

IC TEST SOCKET

Background of the Invention

This invention generally relates to the art of integrated circuit ("IC") testing sockets and, particularly, to a socket for testing an IC package having an array of solder balls on a bottom surface thereof. An IC socket is used for performing burn-in tests of IC packages. In these tests, current is applied to IC package for a given number of hours at given, sometimes elevated temperatures to ensure that the IC package will not fail during normal operation. Such a test socket typically includes a dielectric socket body, or housing, which mounts a plurality of terminals in respective terminal-receiving passages in the body. Contact ends of the test socket terminals engage an array of electrodes on the IC package, and the opposite ends of the terminals have tails which engage circuit traces on a printed circuit board.

One type of electrode array of an IC package is a ball grid array (BGA) which is a grid of solder balls arranged on the bottom surface of the IC package. Examples of sockets for testing and evaluating IC packages of the BGA-type are shown in Japanese Patent Application Laid-Open Nos. Hei 8-273777 and Hei 10-189191. The socket described in Japanese Patent Application No. Hei 10-189191 includes a socket base, a base seat and contact pins on the socket base. A BGA-type IC package is received in a recess in the socket base. The contact pins are scissors-shaped with planar scissors portions. The contact pins are arranged in a grid-shape on the socket base, with the scissors portions extending upwardly, and the IC package is loaded on the scissors portions. The solder balls of the IC package are located between the scissors portions. The base seat has holes into which the scissors portions are inserted, and the base seat is advanced and retracted relative to the socket base in cooperation with the operation of a pressure cover. The scissors portions of the contact pins are brought into contact with the solder balls as the scissors portions are rotated to the balls. This IC test socket has problems caused by the scissors portions of the contact pins being in direct contact with the IC package. Consequently, the movement of the scissors portions causes the IC package to move in various directions from its initial loading position in the test socket. In addition, when the IC package is mounted on the socket, the

scissors portions abut against the IC package so that either the solder balls or the IC package may become damaged.

In the IC test socket described in Japanese Patent Application No. Hei 8-273777 a loading means is provided on the socket body, and contact pins and a slide member are provided. The IC package is loaded on the loading means and is prevented from displacement in various directions from the original loading position. The contact pins cannot be brought into abutment with the IC package. Unfortunately, this IC test socket cannot be used with IC packages in which the solder balls are arranged at a high density, because the contact pins are bifurcated and include contact portions which are shifted in first and second horizontal directions perpendicular to each other, respectively.

The present invention is directed to solving these various problems in an IC test socket for IC packages wherein solder balls are arranged at high densities, providing a simple structure having positive contact with the solder balls.

Summary of the Invention

An object, therefore, of the invention is to provide a new and improved burn-in socket for testing IC packages that have an array of solder balls thereon.

Another object of the present invention is to provide an improved test socket for testing IC packages that utilize BGAs, wherein the test socket includes a plurality of bifurcated contact pins that open evenly under pressure of the actuator of the socket as an IC package is being inserted into the package.

In the exemplary embodiment of the invention, a socket body is provided with a receptacle that receives the IC package. A plurality of terminals are mounted on the socket body, each terminal having opposite contact and terminal portions. The contact portions are disposed and exposed in the receptacle for engaging the IC package solder balls. The contact portions of the terminals are bifurcated to form pairs of opposing jaws, which engage the sides of solder balls inserted therein. A spreader mechanism is movably mounted on the socket body for spreading the jaws of the terminals in opposite directions to open them and create a space into which the solder balls of the IC package may be inserted as the IC package is inserted into the receptacle.

An actuating cover is mounted on the socket body for movement generally toward and away from the receptacle. The cover is operatively associated with the spreader mechanism to

spread the jaws in response to movement of the cover.

According to one aspect of the invention, the spreader mechanism includes a spreader plate having a plurality of wedges that extend between the bifurcated contact portions of the terminals to spread the jaw portions thereof in response to movement of the spreader plate relative to the socket body. The jaws are formed by distal ends of pairs of contact arms, which a restricted zone therebetween, spaced inwardly of the distal ends of the arms, for engaging one of the wedges of the spreader plate. The jaws are configured for engaging the sides of the solder balls at locations spaced from distal ends of the balls beyond the widest cross-sections of the balls.

