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APPARATUS AND METHOD FOR BGA BALL PLACEMENT ✓

FIELD OF THE INVENTION

The present invention relates, in general terms, to an improved method and apparatus for the creation of ball grid arrays, and to the ball grid arrays resulting from the application of such method and apparatus. More particularly, but not exclusively, the invention relates to an improved method and apparatus for the placement of solder balls in such arrays.

0 BACKGROUND OF THE INVENTION

Ball grid arrays, being a plurality of balls of any suitable material, as for example solder, disposed in a pre-determined array (in terms of number and spatial configuration or lay-out) on a given surface are well known in the art and presently available commercially. By way of example only such ball grid arrays enjoy usage

15 in the creation/manufacture of circuits and circuitry for use in integrated circuit components, being components of the type enjoying common usage nowadays in electronic equipment of all types, as for example computers. Generally speaking such arrays comprise or are made up of a substrate (of any known material) onto which are to be deposited a plurality of solder balls, in a pre-determined array in

20 terms of number and disposition, to suit the relevant electric/electronic requirements in terms of connectors, connections, etc. Such arrays, in accordance with the known art, are presently available in, for example, strip form, with the individual segments of such strips being detachable therefrom as required. In accordance with the known art significant problems have been encountered in ensuring correctness and uniformity of production of such ball grid arrays. By way of example only it is

25 essential for the correct operation of the relevant piece of electronic equipment that the requisite array is formed correctly, with the appropriate number of solder balls disposed in the prescribed or required configuration on the relevant surface, substrate or the like.

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In accordance with a first aspect of the present invention, there is provided a method of filling a ball grid array with solder balls, said method including: locating plate means have a plurality of ball-receiving apertures/recesses therein in juxtaposition with a reservoir for said balls; populating said apertures/recesses with balls from said reservoir; moving said plate means, with balls therein, relative to said reservoir to a position remote therefrom; removing said balls from said apertures/recesses of said plate means to a position located above said plate means; and depositing said balls, in a pre-determined array, on a substrate.

In accordance with a further aspect of the present invention, there is provided an apparatus for placing solder balls in a ball grid array on a substrate, said apparatus including: tooling plate means having a plurality of apertures/recesses formed therein, in number and disposition corresponding to said ball grid array; means allowing for populating of said apertures/recesses with solder balls; means for extracting said balls from said apertures/recesses and locating said extracted balls in juxtaposition with such substrate; and means for depositing said balls on said substrate in said array.

DESCRIPTION OF THE DRAWINGS

In order that the invention may be more clearly understood and put into practical effect reference will now be made to a preferred embodiment of an apparatus and a method for the production of a ball grid array in accordance with the invention. The ensuing description is given by way of non-limitative example only and is with reference to the accompanying drawings, wherein there are illustrated, sequentially, the principal steps involved in the manufacture of a ball grid array in accordance with the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in Fig. 1, apparatus in accordance with the present invention includes a reservoir 1 for solder balls 2, such reservoir 1 being in the form of a

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receptacle, of any given or suitable size and shape, for solder balls 2. In an especially preferred embodiment the reservoir 1 may be in the form of a hopper or the like receptacle adapted to house a plurality of solder balls 2 intended for deposition on a suitable substrate 20 whereby to allow for the ultimate creation of a ball grid array of any prescribed/desired type. The arrangement is such that a plate means, generally designated 3, is adapted in use to be disposed beneath, and in juxtaposition with as shown in Fig. 1, the reservoir 1. In the especially preferred embodiment illustrated the plate means 3 has a portion thereof in the form of a template, having a plurality of apertures/recesses 4 formed therein and extending therethrough for receiving and releasably retaining solder balls 2 from said reservoir 1. The number and spatial disposition or lay-out of the apertures/recesses 4 in the plate means 3 corresponds with the number and spatial disposition of balls required in the ball grid array. For different arrays, in terms of number and disposition of balls, different plates/templates 3 may be employed. In the alternative, means may be provided for blocking off selected ones of the apertures/recesses 4 to suit different end requirements.

Preferably the plate means 2 is reciprocally movable relative to the reservoir 1 between the respective positions shown in Figs. 1 and 2. Alternatively, however, the plate means 3 may be in the form of a continuous strip having arrays of apertures/recesses 4 formed therein at spaced-apart positions along the length thereof, such arrays being adapted to pass beneath said reservoir 1, for population by balls 2 therefrom, in a continuous cycle. Preferably means (not shown) may also be provided for imparting a vibrational movement to the plate means 3 and/or the reservoir 1, thereby to assist in properly populating, with a single ball, each and every aperture/recess 4 in the template portion of the plate means 3. A means employed for imparting such vibrational movement is not of the essence of the invention.

