

METHOD AND APPARATUS FOR SOLDER BALL PLACEMENT

Field of the Invention

- 5 The invention relates to ball grid arrays. In particular, the invention relates to an apparatus and method of placing solder balls in the ball grid arrays located upon a substrate prior to the singulation of the substrate.

Background of the Invention

- 10 Ball grid arrays are used to receive solder balls which act as electrodes for connection to integrated circuits. Typically said solder balls are placed whilst the integrated circuits are part of a larger substrates and, therefore, prior to singulation into individual units.
- 15 In placing the solder balls onto the substrates so as to align with each individual unit, the solder balls are typically placed within the predetermined array arrangement then lifted using a picker head for eventual placement onto the substrate.

- One difficulty arises with the nature of the solder balls themselves. In many
- 20 circumstances the solder balls are less than 0.5mm in diameter and, therefore, are subject to electrostatic forces and, if moisture is present, adhesion through surface tension.



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As the placement of the solder balls is a particularly precise procedure, any misalignment or "sticking" may lead to a missing solder ball or alternatively, a cluster of solder balls where only one is required. Accordingly, such problems can lead to a high defect rate of the integrated circuits.

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Two systems of the prior art include US6,607,118 and WO2004/035253. In both cases the arrangement includes placing solder balls in a template and then removal of the solder balls from the template by solder ball picker. Subsequently the solder ball picker delivers the solder balls to a substrate which then undergoes further processing.

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In the disclosure made by US6,607,118, the contents of which are incorporated herein by reference, the engagement of the excess solder balls is avoided through shaking of the picker and subsequently removal of the balls from the picker is also through vibration of the solder ball picker. Whilst at a high enough vibration engagement and
15 disengagement of the solder balls is controllable, the precise positioning of the solder balls is less certain.

Similarly as disclosed in WO2004/035253, the contents of which are incorporated herein by reference, there is no such control on the engagement and disengagement of
20 the solder balls to the solder ball picker.

It is, therefore, an object of the present invention to improve quality control of the solder balls during the placement on a substrate as compared to the prior art.

Summary of Invention

In a first aspect the invention provides a solder ball mounting module comprising a solder ball template having an array of recesses, each recess being in communication
5 with a vacuum source, and each arranged to receive a solder ball; wherein each recess further includes an ejector pin for selectively ejecting the respective solder ball engaged therein.

In a second aspect the invention provides A method for applying a plurality of solder
10 balls to a substrate comprising the steps of: placing a plurality of solder balls in a template having an array of recesses and; ejecting said solder balls using an ejector pin corresponding to each recess; receiving said solder balls by the substrate.

It follows, therefore, that the use of ejector pins to selectively and conclusively remove
15 solder balls from the recesses of the template ensures that solder balls cannot stick within the recesses. Further the use of selectively operable ejector pins can also increase the accuracy of placement of the solder balls by biasing the solder balls along a predetermined path. This is in contrast to methods of the prior art whereby the solder balls merely fall from the recesses and, therefore, lack certainty that the solder balls will
20 follow the desired path.

In one embodiment, the module further includes a retention zone used to retain a supply of solder balls at an extreme end of the module. Thus the supply of solder balls to the

template is provided within the same device for convenience and increasing the speed of loading the template.

In a further embodiment the module may be rotatable about a horizontal axis. By
5 providing a supply of solder balls to the module and then rotating the module, this may provide a flow of solder balls across the template and thus loading or seeding the template with solder balls. Such a surface may be continuous over the length of travel of the solder balls, including the template surface.

10 In a still further embodiment, the combination of a rotatable module and a retention zone provides for an automatic supply of solder balls to the template. Further if the module is rotatable in both directions about the horizontal axis, the module may rotate backward and forward and so may permit the solder balls flow across the template several times. In this embodiment, the chances of filling each recess within the template
15 may be increased and, therefore, may increase the quality of "seeding" of template.

Further, for an embodiment having a rotatable module, the module may be rotated from a first position to a second position with such a rotation causing the flow of solder balls across the template under the action of gravity. Further still, with the rotatable module
20 capable of rotating backward and forward, the module may be rotated from the first position to the second position and back to the first position. Thus, selectively determining the number of times the solder balls will flow across the template. In a still further embodiment the solder balls may flow across the template twice which may be sufficient to ensure the seeding of template.

In a further embodiment the module may be rotatable to a third position, said third position permitting a substrate to be brought proximate to the template for placing of the solder balls on the substrate. Such a substrate may be primed with flux for engaging the
5 solder balls. Still further, the third position may involve the template being directed downwards such that a substrate brought proximate to the template is lifted upwards. Thus in the ejecting of solder balls from the template, gravity may assist the ejecting pins to, firstly, remove the solder balls from the recesses and, secondly, to ensure the solder balls follow the predetermined path for accurate placement on the substrate.
10 Thus with the third position inverting the module, there may be a further advantage in the process whereby the substrate is merely lifted directly upwards rather than at an inconvenient angle or having to suspend the substrate downwards.