According to another aspect of the invention, a retaining mechanism is movably mounted on the socket body for holding the IC package securely in the receptacle. The retaining mechanism is operatively associated with the actuating cover for moving the retaining mechanism. Spring means are provided to normally bias the retaining mechanism toward an operative position to hold the IC package in the receptacle. The cover is effective to move the retaining mechanism to an inoperative position, thereby releasing the IC package.

A further feature of the invention is the provision of a loading plate in the receptacle of the socket body. The IC package is positioned onto the loading plate. The retaining mechanism includes at least one retaining arm for holding the IC package down on the loading plate.

Other objects, features and advantages of the invention will be apparent from the following detailed description taken in connection with the accompanying drawings.

Brief Description of the Drawings

In the course of this detailed description, the reference will be frequently made to the attached drawings in which:

FIG. 1 is vertical sectional view taken through an IC test socket constructed in accordance with the principles of the present invention;

FIG. 2 is a top plan view of the loading plate of the test socket of FIG. 1;

FIG. 3 is a front elevational view, partially in section, of the loading plate of FIG. 2;

FIG. 4 is a side elevational view, partially in section, of the loading plate of FIG. 2;

FIG. 5 is an elevational view of one of the terminals of the socket as it appears in the test socket of FIG.1;

FIG. 6 is a side elevational view of the terminal of FIG. 5;

FIG. 7 is a top plan view of a terminal spreader plate used in the test socket of FIG. 1; FIG. 8 is a front elevational view, partially in section, of the spreader plate of FIG. 7; FIG. 9 is a side elevational view, partially in section, of the spreader plate of FIG. 7; FIG. 10 is a fragmented, partial sectional view of a pair of terminals of the test socket of FIG. 1 engaging two solder balls of an IC package inserted into the test socket;

FIG. 11 is a sectional view similar to that of FIG. 10, but illustrating the wedges of the spreader plate spreading the contact arms of the terminals away from the solder balls;

FIG. 12 is a vertical sectional view of FIG. 1, taken along lines 12-12 thereof, illustrating the test socket actuating cover in its elevated inoperative position;

FIG. 13 is the same view as FIG. 12, but illustrating the test socket cover depressed sufficiently to actuate the spreader plate for spreading the jaws of the terminals;

FIG. 14 is the same view as FIG. 13, but illustrating the test socket cover further depressed a distance to open the retaining arms of the retaining mechanism;

FIG. 15 is the same view as FIG. 1, but with the IC package removed;

FIG. 16 is the same view as FIG. 15, but with the test socket cover depressed to its initial position as shown in FIG. 13;

FIG. 17 is the same view as FIG. 15, but with the test socket cover fully depressed to allow the IC package to be mounted in the socket; and,

FIG. 18 is an enlarged detail view of the contact arms of one of the bifurcated terminals in engagement with the one of the solder balls of an IC package.

Detailed Description of the Preferred Embodiment

Referring to FIG. 1, the invention is embodied in a burn-in socket, generally designated 20, for testing an IC package 22 which includes a conductive array of solder balls 24 arranged on a bottom surface thereof. Such an IC package often is called a BGA ("ball grid array")-type package. The test socket 20 includes a dielectric socket body 26 that defines a receptacle 28 that receives the IC package. The IC package 22 is mounted on a loading plate 30 and the socket body 26 includes a plurality of terminals 32 that engage the solder balls 24 of IC package 22. A spreader mechanism 34 has a plurality of wedges for spreading terminals 32 to engage the solder balls, as described hereinafter. A retaining mechanism 38 holds the IC package 22 down on loading plate 30. The spreader mechanism 34 and retaining mechanism 38 are operatively associated with an actuating cover 40, which is mounted on the socket body 26 for vertical

reciprocating movement relative thereto in the directions of arrow "A". In essence, depressing actuating cover 40 from its inoperative position shown in FIG. 1, is effective to sequentially operate the spreader and retaining mechanisms 34, 38, as described in greater detail below.