The apparatus in accordance with the present invention, in the preferred embodiment illustrated, further includes ball removal means 5 co-operable with the

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plate means 3, and reciprocally movable substantially normally thereto between the end positions shown in Figs. 1 and 3 respectively. The ball removal means 5 includes a plurality of projections 6 adapted, in use, to co-operate with and extend through the apertures/recesses 4 provided in the plate means 3 and operable to
5 cause the balls 2 housed in such apertures/recesses 4 to be ejected therefrom in a subsequent step, to facilitate ultimate deposition thereof on a substrate or the like. Preferably the reservoir 1 is adapted, in use and as shown in Fig. 1, to be disposed over the template portion of the plate means 3 whereby to allow for deposition onto the template portion, under gravity, of solder balls 2, the aim being to populate fully
10 the apertures/recesses 4 provided in the template portion.

In the especially preferred embodiment illustrated the template portion of the plate means 3 is selectively and repeatedly reciprocally movable between two end operating positions, as shown for example in Figs. 1 and 2 of the drawings. In a first operating position (see Fig. 1) the template portion is disposed beneath the
15 reservoir 1 and is adapted to receive and releasably retain, in a pre-determined array in the apertures/recesses 4 thereof, balls 2 fed from said reservoir. In a second position, as shown in Fig. 2, the template portion, with balls 2 disposed in the apertures/recesses 4 thereof as desired, is moved to a position remote from the reservoir 1. When in the second position, and in that regard reference is made to
20 Fig. 3 of the drawings, the balls 2 as disposed on the upwardly extending projections 6 of the ball removal means 5 are then brought into juxtaposition with a vacuum/suction means 10 (of any known type). The arrangement is such that, when the suction/vacuum means 10 is activated, the balls 2 then disposed on the ends of the projections 6, and spaced above the template portion as shown, are drawn into
25 said suction means 10 to be disposed therewithin, in the prescribed array.

The suction/vacuum means 10 includes a substantially hollow head member 11 having a means 12 reciprocally movable therewithin between the positions shown in Figs. 3 and 5, such means 12 being in the form of a member having a plurality of hollow projections 13 extending downwardly therefrom. The projections 13,



equivalent in number and spatial disposition to the projections 6 of the ball removal means 5, are adapted in use to receive and releasably retain the balls 2 as removed/ejected from the template portion of the plate means 3. To assist in retention of the balls 2, in an especially preferred embodiment each projection 13, preferably hollow, will be in flow connection with the suction/vacuum means 10. Once the balls 2 are disposed within the suction head 11, then the template portion of the plate means 3 and associated ball removal means 5 are returned to a position in juxtaposition with the reservoir 1 (as in Fig. 1), whereby to allow for creation of further ball grid arrays in subsequent operations. The balls 2 disposed within the suction head 11 are then transferred into a position disposed above a substrate 20 of any given type (see Fig. 5). When the suction/vacuum is removed, the balls 2 disposed within the suction head 11 are forced under gravity in a downward direction to be deposited on the substrate 20 in the predetermined array. In a subsequent step in the procedure, not an essential feature of the present invention, the substrate 20 with balls 2 disposed thereon is subjected to a fixing process (by any suitable means) whereby to melt/fuse the balls 2 to or with the substrate 20. Preferably such fixing can be achieved using a heating operation, with heat being applied using any suitable means. It should be understood, however, that the method of and means for achieving such fixing is not of the essence of the invention. Indeed other suitable means and methods, as for example by the use of ultrasonic vibrations, may be employed.

In accordance with known techniques, the substrate 20 may be coated with a flux solution or the like (of any known type), which acts as an adhesive to retain solder balls 2 deposited thereon in position prior to fixing. The flux solution may be disposed on the substrate 20 using any known method and apparatus - as for example in a silk screening process - prior to the deposition of the solder balls 2 thereon.

The overall operation of the formation of the substrate 20 and associated ball grid array may be controlled in any suitable manner, as for example by computer.



The actual means of achieving such control, however, is not of the essence of the invention.

The principal steps in the method of the present invention, employing the apparatus described earlier, are now explained in detail, and in sequence.

