liquid from a nozzle onto a substrate such as a printed circuit board. The method allows to effectively deposit thin layers of flux or other viscous liquid onto a printed circuit board. The layer of flux provides a more reliable connection for the electric components and reduces the cost of printed circuit board manufacture.

Various additional advantages, objects and features of the invention will become more readily apparent to those of ordinary skill in the art upon consideration of the following detailed description of the presently preferred embodiment taken in conjunction with the accompanying drawings.
Detailed Description of Drawings

[0021]

Fig. 1 is a disassembled perspective view of a nozzle assembly attached to the end of a liquid dispenser;

Fig. 2 is an enlarged partial cross-sectional view of the nozzle assembly of Fig. 1 taken along line 2-2 and showing the discharge of a droplet of liquid;

Fig. 3 is an enlarged partial cross-sectional view similar to Fig. 2 but showing the discharge of air;

Fig. 3A is an enlarged view of encircled portion "3A" in Fig. 2;

Fig. 4 is a block diagram of a control device for use with the liquid dispenser of Fig. 1;

Fig. 5 is a schematic representation of the on/off time profiles for a fluid valve and an air valve implemented by the liquid dispenser of Fig.

Detailed Description of Preferred Embodiment

[0022] Referring first to Fig. 1, a dispenser apparatus 10 includes a dispenser body 12, a liquid dispensing nozzle body 14, and an air discharge body 16. While nozzle body 14 and air discharge body 16 are shown as separate pieces, they may also be integrated into a single-piece nozzle. The dispenser 10 is specifically adapted for dispensing liquids, such as heated thermoplastic liquids, hot melt adhesives or solder flux, but other liquid dispensers can benefit from the invention as well. Furthermore, the dispenser 10 is adapted to dispense liquids in discrete amounts, such as droplets or dots, or in continuous beads. As shown in Fig. 1, the dispenser body 12 used in conjunction with the liquid dispensing nozzle body 14 and air discharge body 16 is constructed to dispense droplets liquids, such as of solder flux, onto a substrate.

[0023] With reference now to Figs. 2 and 3, the dispenser body 10 has a liquid supply passageway 18 which communicates with a pressurized source 20 of liquid 22. This liquid 22 may, for example, be solder flux or other viscous liquids that will benefit from this invention. As a general guideline for solder flux applications, the pressure of the solder flux 22 within the liquid supply passageway 18 ranges between about 0.103 bar (1.5 psi) and about 0.345 bar (5 psi) for lower viscosity fluxes and 0.689 to 1.38 bar (10-20 psi) for higher viscosity fluxes. The dispenser body 12 also includes a valve stem 24 mounted within the liquid supply passageway 18 that is selectively retractable from engagement with a valve seat 26. The dispenser body 12 may include a conventional spring return mechanism (not shown) operatively connected to the valve stem 24. The spring return mechanism closes the valve stem 24 against the valve seat 26 to stop the flow of liquid through dispenser 10 in a known manner.

[0024] Accordingly, dispenser body 12 and its associated valve stem 24 can serve as an on/off fluid or liquid valve by moving the valve stem 24 into and out of engagement with the valve seat 26. One suitable dispenser and valve actuating mechanism is found in U.S. Patent No. 5,747,102. The valve stem 24 may be, for example, pneumatically or electrically actuated in response to a control device 28 (Fig. 4) to selectively dispense the solder flux 22 from the liquid supply passageway 18 to the attached liquid dispensing nozzle body 14.

[0025] For controlling dispensing of liquid material, control device 28 includes a dispenser valve on timing and driver circuit 30 that is operatively connected to valve stem 24 to retract valve stem 24 from valve seat 26 in response to a trigger signal 32 received from a trigger circuit 34. Upon receipt of trigger signal 32, circuit 30 retracts or disengages valve stem 24 from valve seat 26 for a pre-selected amount of time, preferably selectable in a range from 0 ms about 100 ms, to permit the flow of liquid 22 from dispenser 10 as described in detail below. When the pre-selected open state of valve stem 24 expires, valve stem 24 is re-engaged with valve seat 26 to stop the flow of liquid 22.

