TOP LOADING SOCKET FOR BALL GRID ARRAYS

FIELD OF THE INVENTION

The present invention relates to sockets for surface mounted, high pin count integrated circuit packages, and more particularly to test, burn in, and general purpose sockets for ball grid array integrated circuit packages.

BACKGROUND OF THE INVENTION

Surface mounted, high pin count integrated circuit packages have been dominated by quad flat packs (QFPS) with various pin configurations, for example, leadless, J-leaded, and gull wing leaded. These packages have closely spaced leads for making electrical connections distributed along the four edges of the flat packages. These packages have become limited by being confined to the edges of the flat pack even though the pin to pin spacing is small. To address this limitation, a new package, a ball grid array (BGA) is not so confined because the electrical contact points are distributed over the entire bottom surfaces of the packages. More contact points can be located with greater spacings than with the QFPS. These contacts are solder balls which facilitate flow soldering of the packages onto a printed circuit board. BGA's are popular alternatives to QFP's.

Sockets that accept BGA's are necessary for testing, burn-in, re-programming, and sometimes for production use where the integrated circuit may need replacing. Several such sockets have been developed by

various manufacturers to satisfy this need. Most of these sockets are of a clam shell design, where a hinged top opens to allow package entry, and closing the top retains the package within the socket. The socket includes a bed of contacts spaced to match the BGA contacts and a top located spring or spring loaded surface is arranged to press the package onto the bed of contacts to ensure electrical connection for all the contacts. Some of the prior art BGA sockets align the IC contacts in holes in a printed circuit board. The contacts are arranged to extend through the holes to the other side of the printed circuit board where electrical connections are made. Such an arrangement of surrounding the contacts within holes and enclosing the BGA packages within the socket has the undesirable feature of retaining heat in the BGA packages during test or burn-in, while preventing heat sinks from being directly mounted onto the BGA package.

Such prior art sockets may be adequate for small scale handling of BGA, but, because of the many separate and complex physical actions needed to insert, test, and extract the BGA package, such clam shell sockets are: costly, unwieldy, and unreliable when used for production processing large numbers of BGA packages.

Another limitation of available BGA sockets occurs since the socket contacts place forces onto the IC contacts in the same direction. These forces drive one side of the package against an abutment of the socket. With a large number of contacts this cumulative force of many spring loaded contacts is very large and may physically damage the package.

It is an object of the present invention to provide a BGA socket needing few and simple physical operations to insert and extract an IC package. A related object of the present invention is to provide means for retaining the

BGA package while providing low electrical resistance connections between the balls and the socket connections while operating with vibrations, mechanical shock and temperature variations.

Yet another object of the present invention is to provide a socket where the lower part of the BGA ball contacts are not contacted such that the ball bottom surface is unaltered or deformed so that the BGA package will not be impair for soldering to a printed circuit board or other such final end use.

It is another object of the present invention to provide a socket where there are only substantial mechanical forces of the BGA ball contacts and none on the BGA package itself.

It is yet another object of the present invention to provide a BGA socket with no obstructions that need to be avoided when inserting and extracting the BGA package.

It is another object to provide a BGA socket that provides superior heat dissipation capabilities.

SUMMARY OF THE INVENTION

The foregoing objects are met in a socket for test and burn-in of ball grid array packages including a top structure defining an opening large enough to allow the grid array package to pass through with the ball contacts facing downward, the ball contacts defining a plane. For descriptive purposes herein the end of the ball contacts remote from the BGA package body is considered a bottom pole and the top of the ball contact connected to the BGA package a top pole with meridians running between the poles and an equator encircling the ball equidistant from the poles. There is a plurality of electrical contacts fixed

to said socket with a first end, having edges in a preferred embodiment, arranged to mate with the ball contacts, a slidable plate with through holes, through which said electrical contacts extend, forming openings between the first ends and the edges of the holes, means arranged to provide a displacement to said slidable plate in a direction parallel with said plane reducing the opening, such that an interposing BGA ball contact is captured between the edges making contact with the ball above the equator and the sides of the holes. There are spring means for maintaining the force on the captured BGA ball. In a preferred embodiment, cam and axle means provide the means for displacement of the slidable plate. Means are provided for driving the cam axle to compress the spring means thereby providing a larger opening between the sides of said hole and each of said electrical contacts, said larger opening suitable for accepting the ball contacts, and means for removing the driving force whereby the spring means acts such that said ball contacts are driven into electrical continuity with said electrical contacts.

In a preferred embodiment the socket electrical contact includes a cupped and bifurcated or forked end. The forked extensions have edges which contact the BGA ball contacts above the balls' equator providing a detent action on the ball contacts which are thereby retained. The edges are arranged, in a preferred embodiment, to engage the ball contacts on either side of a meridian. When such connections are made to the ball contacts the BGA package is retained in the socket and the socket is arranges such that forces on the ball contacts are the only forces on the BGA package. The frame lever arm or

lid is not in contact with the BGA package when the BGA package is so retained in the socket.

In another preferred embodiment, the means for displacement is a force directed vertically through the integrated circuit towards the plane wherein the ball contact is driven into the through hole and makes a larger opening for entry of the ball contacts. The first end of the contact is cupped to provide a detent action by the cupped end as the ball contact is driven into the opening.