5 In a first step a template of any given type, having a plurality of recesses/apertures 4 extending therethrough and arranged in a predetermined manner thereon, is disposed below a reservoir or supply 1 of solder balls 2. Gravity feed, in conjunction preferably with a slight vibrating movement, allows for population of each aperture/recess 4 of the template with a single solder ball 2. The template, with apertures/recesses 4 fully populated, is then shifted laterally away from the reservoir 1 for balls. Such sideways movement ensures that any excess balls are removed from the template.

15 The ball removal means 5 is then activated to result in removal of the balls 2 from the apertures/recesses 4, for deposition on the projections 6 extending above the template. The suction/vacuum means 10 is then activated to draw the balls 2 into the head member 11 thereof. Once such is achieved, the template is returned to the position under the reservoir 1, for use in a subsequent procedure. The suction/vacuum means 10, with balls 2 therein, is then brought into position relative to a substrate 20 having a flux screen thereon. Upon removal of the suction/vacuum the balls 2 drop down onto the substrate 20 and associated screen, to be affixed thereto in a subsequent fixing step.

25 The method and apparatus in accordance with the present invention allow for the creation, in a simple and cost-effective manner, of a ball grid array. The present applicant's arrangement ensures full population of the template - in the desired configuration - and accurate location of the solder balls 2 on a suitable substrate 20. In that regard it should be realized that, because of the actual physical size (dimensions) of the balls employed, and furthermore because of the distance travelled by such balls, under gravity, from the hopper to the plate means, all apertures/recesses will be populated by one ball and one ball only. The preferred use

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of an additional vibrational movement further ensures that such is the case.

The end result of the utilisation of the method and apparatus in accordance with the present invention will be a substrate which, on one side thereof, will have a plurality of - an array of - solder balls deposited thereon and affixed thereto in an
5 ordained pattern and number.

Finally it is to be understood that the foregoing description refers merely to preferred embodiments of the invention and that variations and modifications will be possible thereto without departing from the spirit and scope of the invention, the ambit of which is to be determined from the following claims.

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CLAIMS

1. A method of filling a ball grid array with solder balls, said method including: locating plate means have a plurality of ball-receiving apertures/recesses therein in juxtaposition with a reservoir for said balls; populating said apertures/recesses with balls from said reservoir; moving said plate means, with balls therein, relative to said reservoir to a position remote therefrom; removing said balls from said apertures/recesses of said plate means to a position located above said plate means; and depositing said balls, in a pre-determined array, on a substrate.
2. The method as claimed in claim 1, wherein said reservoir is a hopper or the like receptacle adapted to be disposed over said plate means and in juxtaposition therewith, said hopper or the like feeding balls, under gravity, onto said plate means whereby to populate the apertures/recesses provided therein.
3. The method as claimed in claim 2, wherein at least one of said reservoir and/or said plate means is adapted to be subjected to a vibratory movement whereby to facilitate population of said apertures/recesses of said plate means with balls from said reservoir.
4. The method as claimed in any one of the preceding claims, wherein said plate means, with apertures/recesses populated with balls, is displaced from said reservoir to a position remote therefrom, and wherein said balls are caused to be ejected from said apertures/recesses of said plate means and to be disposed, in said pre-determined array, at a location substantially vertically above said plate means, said balls being disposed on the free ends of movable projection members adapted to penetrate said apertures/recesses of said plate means and to extend thereabove.
5. The method as claimed in claim 4, wherein said plate means is reciprocally movable relative to said reservoir between a first position, in juxtaposition with said reservoir, to a second position laterally removed therefrom.
6. The method as claimed in claim 4 or claim 5, wherein said balls are lifted from said projection members, to be retained in said pre-determined array in a plurality of corresponding apertures/recesses provided in a receiving means adapted to be



disposed over said plate means when in said position remote from said reservoir.

7. The method as claimed in claim 6, wherein said receiving means includes suction means associated therewith for lifting said balls from said projections and releasably retaining said lifted balls.

8. The method as claimed in any one of the preceding claims, wherein said suction means is brought into juxtaposition with a substrate, thereby to allow for deposition of said balls on said substrate in said pre-determined array.

9. The method as claimed in claim 8, wherein said suction means includes a suction head, operably connected to a source of suction or vacuum, said suction head including means, corresponding in number and disposition to the number of and disposition of said balls in said array, for releasably receiving said balls from said projections.

10. The method as claimed in claim 8 or claim 9, wherein said substrate, with balls deposited thereon, is subjected to a fixing step.

11. The method as claimed in claim 10, wherein fixing of said balls relative to said substrate is achieved in a heating operation.

12. The method as claimed in claim 8, wherein said fixing of said balls relative to said substrate is achieved ultrasonically.