[0026] A retainer 36 has internal threads 38 at one of its ends to engage external threads 40 of dispenser body 12. The retainer 36 has an internal shoulder 42 with a throughhole 44 located at the center of the internal shoulder 42. The throughhole 44 is in fluid communication with both the liquid supply passageway 18 and the liquid dispensing nozzle body 14. The internal shoulder 42 retains the valve seat 26 and a seal member 46 an an end portion 48 of dispenser body 12 when the retainer 36 is threaded onto the external threads 40 of dispenser body 12. As such, the seal member 46, which is preferably constructed of Teflon®, sealingly engages the end portion 48 to prevent the solder flux 22 from leaking past the threads 38, 40. The retainer 36 also has internal threads 50 at its other end. The internal threads 50 are adapted to receive external threads 52 of the liquid dispensing nozzle body 14. Upon threading the liquid dispensing nozzle body 14 onto the internal threads 50, an end 54 of liquid dispensing nozzle body 14 contacts and sealingly engages the internal shoulder 42 of the retainer 36 to prevent the solder flux 22 from leaking past the threads 50, 52.

[0027] The liquid dispensing nozzle body 14 has an internal liquid passageway 56 which is in fluid communication with the liquid supply passageway 18 and a liquid discharge passageway 58a of a nozzle tip 58 extending from end portion 60 of the liquid dispensing nozzle body 14. The end portion 60 has external threads 62 for engaging internal threads 64 of the air discharge body 16, and more specifically, a plate 66. The plate 66 is press fit into a recess 68 of the air discharge body 16.

[0028] The air discharge body 16 has an air chamber 70 and an air discharge orifice 72 which are in fluid communication with an air inlet passageway 74. The air inlet passageway 74 is operatively connected to an air control valve 76 (Figs. 3 and 4), which may be a solenoid valve.
operatively connected to a supply of pressurized air 78. For controlling emitted bursts of pressurized air from air-discharge orifice 72, control device 28 includes an air delay timing circuit 80 coupled to an air valve an timing and driver circuit 82 that are operatively connected to the air control valve 76. As described in greater detail below, control device 28 and air control valve 76 synchronize the discharge bursts of air from air discharge orifice 72 with the discharge of liquid from liquid discharge passageway 58a. [0029] Preferably, air control valve 76 selectively delivers controlled bursts of pressurized air to the air chamber 70 that subsequently exit through air discharge orifice 72. Preferably, air pressure of air supply 78 ranges between about 10 psi and about 30 psi. Higher viscosity materials will generally need higher pressure air. In certain applications, it may be advantageous to impinge a droplet or droplets of liquid with multiple bursts of pressurized air. Also, the pressurized air bursts may be discharged at different pressures to achieve a desired flattening of the liquid droplet. There may also be various applications in which it would be desirable to flatten or spread out certain liquid droplets, but leave other droplets in their typical dispensed condition. [0030] Advantageously, the air chamber 70 and the air discharge orifice 72 are co-axially aligned with the liquid discharge passageway 58a extending from end portion 60 of liquid dispensing nozzle body 14. Preferably, the liquid discharge passageway 58a is disposed within and surrounded by the air chamber 70 and the air discharge orifice 72. [0031] In operation, the dispenser 10 is adapted to dispense a droplet 84 of flux 22 onto a substrate 86, such as a printed circuit board. Generally, printed circuit board 86 will require several droplets 84 of flux 22 dispensed over specific, discrete areas thereof. During the dispensing operation, the circuit board 86 is held in place and the dispenser 10 is moved relative to the circuit board 86 to each of the desired dispensing locations. [0032] The dispensing method or process contemplated by the present invention begins by positioning the dispenser 10 above a desired dispensing location above the substrate 86. The distance between an end 88 of the liquid discharge passageway 58a and the circuit board 86 can range from about 0.5 mm (0.02 inches) to about 19 mm (0.75 inches) depending on the application conditions. Next, the valve stem 24 is selectively disengaged from the valve seat 26 in response to receipt of trigger signal 32 by circuit 30 so that the pressurized solder flux 22 can flow through the liquid passageway 56 of liquid dispensing nozzle body 14 for a pre-selected amount of time, as determined by circuit 30. After the pre-selected amount of time of fluid flow has expired, the valve stem 24 re-engages the valve seat 26 to stop further flow of the solder flux 22 into liquid passageway 56. Therefore, and as shown in Figs. 2 and 3, a droplet 84 of solder flux 22 is formed and then dispensed from the liquid discharge passageway 58a of the liquid dispensing nozzle body 14.