Referring to FIGS. 2-4, the loading plate 30 is generally rectangular and has a top loading surface 30a on which the IC package 22 is positionable. The loading plate 30 includes a pair of latch arms 42 (FIG. 3) that depend therefrom and are dimensioned for insertion into appropriate latch holes (not shown) disposed in the socket body 26 to fix the loading plate to the socket body 26. Four upstanding guide posts 44 are provided at each of the four corners of the loading plate 30. The guide posts are configured, preferably with chamfered inside edges 44a that are engaged by the corners of the IC package 22 in order to guide the IC package 22 down onto loading surface 30a of the loading plate 30. The IC package 22 is loaded downwardly in the direction of arrow "B" (FIG. 3) within the guide posts 44 onto the loading surface 30a of the loading plate 30. A plurality of ball-insertion passages, or slots 46, are formed in the loading plate for receiving the solder balls 24 (FIG. 1) of the IC package 22. In order to accommodate the bifurcated contact arms of terminals 32, the loading plate passages or slots 46 are longer than the width of the solder balls.

Referring now to FIGS. 5 and 6, each terminal 32 is formed of conductive metal material in a manner so as to have a certain amount of elasticity. Each terminal is disposed in the socket body 26 below the loading plate 30, and each terminal includes a mounting base portion 48 having a retaining tooth 48a for skiving into, or otherwise engaging, the material of socket body 26. A tail portion 50 of each terminal 32 projects outwardly from the mounting base portion 48 of the socket body 26 (FIG. 1) for insertion into an appropriate hole in a printed circuit board and for connection, as by soldering, to a circuit trace on the circuit board and/or in the through hole. A bifurcated contact portion 52 projects from the opposite end of base 48 and is formed by a pair of contact arms 54. The contact arms 54 terminate in opposing jaws 56 at the distal ends of the arms 54 and the terminals 32. These jaws 56 are pointed at contact tips 56a thereof. Finally, a pair of opposing spreading shoulders 58 are formed inside the contact arms 54 and are spaced inwardly of jaws 56.

FIGS. 7-9 show the terminal spreader mechanism 34 which includes a rectangular spreader plate 60 which has a plurality of through passages 62 that are separated by partition portions 64. As seen best in FIG. 8, the partition portions 64 form downwardly projecting wedges between the passages 62. As will be seen hereinafter, the contact arms of the terminals

32 extend into passages 62, and the wedges 64 are effective to spread the jaws of the arms in response to VERTICAL movement of the spreader plate 60. A plurality of bosses 66 project downwardly from spreader plate 60 for seating a plurality of coil springs 68, as seen best in FIG. 1. The springs 68 are sandwiched between the socket body 26 and the spreader plate 60 to spring-load the spreader plate 60. The spreader plate is located beneath loading plate 30.

FIGS. 10 and 11 show the positional relationship between the terminals 32 and spreader plate 60, IC package 22 and solder balls 24. In particular, it can be seen that the contact arms 54 of the terminals 32 project through the passages 62 of the spreader plate 60. The wedges 64 between the passages 62 are aligned between the contact arms of the terminals in line with spreading shoulders 58 of the terminals. FIG. 10 shows the terminal jaws 56 engaging the sides of the solder balls 24 of the IC package 22. When the spreader plate 60 is depressed or pushed downwardly in the direction of arrow "C" (FIG. 11), the wedges 64 move downwardly into engagement with the spreading shoulders 58 on the insides of the terminal contact arms 54. This causes the contact arms 54 to move outwardly and spread the jaws 56 in opposite directions as indicated by arrows "D" (FIG. 11) away from the sides of the solder balls 24. The solder balls 24 now are free from the jaws as seen in FIG. 11, and the IC package 22 is free to be lifted out of the test socket, subject to the constraints of retaining mechanism 38. When pressure is released from spreader plate 60, the springs 68 (FIG. 1) push the spreader plate 60 back upwardly, removing the wedges 64 from their engagement with the spreading shoulders 58, and the contact arms 54 and jaws 56 will move back inwardly toward each other under their own resiliency.