Alternatively the third position may have the template directed upwards where a
15 particular design may make advantageous use of such a position.

In one embodiment, the recesses in the template may be such that on receiving the solder balls, a very small portion of the solder ball, such as of the order of 50 to 100 microns project above the face of the template. The projection of the solder balls may
20 be used to measure the depth of the recesses in the manufacturing of the template. In a further embodiment, the module may further include a wiper such that solder balls may be wiped across the template through the action of a wiper travelling across the template with a wiping blade about 0.1mm above the face of the template to prevent damaging the solder balls in the recesses. This may further provide quality control in addition to

the flow of the solder balls across the template by forcing solder balls into any vacant recesses.

In a further embodiment, the module may further include a second retention zone at an
5 opposed end to the first retention zone. In this case, a backward and forward rotation of
the module about a horizontal axis may involve the solder balls travelling from one
retention zone to the next retention zone. Still further, a second retention zone may
provide a convenient additional supply of solder balls such that as each substrate
receives solder balls, only one side of the module being the first or the second retention
10 zone need to be supplied with additional solder balls. This may further assist in the
speed of the process by ensuring the module is fully utilised.

In an embodiment whereby a substrate is brought proximate to the template and so the
solder balls are applied directly to the substrate, this has distinctive advantage over the
15 prior art by eliminating the solder picker. As noted in both US6,607,118 and
WO2004/035253, the solder balls are applied to the substrate from the template by first
engaging a solder ball picker which transfers the solder balls to the substrate. By
eliminating this intermediate step, firstly any mishandling of the solder balls by the
picker is eliminated. Further the machinery required to manufacture and implement
20 such a picker may be reduced and so reducing the cost of the overall device.

Further still, by using the ejector pins, this may reduce the chances of contamination of
the flux onto the template as the solder balls may spin flux onto the template if air
purging or vibration is used.

In a further embodiment, this system may be able to handle more solder balls such as in excess of 40,000 as it may have a less demand on the vacuum source by eliminating the picker.

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In a third aspect the invention provides a solder ball mounting module comprising a solder ball template having an array of recesses, each recess being in communication with a vacuum source, and each arranged to receive a solder ball and; first and second solder ball retention zones for retaining a supply of solder balls said retention zones
10 located on opposed sides of said template.

In a fourth aspect the invention provides a method for filling an array of recesses in a template with solder balls comprising the steps of: providing a supply of solder balls in each of two retention zones; rotating said module so as to move said solder balls from
15 one retention zone to the second retention zone, so that said solder balls move across a template; depositing said solder balls in recesses of the template as a result of the movement of solder balls across the template.

In one embodiment the module may prepare the solder balls according to different
20 package pattern and to place the prepared solder balls onto the package substrate. The solder balls may be attached to area-array package substrates via solder ball placement machines prior to a reflow oven where they form the final interconnection to the substrate.

Brief Description of Drawings

It will be convenient to further describe the present invention with respect to the accompanying drawings that illustrate possible arrangements of the invention. Other
5 arrangements of the invention are possible and consequently the particularity of the accompanying drawings is not to be understood as superseding the generality of the preceding description of the invention.

Figures 1 to 6 are elevation views of a solder ball mounting module according to one
10 embodiment of the present invention showing sequential steps in the placement of solder balls.

Figure 7 is an elevation cross sectional view the ejector pins according to a further
embodiment of the present invention.

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Figure 8 is an isometric view of an ejector pin block according to a further embodiment
of the present invention.

Description of Preferred Embodiment

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Figure 1 shows the first stage in the method according to the present invention. Here a solder ball mounting module 5 is in a first position ready to fill recesses 20 in a ball grid array template 22. In this first position, solder balls 15 are located within a storage area, in this case, a solder ball retention zone 10. The retention zone 10 is arranged such that

solder balls 15 are kept within the zone at varying angles of the module 5 through a partially enclosing surface 13.

The module 5 includes a continuous surface 50 upon which the solder balls 15 can flow so as to pass over the template 22. At an opposed end of the surface 50 is a second solder ball retention zone 45 to receive the solder balls as they flow pass the template 22 and so be collected. Within the range of rotation of the module 5, the respective retention zones 10, 45 can therefore keep the solder balls retained without them flowing out from the module 5 but still maintaining an open arrangement so as to provide access for a substrate 95 to be brought proximate to template 22. Further shown in Figure 1 is a wiper 40 which is movable linearly across the surface 50 whilst maintaining a wiping blade 42 at a predetermined gap with the surface. Such a gap may be in the range 50 to 250 microns, and more specifically about 100 microns. Accordingly, the wiping blade 42 moves contiguously across the template surface, that is, close to but not in actual contact with, the template surface.