13. A method of filling a ball grid array with solder balls, said method including: extracting a plurality of balls from a reservoir therefor and depositing said balls on a tooling plate member, said tooling plate member having a plurality of apertures/recesses therein corresponding in number and disposition to said ball grid array, such that each aperture/recess is populated by a single ball; moving said tooling plate member, with deposited balls, to a position remote from said reservoir for balls; extracting said balls from said tooling plate member, in said array; and depositing such balls on a substrate.

14. An apparatus for placing solder balls in a ball grid array on a substrate, said apparatus including: tooling plate means having a plurality of apertures/recesses formed therein, in number and disposition corresponding to said ball grid array;



means allowing for populating of said apertures/recesses with solder balls; means for extracting said balls from said apertures/recesses and locating said extracted balls in juxtaposition with such substrate; and means for depositing said balls on said substrate in said array.

15. The apparatus as claimed in claim 12, including a reservoir for solder balls, adapted to be located in juxtaposition with said tooling plate means to allow for population of said apertures/recesses thereof with balls.

16. The apparatus as claimed in claim 15, wherein said reservoir is a hopper or the like receptacle adapted to be disposed over said tooling plate means and in juxtaposition therewith, said hopper or the like feeding balls, under gravity, onto said tooling plate means whereby to populate the apertures/recesses provided therein.

17. The apparatus as claimed in claim 15 or claim 16, including means for imparting a vibrating movement to said tooling plate means and/or said reservoir for balls, whereby to assist in populating said apertures/recesses of said tooling plate means.

18. The apparatus as claimed in any one of the preceding claims, including means for displacing said plate means, with apertures/recesses populated with balls, from said position in juxtaposition with said reservoir to a position remote therefrom, said displacement means including means for imparting a reciprocating motion to said plate means and/or said reservoir.

19. The apparatus as claimed in any one of claims 14 to 18, including means for causing said balls to be ejected from said apertures/recesses of said plate means and to be disposed, in said pre-determined array, at a location substantially vertically above said plate means.

20. The apparatus as claimed in claim 19, wherein said means for ejection of balls includes a member, adapted to be reciprocally movable in a direction substantially normal to said plate means, and having a plurality of protrusions/projection members thereon, said means for ejection being selectively and sequentially movable between a first position, wherein said protrusions/projections are not disposed within said



apertures/recesses of said plate means, to a second position wherein said protrusions/projections extend into and protrude through said apertures/recesses of said plate means, the arrangement being such that said balls are ejected from said apertures/recesses and disposed releasably on the free ends of said protrusions/projections.

21. The apparatus as claimed in any one of claims 18 to 20, wherein said plate means is reciprocally movable relative to said reservoir between a first position, in juxtaposition with said reservoir, to a second position laterally removed therefrom.

22. The apparatus as claimed in claim 20, including means for lifting said balls from said protrusions/projections, to be retained in said pre-determined array in a plurality of corresponding apertures/recesses provided in a receiving means adapted to be disposed over said plate means when in said position remote from said reservoir.

23. The apparatus as claimed in claim 22, wherein said receiving means includes suction means associated therewith for lifting said balls from said protrusions/projections and releasably retaining said lifted balls.

24. The apparatus as claimed in claim 23, wherein said suction means is brought into juxtaposition with a substrate, thereby to allow for deposition of said balls on said substrate in said pre-determined array.

25. The apparatus as claimed in claim 23 or claim 24, wherein said suction means includes a suction head, operably connected to a source of suction or vacuum, said suction head including means, corresponding in number and disposition to the number of and disposition of said balls in said array, for releasably receiving said balls from said protrusions/projections of said means for ejection of balls.

26. The apparatus as claimed in claim 25, wherein said suction head includes a plurality of apertures/recesses therein, in size, number and disposition corresponding to the number of balls in said array, each adapted to receive a single ball from said means for ejecting balls from said plate means.

27. The apparatus as claimed in claim 25 or claim 26, wherein said suction head



includes a member, reciprocally movable therewithin, including a plurality of protrusions/projections thereon corresponding in number and disposition to the number and disposition of balls in said array, said protrusions/projections being operable to releasably retain balls ejected from said plate means and to assist in deposition of said balls on said substrate in said pre-determined array.

28. The apparatus as claimed in any one of claims 14 to 27, including means for fixing said deposited balls to said substrate.

29. The apparatus as claimed in claim 28, wherein said fixing means is in the form of a heating means or element adapted to apply heat energy to said substrate/ball combination.

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