

LASER REFLOW WITH TEMPLATE FOR SOLDER BALLS OF BGA PACKAGING

FIELD OF THE INVENTION

5 The present invention relates to the use of soldering in the electrical connection between an IC device and a printed circuit board. In particular, the present invention relates to the use of laser technology for the reflowing of solder balls on a ball grid array (BGA) device.

10 BACKGROUND OF THE INVENTION

Ball grid array (BGA) packaging of integrated circuit (IC) devices is gaining increasing importance in IC device production. In BGA packaging, the IC chip is commonly mounted on a copper substrate with pads, whereon flux is applied followed by the placement of solder balls. The solder balls are then
15 soldered onto the pads in a reflow oven.

The conventional method of ball placement is to use a vacuum suction head with the appropriate array of suction holes to pick up the soldering balls. The balls sucked up in the proper array onto the head are then lowered onto a substrate with pre-applied flux. This BGA assembly can then
20 be conveyed to the reflow oven for soldering of the solder balls.

Current trend in IC chip production is for greater IC density per chip. The higher the IC density, the greater the number of interconnects required on the same chip size. Therefore, there has been a demand for BGA packages with higher density pads and solder balls. In these high density BGA

packages, the number of interconnecting pads per chip can be as high as 1,000 to 2,000, compared to a low density BGA package of below 400 pads per chip for the same surface area. For high density packages above 400 pads per chip, the pitch (distance between two solder balls) and solder ball size have to be reduced accordingly. For example, a low density BGA configuration of below 400 pads per chip with a pad diameter of 25 mil. and pitch of 50 mil. can use solder balls of 30 mil. diameter. In the case of high density BGA configurations for example with pads diameter of 10 mil. and pitch of 20 mil., solder balls of 12 mil. diameter have to be used instead.

10 This reduced pitch and ball size poses a problem for the soldering process. The first problem is placement problem. Due to the very small size and light weight of the solder balls, even a minute air turbulence or a minor warpage of the substrate might result in a displacement of the ball position. Because of the fine pitch required in high density arrays, even a slight
15 displacement may result in bridging, which is the mixing of two soldering balls to form a connection during the process of soldering in a reflow oven. Once bridging occurs, the entire package has to be rejected. Consequently, conventional method of ball placement using the vacuum suction head results in high rejection rates due to bridging. The second problem is in the
20 transfer of the packaging from the ball placement site to the reflow oven. Even if the solder balls were placed accurately, the movement necessary to transfer the packaging to the reflow oven would cause the balls to be displaced. In addition to the problems stated above, the equipment for the various steps of ball placement and reflowing are bulky and expensive.
25 There is therefore a need to improve the packaging process by designing new concepts of ball placement which would prevent displacement of the

solder balls and bridging while minimizing the amount of equipment involved in the process.

OBJECT OF THE INVENTION

5 It is an object of the present invention to provide an accurate method of solder ball placement in the packaging of BGA devices.

It is another object to reduce the occurrence of solder ball bridging in the reflowing process in BGA assembly line.

It is a further objective to eliminate the necessity of a reflow oven in the
10 soldering of solder balls on BGA devices.

SUMMARY OF THE INVENTION

The present invention is a system for solder ball placement and reflow on BGA packaging comprising means for template alignment, means for solder ball placement and a laser head. The template is aligned with connection
5 pads located on the surface of the substrate with pre-applied flux. The aligned template allows accurate guiding of the balls onto the pads by the ball placement means. One ball is dropped into each hole in the template directly onto the pads containing a layer of flux. The solder balls positioned on the pads are then exposed to a laser via the laser head, resulting in the
10 rapid melting of the solder balls directly onto the substrate pads. The melted balls are then allowed to cool rapidly. This laser reflow with template method eliminates the use of the reflow oven, which is a bulky equipment involved in the packaging of BGA devices, while increasing the accuracy of the ball placement and alleviates the problem of ball bridging.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic illustration of the template-guided ball placement step according to the present invention.

Figure 2 is a schematic illustration of the laser reflow step according to the
5 present invention.

Figure 3 is a schematic diagram to show the positioning of a laser head for laser reflow of the solder ball.

Figure 4 is a flow diagram to illustrate the steps involved in the laser reflow process according to the present invention.

DESCRIPTION OF THE INVENTION

The present invention utilizes a combination of two separate techniques to achieve synergistically superior results in the packaging of high density BGA devices. The first technique involves the use of a template to guide the
5 release and placement of the ball from a conventional ball sucking head. Once the balls are properly placed above the substrate and within the template, the second technique of laser reflow is used, which causes the melting and effective soldering of the solder balls. The template can then be removed and the device transferred directly to the cleaner to remove the flux
10 residue, eliminating the use of the bulky reflow oven, and also reducing the time required to complete the packaging process.