Further shown in Figure 1 is a vacuum manifold 35 which provides a vacuum source to each of the recesses 20 within the template 22 so that solder balls coming proximate to the recesses may be engaged by the recesses and held in place by the vacuum source.

The following will now describe the method according to one embodiment of the present invention with sequential steps described in Figures 1 to 6.

As mentioned previously, Figure 1 shows the module 5 in a first position ready for application of the solder balls 15 to the template 22. From the first position the module 5 rotates at 30 in a clockwise direction about a horizontal axis. Figure 2 shows the module 5 having rotated to a second position. In the second position, the first retention zone 10 is now higher than the second retention zone 45 and consequently the solder balls 15 have flowed along the continuous surface 50 to collect at the opposed end. Now a supply of solder balls 55 have collected at the wiper 40. The supply of solder balls 55 represent the excess solder balls which have not been engaged by the recesses. As the solder balls have flowed along the continuous surface 50, the recesses 20 have now engaged solder balls 60 through the application of a vacuum. At this stage, whilst the likelihood of all the recesses now being in contact with solder balls is high, this cannot be assured and so further quality checks are required. From this second position shown in Figure 2, the module 5 will now rotate 65 in a counter clockwise direction until it returns to the first position as shown in Figure 3. The quality measures implemented include a second flow of solder balls across the template and so having an excess of solder balls 73 now retained in the first retention zone 10. Any recesses that had not received solder balls will have had a second opportunity to receive a solder ball and so increase the likelihood that all recesses are now engaged.

A further problem involves the retention of solder balls 75 on the template but not engaged by a recess 20. To remove these excess solder balls 75, the wiper 40 now moves from a position adjacent to the second retention zone across the template 22 in a direction 70 towards the first retention zone 10. In so doing the wiper blade 42 will engage any solder balls that have "stuck" to the template but not engaged by a recess.

On completion of the wiping process, the wiper 40 will finish adjacent to the first retention zone 10 as shown in Figure 4. The module 5 can now rotate 85 from the first position in a counter clockwise direction until it reaches a third position whereby the module is now inverted and the template is directed downwards.

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Because the retention zones 10, 45 include a partially enclosed space 105, the solder balls 90 which have collected in the first retention zone 10 are prevented from falling from the module 5 and can, therefore, be used on subsequent processes.

10 Thus the retention zones 10, 45 may be sized so as to accommodate a large volume of solder balls sufficient to satisfy the filling requirements of several substrates 95 without having to be recharged.

Figure 4 shows the module 5 in the third position with a substrate 95 being directed
15 upwards 100 towards the template 22. In this case, the substrate 95 has already received flux upon which the solder balls will be affixed following ejection from the template 22.

Figure 5 shows the substrate 95 in a position proximate to the template 22. Here the solder balls 115 have been ejected from the recesses by individual ejection pins 110,
20 said ejector pins shown in more detail in Figure 7. Thus in a dual action of releasing the vacuum and pushing the solder balls out of the recesses by the individual ejection pins 110, the certainty of ensuring that each of the solder balls are applied to the substrate 95 is extremely high.

The operation of the ejector pins 110 may be in several forms. For instance the ejector pins may be selectively operable by an operator or automatically operated by control system. Alternatively the ejector pins may be operated, i.e. project forward to eject the solder balls on release of the vacuum. In this case, the ejector pins may be withdrawn
5 through activation of the vacuum and on release of the vacuum be biased by an inline spring forcing them forward. Thus in this embodiment the ejector pins may be subject to automatic control.

The precise position of the substrate 95 relative to the template 22 will depend on the
10 circumstances. In most circumstances, the flux on the substrate 95 must be kept clear of the recesses or else contaminate the template and, therefore, require cleaning. Accordingly a small separation of the substrate having the flux applied from the recesses may be required in many circumstances.

15 To ensure correct replacement, the balls may be dropped from a small, predetermined height from the recesses. Alternatively the pins may project sufficiently from the recesses to press the balls into the flux so as to have a further degree of certainty on placement. Either method of placement of the solder balls will fall within the scope of the present invention and these two alternatives are mere embodiments having relative
20 advantages over each other.

On placement of the solder balls 115 on the substrate 95, the substrate can then be removed 120 as shown in Figure 6 whereby the module 5 is now in a position to rotate back to the first position and the substrate 95 having solder balls 115 attached thereto

may be removed for further processing such as a final inspection and singulation into individual integrated circuit units.