As shown in Fig. 3, the droplet 84 thereafter falls from the liquid discharge passageway 58a to rest upon the substrate 86 as a slightly flattened droplet 84a (Fig. 3). The droplet 84a forms a contact area 92a with the substrate 86. [0033] In response to the trigger signal 32 that initiates dispensing of the droplet 84a, air delay timing circuit 80 initiates a pre-selected timing circle to delay the generation and emission of a burst of pressurized air from air discharge orifice 72 until the pre-selected timing circle expires. Upon expiration of the timing cycle, air control valve 76 opens for a pre-selected amount of time in response to air valve an timing and driving circuit 82. Preferably, the open state of air control valve 76 is selectable in a range from 0 ms to about 100 ms. [0034] The burst of pressurized air enters air chamber 70 and subsequently discharges through air discharge orifice 72. The pressurized air, as indicated by the vertical arrows in Fig. 3, thereby impinges upon the droplet 84a such that the droplet 84a is sufficiently flattened to form a flattened droplet 84b, and the contact area 92a is increased to a contact area 92b underneath droplet 84b, as best shown in Fig. 3A. As such, the height of the flattened droplet 84b is greatly reduced from that of droplet 84a and the contact area 92b is notably greater than contact area 92a. That is, the solder flux 22 of droplet 84b, once impinged by the burst of pressurized air, spreads out and covers more of the substrate 86 as compared to the initial droplet 84a. [0035] After the burst of air impinges upon droplet 84a, the dispensing operation for one droplet is complete and the dispenser is repositioned over the next desired dispensing location. This dispensing process continues repeatedly over the printed circuit board until all the desired dispensing locations are covered with flattened droplets of solder flux 22. It should be noted that droplet 84a may be comprised of more than one droplet dispensed at the same, or approximately the same, location. In other words, the use of the singular term "droplet" should not be interpreted in a limiting manner in this regard.

[0036] As shown schematically in Fig. 5, the valve stem 24, acting as a fluid valve, and the air control valve 76, acting as an air valve, cyclically open and close to respectively dispense discrete amounts of solder flux 22 and bursts of pressurized air. For solder flux dispense applications, the fluid valve 24 preferably remains open a time "t1" ranging between about 2 msec. and about 4 msec. Similarly, the air control valve 76 preferably remains open a time "t2" ranging between about 3 msec. and about 6 msec. for solder flux dispense applications. The air control valve 76 is operable to open a pre-selected duration of time after the fluid valve 24 is opened, as represented by delay time "t3". Therefore, the air control valve 76 can open up prior to the valve stem 24 closing down. If the delay time "t3" is zero, then the air control valve 76 opens at the time the liquid valve 24 opens. In contrast, if the delay time "t3" is equivalent to the time "t1", then the fluid valve 24 closes at the same time that the air control...
valve 76 opens. Preferably, for solder flux dispense applications, the delay time \( td \) ranges between about 2 msec. and about 4 msec. Of course, those of ordinary skill in the art will readily appreciate that the dispense times for liquid material and pressurized air, as well as the pre-selected delay between the respective liquid air dispense cycles, will vary for a particular dispensing application.

As can be appreciated, the amount of solder flux 22 dispensed by the dispenser 10 is dependent on factors such as the pressure of the source 20, the length of time \( t_\text{f} \), that the fluid valve 24 remains open, and the physical dimensions of the liquid dispensing nozzle Body 14. For instance, increasing the internal diameter of the liquid passageway 56 and the liquid discharge passageway 58a at nozzle tip 58 will allow more flux 22 to discharge for a given amount of time \( t_\text{f} \). As such, different nozzle adapters 14 with differently sized liquid passageways 56 and liquid discharge passageways 58a can be readily threaded into the nozzle adapter retainer 36 to form different sized droplets. As can be further appreciated, the liquid dispensing nozzle body 14 and the air discharge body 16 could be formed as an integral unit.

Claims

1. A method of providing contact areas (92b) on a printed circuit board (86) in preparation of securing electrical components thereto using a dispenser (10) having a nozzle (14) in fluid communication with a source (20) of viscous liquid (22) having a high surface tension; the method being characterized by providing the dispenser with an air discharge passage (72) in fluid communication with a source of pressurized air, dispensing at least one droplet (84a) of the viscous liquid from the nozzle (14) onto the printed circuit board (86) to form an initial contact area between each droplet (84a) and the printed circuit board (86) having a high surface tension of the droplet (84a) causing the initial contact area (92a) to remain substantially constant; and discharging at least one burst of air from the air discharge passage (72) for impinging each droplet (84a) after the droplet (84a) contacts the printed circuit board (86) to overcome the high surface tension, and thereby increase the initial contact area (92a) between each droplet (84a) and the printed circuit board (86).