With the above description of the movement of the terminal contact arms 54 and jaws 56, it should be understood that the jaws 56 project upwardly into the ball-receiving slots 46 of the loading plate 30. (FIGS. 2-4.) The solder ball-receiving slots 46 are sufficiently long to accommodate both the solder balls 24 of the IC package 22 and the movement of jaws 56 of the terminals 32, as described above.

An actuating mechanism 70 for the spreader mechanism 34 and the spreader plate 60 will now be described, primarily with reference to FIG. 12. The actuating mechanism 70 is effective for moving the spreader plate 60 up and down to open and close the terminal jaws 56. The actuating mechanism 70 includes socket cover 40, a pair of cross links 72 and springs 68 which bias the spreader plate 60. The test socket cover 40 is mounted on the socket body 26 for vertical reciprocating movement relative thereto as indicated by "A" in FIG. 1. A pair of cross links 72 (FIG. 12) are located on opposite sides of the loading plate 30. As seen in FIG. 1, these

cross links 72 include a pair of levers 74a and 74b. The lever shafts 74c are provided at one end of the respective levers 74a and 74b. In addition, depressing portions 76 are provided on the sides of levers 74a and 74b and project like flanges for engaging spreader plate 60. Arcuately shaped sliding portions 74b at opposite ends of levers 74a and 74b slide along an inner surface 40a of cover 40. Lever shafts 74c are inserted into lever holes (not shown) formed in socket body 26. Levers 74a and 74b are pivotable about the lever shafts. The levers intersect each other and, as such, depressing portions 76 of the levers are brought into contact with a surface on spreader plate 60, and the levers are prevented from swinging thereover. The cover 40 is mounted on socket body 26 with the sliding portion 74d of each lever 74a, 74b in contact with inner surface 40a of the cover 40.

The operation of the actuating mechanism 70 now will be described in relation to FIGS. 12 and 13. FIG. 12 shows a state wherein spreader plate 60 is at an upper limit position, and FIG. 13 shows a state where the spreader plate is located between the upper limit position and a lower limit position. When the cover 40 is depressed and lowered downwardly from the upper limit position shown in FIG. 12, the sliding portions 74d of levers 74a and 74b slide along the inner surface 40a of the socket cover 40. During this movement, the levers 74a, 74b pivot about their lever shafts 74c so that the depressing portions 76 will depress the spreader plate 60. Since the wedges 64 (Figs. 7-11) are integral with the spreader plate 60, the wedges 64 move downwardly as the spreader plate 60 compresses the springs 68. When the depressing force on cover 40 is released, the spreader plate 60 is pushed upwardly by the forces of the springs 68. Of course, vertical movement of the spreader plate 60 and the wedges 64 is effective to open and close the jaws 56 of terminals 32 as described above in relation to FIGS. 10 and 11.

The retaining mechanism 38 for holding IC package 22 down onto loading plate 30 now will be described in relation to FIG. 12. Specifically, the retaining mechanism 38 includes a pair of pusher arms 80, a pair of depressing posts 82 that depend from the underside of the socket cover 40 and a pair of coil springs 84. The pusher arms 80 are arranged on opposite sides of the loading plate 30. Each pusher arm 80 includes a body or arm portion 80a, a hook portion 80b and a spring engaging portion 80c. The pusher arms have pivot shafts (not shown) that pivotally mount them on the socket body 26. The springs 84 are effective to bias hook portions 80b of the pusher arms 80 inwardly toward each other over the top of the loading plate 30 and an IC package mounted on the loading plate. The pusher arms are effective to hold the IC package down onto the loading plate. The IC package 22 is sandwiched between the hook portions 80b

of the pusher arms 80 and the loading plate 30.

The operation of retaining mechanism 38 now will be described. FIG. 12 illustrates a condition wherein the hook portions 80b of the pusher arms 80 hold the IC package 22 down on the loading plate 30. FIG. 13 shows the condition wherein the depressing posts 82 of the cover 40 are brought into initial contact with the engaging portions 80c of the pusher arms 80. FIG. 14 illustrates a further condition wherein the depressing posts 82 of the cover 40 have rotated the pusher arms 80 against the biasing of coil springs 82 to move the hook portions 80b of the pusher arms outwardly from engagement with the IC package 22 on top of the loading plate 30. Thus, all restraints on the IC package 22 are removed, and the IC package 22 may be lifted out of the test socket. When the depressing forces on cover 40 are released, the pusher arms 80 return under the biasing of coil springs 84 to their position shown in FIG. 12.