Figure 7 shows the individual ejector pins 110 and the template 22. The pins are spring
5 loaded so that the pins will not be damaged if come into contact with foreign particles
and also to protect the solder balls from the over loaded pins.

Figure 8 shows an alternative arrangement of the ejector pins 130. Whereas for the
embodiment of Figure 7, the pins are individually placed and controlled, in the
10 embodiment of Figure 8, the pins 130 are formed from a single block 135, and thus are
placed and controlled as a unitary member. In this case, the pins are formed from the
block 135 using an ED process to etch the material from the block to form the pins. This
may be cheaper alternative as compare to the fabricating individual pins. More labour
hours may be required to insert the pins into the respective pins housings. This pin block
15 135 can be arranged so that one device of the substrate corresponds to one pin block and
this pin block may also be spring loaded.

Claims

1. A solder ball mounting module comprising
a solder ball template having an array of recesses, each recess being in
5 communication with a vacuum source, and each arranged to receive a solder
ball;
wherein each recess further includes an ejector pin for selectively ejecting the
respective solder ball engaged therein.
- 10 2. The module according to claim 1 further including a solder ball retention zone
for retaining a supply of solder balls at an extreme end of the said module.
3. The module according to claim 1 or 2, wherein each ejector pin is an individual
members, acting separately from the other ejector pins.
- 15 4. The module according to claims 1 or 2 further including an ejector pin block,
where said ejector pins are integrally connected to said ejector pin block.
5. The module according to any one of the preceding claims, wherein said module
20 includes a continuous surface permitting the movement of solder balls, said
module rotatable about a horizontal axis from a first position to a second
position whereby the said rotation biases solder balls to move across the module
over the template so as to permit engagement of a solder ball in the respective
recess.

6. The module according to claim 5 wherein said module is further rotatable to a third position.
- 5 7. The module according to claim 6 wherein said recesses eject the balls to be received by a substrate at the third position.
8. The module according to claim 5 or 6 wherein in said third position, said table is inverted such that the direction of ejection of said solder balls by said ejector
10 pins is vertically downwards.
9. The module according to any one of the preceding claims wherein the module further includes a second solder ball retention zone located at an opposed end to
15 the first retention zone such that on rotating from the first to the second position, said solder balls are biased to roll from the first retention zone to the second retention zone, via the template.
10. The module according to any one of the preceding claims wherein in the first
20 position said table is inclined to a vertical axis with the first retention zone located below the second retention zone and in the second position, the first retention zone is located above the second retention zone.

11. The module according to any one of the preceding claims further including a wiper having a wiping blade for selectively moving the wiping blade contiguously across the surface of the template so as to remove any solder balls projecting therefrom.

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12. The module according to any one of the preceding claims further including a rotation mechanism arranged to rotate the module from the first position to the second position in a clockwise rotation and arranged to rotate from the first position to the third position in a counter clockwise position.

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13. A method for applying a plurality of solder balls to a substrate comprising the steps of:

placing a plurality of solder balls in a template having an array of recesses and;
ejecting said solder balls using an ejector pin corresponding to each recess;

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receiving said solder balls by the substrate.

14. The method according to claim 13 wherein the placing step comprises the steps of:

providing a supply of solder balls in a retention zone;

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rotating said modules so as to move said solder balls from the retention zone across the template and

depositing said solder balls in the recesses of the template as a result of the movement of solder balls across the template.

15. The method according to claim 13 or 14 further including the step of rotating the module to a third position and bring the substrate proximate to the template prior to the ejecting step.
- 5 16. The method according to any one of claims 13 to 15 whereby the placing step further includes rotating the module from a first position to a second position so as to cause the solder balls to move across the template.
- 10 17. The method according to claim 16 further including the step of rotating the module from the second position to the first position so as to move the solder balls back across the template.
- 15 18. The method according to claim 16 or 17 further including the step of moving a wiping blade contiguously across a surface of said template, and so wiping the solder balls across the template so as to bias the solder balls into the respective recesses.
- 20 19. A solder ball mounting module comprising
a solder ball template having an array of recesses, each recess being in communication with a vacuum source, and each arranged to receive a solder ball and;
first and second solder ball retention zones for retaining a supply of solder balls said retention zones located on opposed sides of said template.

20. A method for filling an array of recesses in a template with solder balls comprising the steps of:

providing a supply of solder balls in each of two retention zones;

rotating said module so as to move said solder balls from one retention zone to

5 the second retention zone, so that said solder balls move across a template;

depositing said solder balls in recesses of the template as a result of the movement of solder balls across the template.

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