2. The method of claim 1, wherein the steps of dispensing and discharging are repeated such that subsequent droplets form a layer of the viscous material over a desired area of the printed circuit board.

3. The method of any of claim 1-2, wherein the step of discharging the burst of air is initiated before the step of dispensing the droplet is completed.

4. The method of any of claims 1-2, further comprising: discharging multiple bursts of air from the air discharge passage for impinging the droplet and increasing the contact area.

5. The method of claim 4, wherein the multiple bursts of air are discharges at different pressures.

6. The method of claim 1, wherein the viscous liquid is solder flux.

Patentansprüche

1. Verfahren zur Herstellung von Kontaktflächen (92b) auf einer gedruckten Schaltplatte (86) als Vorbereitung für die Befestigung elektrischer Komponenten an der gedruckten Schaltplatte (86) unter Verwendung einer Ausgabevorrichtung (10) mit einer Düse (14), die in Strömungsverbindung mit einer Quelle (20) einer viskosen Flüssigkeit (22), die eine hohe Oberflächen-Spannung besitzt, steht; gekennzeichnet durch die Verfahrensschritte:

- Bereitstellen der Ausgabevorrichtung mit einem Luftausgabekanal (72), der in Strömungsverbindung mit einer Druckluftquelle steht;
- Ausgeben mindestens eines Tropfens (84a) der viskosen Flüssigkeit aus der Düse (14) auf die gedruckte Schaltplatte (86), um eine Anfangs-Kontaktfläche zwischen jedem Tropfen (84a) und der gedruckten Schaltplatte (86) zu bilden, wobei die hohe Oberflächenspannung des Tropfens (84a) bewirkt, dass die anfängliche Kontaktfläche (92a) weitgehend konstant bleibt; und
- Ausstoßen mindestens eines Luftstoßes aus dem Luftausgabekanal (72) auf jeden Tropfen (84a), nachdem der Tropfen (84a) die gedruckte Schaltplatte (86) berührt hat, damit die hohe Oberflächenspannung jedes Tropfens reduziert wird, so dass die anfängliche Kontaktfläche (92b) zwischen jedem Tropfen (84a) und der gedruckten Schaltplatte (86) vergrößert wird.

2. Verfahren nach Anspruch 1 dadurch gekennzeichnet, dass die Verfahrensschritte des Ausgabens und des Ausstoßens derart wiederholt werden, dass die nachfolgenden Tropfen eine Schicht des viskosen Materials auf einer gewünschten Fläche der gedruckten Schaltplatte bildet.

3. Verfahren nach einem der Ansprüche 1-2 dadurch gekennzeichnet, dass der Verfahrensschritt des Ausstoßens des Luftstoßes eingeleitet wird, bevor der Verfahrensschritt des Ausgabens des Tropfens
Revendications

1. Procédé d’établissement de surfaces de contact (92b) sur une carte à circuit imprimé (86) en vue de préparer la fixation de composants électriques à celle-ci, utilisant un distributeur (10) comportant une buse (14) en communication de fluide avec une source (20) de liquide visqueux (22) présentant une tension superficielle élevée; le procédé étant caractérisé par les étapes ci-dessous:
   équipement du distributeur d’un passage de décharge d’air (72), en communication de fluide avec une source d’air sous pression;
   distribution d’au moins une gouttelette (84a) du liquide visqueux à partir de la buse (14) sur la carte à circuit imprimé (86) pour former une surface de contact initiale entre chaque gouttelette (84a) et la carte à circuit imprimé (86), la tension superficielle élevée de la gouttelette (84a) assurant le maintien pratiquement constant de la surface de contact initiale (92a); et décharge d’au moins un jet d’air à partir du passage de décharge d’air (72) pour heurter chaque gouttelette (84a) après le contact entre la gouttelette (84a) et la carte à circuit imprimé (86), pour surmonter la tension superficielle élevée et accroître ainsi la surface de contact initiale (92b) entre chaque gouttelette (84b) et la carte à circuit imprimé (86).

2. Procédé selon la revendication 1, dans lequel les étapes de distribution et de décharge sont répétées, de sorte que les gouttelettes successives forment une couche du matériau visqueux au-dessus d’une surface voulue de la carte à circuit imprimé.

3. Procédé selon l’une quelconque des revendications 1-2, dans lequel l’étape de décharge du jet d’air est initialisée avant l’achèvement de l’étape de distribution de la gouttelette.
REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 4957783 A [0012]
- US 4970985 A [0012]
- US 5747102 A [0024]