The operation of inserting an IC package 22 into test socket 20 is shown best in FIGS. 15-17. FIG. 15 shows the inoperative condition of test socket 20 with its cover 40 and spreader plate 60 in their upper limit positions. The wedges 64 of the spreader plate 60 are elevated relative to the spreading shoulders of terminals 32 so that the jaws 56 of the terminals 32 are in their closed or relaxed positions as shown in FIG. 10. In addition, the pusher arms 80 of the retaining mechanisms 38 are biased inwardly by the coil springs 84 as seen in FIG. 12.

FIG. 16 illustrates the socket cover 40 depressed in the direction of arrow "E". In this position, the wedges 64 of the spreader plate 60 have been moved downwardly into engagement with the spreading shoulders 58 of terminals 32 as shown and described above in relation to FIG. 11. The wedges spread jaws 56 at the ends of terminal contact arms 54. At this point, it should be understood that pusher arms 80 still are not pivoted outwardly and remain in the position shown in FIG. 13 and described above.

FIG. 17 shows the socket cover 40 depressed to its lower limit position and where the spreader plate wedges 64 have completely spread the jaws of the terminals 32 open. In addition, the pusher arms 80 have been rotated to their outermost position as shown in FIG. 14, so that the IC package 22 (FIG. 17) can be inserted into the test socket 20 with its solder balls 24 inserted between the spread-apart and open jaws of terminals 32. It can be understood that the IC socket and solder balls are inserted between the spread jaws in a continuous linear motion as represented by arrow "F" (Fig. 17). When the IC package 22 is fully inserted onto the top of loading plate 30, cover 40 is released to allow a sequence of actions to take place. First, coil springs 84 (FIGS. 12-14) are effective to pivot the pusher arms 80 back inwardly so that the

hook portions 80b engage the top of IC package 22. This ensures that the IC package is held down securely onto the top of loading plate 30 before the jaws of the terminals engage the solder balls 24. Secondly, the coil springs 68 push the spreader plate 60 back upwardly to its upper limit position which withdraws spreader plate wedges 64 from between the terminal contact arms. The terminal jaws 56 then move inwardly toward each other with equal forces against the sides of solder balls 24 of the IC package. From the foregoing, it can be understood that the pusher arms 80 engage the IC package 22 before the terminal jaws 56 engage the IC package solder balls 24. This ensures that the IC package 22 is held downwardly on the loading plate 30 before the jaws 56 are released for engaging the solder balls 24. As a result, uneven pressures and possible damage to the solder balls 24 by the retaining mechanism is substantially prevented.

FIG. 18 illustrates the condition wherein the jaws 56 of one terminal 32 are engaged with opposite sides of one of the solder balls 24 of IC package 22. It can be seen that the jaws 56 engage the solder ball 24 over the center of the solder ball. The jaws 56 engage the sides of the solder ball at locations spaced from a distal end 90 of the ball beyond the widest cross-section of the ball as represented by double-headed arrow 92. The jaws engage the solder ball through pointed contact tips 56a.

It will be understood that the invention may be embodied in other specific forms without departing from the spirit or central characteristics thereof. The present examples and embodiments, therefore, are to be considered in all respects as illustrative and not restrictive, and the invention is not to be limited to the details given herein.

CLAIMS:

1. A burn-in socket for testing an IC package having an array of solder balls on a bottom surface thereof, comprising:
 - a socket body having a receptacle for receiving the IC package;
 - a plurality of terminals mounted on the socket body with contact portions exposed in the
 - 5 receptacle for engaging the solder balls of the IC package, each of the terminal contact portions being bifurcated and having a pair of opposing jaws disposed thereon for engaging the sides of a single solder ball therebetween when said IC package is inserted into the receptacle socket body; and,
 - a spreader mechanism movably mounted on the socket body for spreading said jaws in
 - 0 opposite directions to allow said IC package solder balls to be inserted between the spread jaws in a continuous linear motion as the IC package is inserted into said receptacle.
2. The burn-in socket of claim 1, wherein said socket body includes an actuating cover movably mounted thereto for movement toward and away from said receptacle, the actuating cover being operatively associated with said spreader mechanism to spread said jaws in response to movement of said actuating cover.
3. The burn-in socket of claim 1, wherein said spreader mechanism includes a spreader plate disposed in said receptacle, the spreader plate including a plurality of wedges disposed thereon that extending between said terminal bifurcated contact portions to spread said jaws in response to movement of said spreader plate relative to said socket
- 5 body.
4. The burn-in socket of claim 3, wherein said jaws are defined by distal ends of a pair of contact arms of each bifurcated contact portion of each terminal, the contact arms defining a restricted zone therebetween spaced inwardly of the distal ends of the arms for engagement by one of the wedges of the spreader plate.
5. The burn-in socket of claim 1, wherein said jaws are configured for engaging the sides of

the solder balls at locations spaced from distal ends of the balls beyond the widest cross-sections of the balls.

6. The burn-in socket of claim 1, further including a retaining mechanism movably mounted on the socket body for holding said IC package within said receptacle.
7. The burn-in socket of claim 6, including an actuating cover movably mounted on said socket body and operatively associated with said retaining mechanism for moving said retaining mechanism.
8. The burn-in socket of claim 6, further including means for biasing said retaining mechanism toward an operative position to hold the IC package in the receptacle, said actuating cover being effective to move the retaining mechanism to an inoperative position releasing the IC package.
9. The burn-in socket of claim 6, further including a loading plate disposed in said receptacle and onto which the IC package is positioned, said retaining mechanism including at least one retaining arm for holding the IC package down on the loading plate.
10. A burn-in socket for testing an IC package having an array of solder balls on a bottom surface thereof, comprising:
 - a socket body having a receptacle for receiving the IC package; a plurality of terminals disposed in the socket body for engaging the solder balls of the IC package, the terminals including contact portions which are disposed in the receptacle, each of said terminal contact portions including a pair of opposing jaws for engaging one of said IC package solder balls, the terminal contact portion jaws being resiliently biased toward each other;
 - a spreader mechanism movably mounted on the socket body for spreading said terminal contact portion jaws in opposite directions to define an opening therebetween that will receive one IC package solder ball in a continuous linear motion as the IC package is inserted into the receptacle;
 - a retaining mechanism movably mounted on the socket body for retaining said IC

package in place within said receptacle; and,

5 an actuating cover operatively associated with the spreader mechanism and retaining mechanism, the actuating cover being movably mounted on the socket body for moving generally toward and away from the receptacle in order to pen said terminal contact portion jaws and moving said retaining mechanism in response to movement of the cover.

11. The burn-in socket of claim 10, including means for biasing said retaining mechanism into a first position where said retaining mechanism holds said IC package within said receptacle, movement of said actuating cover being effective to overcome said biasing means and move the retaining mechanism into a second position where said retaining
5 mechanism releases said IC package.

12. The burn-in socket of claim 10, including a loading plate disposed in said receptacle and for supporting said IC package when said IC package is inserted into said receptacle, said retaining mechanism including at least one retaining arm for holding said IC package on said loading plate.

13. The burn-in socket of claim 10, wherein said spreader mechanism includes a spreader plate having a plurality of wedges depending therefrom, whereby movement of said spreader plate in one direction moves said wedges between said terminal contact portion jaws and spread said jaws apart.

14. The burn-in socket of claim 13, wherein said terminal contact portion jaws are defined by distal ends of a pair of contact arms of each terminal contact portion, the contact arms defining a restricted zone therebetween spaced inwardly of the distal ends of the arms for engagement by one of the wedges of the spreader plate.

15. The burn-in socket of claim 10, wherein said terminal contact portion jaws are configured for engaging surfaces of said solder balls at locations spaced from distal ends of the balls beyond the widest cross-sections of said solder balls.

16. The burn-in socket of claim 10, wherein said actuating cover is operatively associated with said spreader mechanism and said retaining mechanism such that said retaining mechanism holds said IC package while said spreader mechanism is released to allow said opposing jaws to engage the sides of said solder balls.