Figure 1 shows a schematic illustration of the ball placement process according to the present invention. After flux is applied to the substrate 20 according to conventional methods, a template 22 of the high density array is placed over the substrate. A ball sucking head 24 with solder balls in
15 position is aligned over substrate, using the template as a guide. When the array in the ball sucking head is aligned with the array of the template, the vacuum on the ball sucking head is released, and the solder balls are discharged onto the substrate with flux. The ball sucking head may be a
20 conventional one commonly used in BGA packaging, with the array adapted for high density devices. The template can be a wire mesh with the mesh size of the required density. The template may be made from any material which is heat tolerant such as stainless steel and aluminum. A preferred material is stainless steel. The wire of the mesh should be thick enough to
25 prevent a solder ball from rolling over the wire. For example, for a solder ball

with diameter of 12 mil, the thickness of the wire of the mesh, as indicated by reference numeral **26** of Figure 3, may be around 12 mil, to prevent the ball from rolling out of the cavity **27**. In addition, the inner area of the cavity should preferably be slightly larger than the cross-sectional area of the solder ball for ease of placement by the ball sucking head, and prevention of a ball getting easily attached to the wire mesh. A preferred area is 15-35% larger than the cross-sectional area of the solder ball.

Figure 2 illustrates how a matrix laser head is used to reflow the solder balls. The ball sucking head is moved away from the substrate after ball placement, and a laser head **30** is placed over the template and solder balls and melted rapidly under the laser beam to form intermetallic fusion. Once the laser beam is switched off, the molten solder ball cools rapidly at a high cooling rate. The laser head is preferably a gyroscope head or matrix type head comprising of a series of optical fibers arranged in an identical array as the ball array. Lasers such as neodymium:yttrium-aluminum-garnet (Nd:YAG) laser is suitable for laser reflow. The laser reflow may be performed under normal ambient conditions, or it can be performed in a nitrogen environment. The duration and intensity of the exposure varies with the different solder balls, and can be determined with routine experimentation.

Figure 3 shows the alignment of the optic fibers of the laser head with the solder balls **28** placed inside the cavities **27** of the template **29** above the layer of flux **32**. The optical fibers are housed in a housing **34** which fixes the array of the optical fibers **36** to match the array of the pads and the

solder balls. The wire mesh of the template has a height **26** approximately the same as the diameter of the solder balls.

Figure 4 is a flow diagram to show the process according to the present invention. After flux application **40**, the template is aligned with the substrate
5 followed by ball placement with the ball sucking head **42**. After step **42**, a visual check **44** is preferably performed to ensure that the balls are placed properly, followed by laser reflow **46**. Steps **42-46** are preferably performed with the package stationary to minimize any disturbance to the balls once they are placed onto the substrate. After laser soldering, the
10 package may be heated in a reflow oven or a hot plate **48** for a short time to smoothen and polish the surfaces of the soldered balls. The visual checking step is preferably performed using a camera, for example a CCD (capacitor charge device) camera.

While the present invention has been described particularly with
15 references to Figs 1 and 4, it should be understood that the figures are for illustration only and should not be taken as limitation on the invention. It is contemplated that many changes and modifications may be made by one of ordinary skill in the art without departing from the spirit and the scope of the invention described.



CLAIMS

- 1 1. A system of solder ball placement and laser reflow of ball grid array
- 2 packaging of an IC chip with a substrate having an array of pads
- 3 comprising :
- 4 means for template alignment
- 5 a template with an array of cavities matching said array of pads,
- 6 means for solder ball placement and
- 7 a laser module with a laser head adapted to send at least one laser
- 8 beam onto said solder balls,
- 9 said system performing the sequential steps of :
- 10 aligning said cavities of said template with said array of pads having
- 11 pre-applied flux;
- 12 aligning said means for solder ball placement with said substrate
- 13 using said template as a guide so that an array of solder balls is aligned
- 14 with said array of pads;
- 15 discharging said aligned solder balls onto said pads with pre-applied
- 16 flux so that one solder ball is placed within each cavity of said template;
- 17 aligning said laser head with said substrate; and
- 18 discharging a laser beam onto said solder ball such that said solder
- 19 balls are melted and soldered onto said pad.



- 1 2. A system for solder ball placement and laser reflow according to claim 1
2 wherein said system further comprises a camera, and an additional step
3 of visual checking with said camera is performed after solder ball
4 placement.
- 1 3. A system of solder ball placement and laser reflow of ball grid array
2 packaging according to claim 1 wherein said laser head is a matrix laser
3 head.
- 1 4. A system of solder ball placement and laser reflow of ball grid array
2 packaging according to claim 1 wherein said laser head delivers a
3 Nd:YAG laser beam.
- 1 5. A system of solder ball placement and laser reflow of ball grid array
2 packaging according to claim 1 wherein said laser soldering step is
3 performed under nitrogen environment.
- 1 6. A system for solder ball soldering placement and laser reflow according
2 to any one of the preceeding claims wherein an additional step of heat
3 polishing of said solder balls is performed with a reflow oven or a heat
4 plate after said laser soldering step.
- 1 7. An apparatus for solder ball placement and laser reflow of ball grid array
2 packaging of an IC chip with a substrate having an array of pads for
3 interconnection comprising :
4 means for template alignment;
5 means for solder ball placement; and
6 a laser head adapted to send a laser beam onto said solder balls.