In a preferred embodiment, the means for driving the slidable plate containing the array of holes includes the cam axle rotated by a top structure lever arm extension in contact with a cam axle handle, the lever arm extension is angled above the socket, and where the lever arm extension is arranged on the periphery of the socket such that the lever arm extension does not interfere with the open top insertion and extraction of the integrated circuit, and where the lever arm extension has a surface in contact with the can axle handle such that depressing the lever arm extension enlarges the distance between the ball contacts and the opposing surfaces of the corresponding holes such as to allow insertion or removal of the ball contact into the hole. The lever arm extension has guide surfaces chamfered to align the BGA package with the electrical contacts of the socket with the lever arm extension depressed, and further that the lever arm extension when not depressed do not contact the retained BGA package. The top structure open to allow cooling air to circulate around the BGA package and/or heats sinks to be attached thereto.

In a preferred embodiment there is a torsional spring that returns the cam axle handle and the lever arm extension to the initial angled position - the rest position with no external forces exerted. This action rotates the cam which displaces the slidable plate which drives the interposing BGA ball contacts into the electrical contacts of the socket. The position of the socket with the lever arm extension is depressed is termed the open position.

Other objects, features and advantages will be apparent from the following detailed description of preferred embodiments thereof taken in conjunction with the accompanying drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a perspective view of a preferred embodiment of the present invention in the BGA engaged position;

FIG. 1B is a perspective view of a preferred embodiment in the open position with the frame/lever depressed;.

FIG. 2A is a side view of the slidable plate, socket contacts, BGA ball contacts, and the cam axle in the rest position;

FIG. 2B is a side view of the slidable plate, socket contacts, BGA ball contacts, and the cam axle in the open position;

FIG. 3A is a side view detail showing the ball contact and the socket contacts with the socket in the open position;

FIG. 3B is a side view detail showing the ball contact and the socket contacts with the socket in the engaged position;

FIG. 4 is a perspective view of an individual bifurcated socket contact with sharp edges;

FIG. 5 is a top view of a BGA test and burn-in socket showing the alignment surfaces of the top structure frame;

FIG. 6A is a top view of an individual package ball contact, socket contact, and top plate in the engaged position;

FIG. 6B is a top view of an individual package ball contact, socket contact, and top plate in the open position; and

FIG. 7A, 7B, and 7C are cross sectioned views of another preferred embodiment of the interaction of the socket contacts and the ball contacts of a BGA.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1A and 1B are perspective views of a socket 2 made in accordance with the present invention. The socket itself is constructed for dielectric insulating materials, that are well known in the art, and the electrical contacts 12 are made of materials that are also well known in the art. There is a slidable plate 3 populated with through holes 14 where elongated contacts 12 extend upward into each hole. In this embodiment, the top structure includes an extension a lid, which forms a lever are 4 that pivots along one edge of the socket about a lid axle 13 constructed opposite a cam axle 6 that traverses the socket. The portion of the lid remote from the lid axle is arranged to contact slide pins 8, or, alternatively but not shown, cam handle rounded surfaces 9 located at the ends of the cam axle handles 5. The contacting rotates the cam axle during the

socket opening process. The lever arm 4 is manufactured as a frame around the periphery of the socket external from the BGA package insertion area 20. The corners of the inner surfaces of the frame lever arm have chamfered surfaces 15 that guide the package 21 into the socket in an aligned position. FIG. 1B shows the socket in the open position, the frame lever arm is depressed to be parallel with the plate 22. A BGA package comes into contact with the chamfered edges which positions the corners of the BGA package such that the ball contacts 16 each enter a corresponding hole in the plate.

When inserting or removing the BGA package from the socket the frame lever arm, as shown in FIG. 1B - the open position, the frame encircles and does not encroach on the area 20 so as to not interfere with the BGA package insertion or removal.

In FIG. 1A, the cam axle torsion springs 10 act to return the cam axle handles 5 and the frame lever arm 4 back to the BGA engaged position - where the BGA package, if inserted, is retained in the socket. The frame lever arm 4 extends beyond the cam axle 6 to provide a large press down area 25 for ease of operation. The frame lever arm travels upwards until stops 26 built into the base stop the upward travel.

FIGS. 2A and 2B show operation of the cam axle 6. This preferred embodiment is one example of the many variations of cams, cam followers, cam handles with spring actions known in the art. Referencing FIG. 2A the cam axle 6 is positioned at an angle to push the strike plate 7, that is attached to the slide top plate 3, to a position corresponding to the largest radius 18 of the

cam axle. FIG. 2B shows the frame lever arm depressed downward flat against the top plate 3. The cam axle 6 via the cam handle 5 is rotated as shown. The flat of the cam 17 is positioned parallel to the strike plate 7 resulting in the top plate return spring 11 moving the top plate 3 toward the cam axle 6. In the open position shown in FIG. 2B, the through holes are positioned such that the socket contacts 12 are against one wall of the hole to allow the ball contacts 16 to enter or exit the holes. The ball is positioned b between the socket contacts and the opposing surface of the holes 21. The top plate return spring 11, as shown, can be positioned at different locations along the top plate edge remote from the cam axle, or several springs may be positioned along this remote edge. Also a coil spring 11 is shown, but leaf springs or other such springs known in the art may be used.

Referring back to FIG. 1B, the frame lever arm 4 has chamfered surfaces 15 which engage the corners of the BGA package 21 and guide the package to align the ball contacts 16 with the holes 14. With reference first to FIG. 2B and then 2A, the movement of the top plate 3 moves the hole surfaces 21 move the ball contacts into the socket contacts 12 making electrical connections thereto. The travel distance of the top plate 3 is determined by the different between the cam axle outside radius 18 and the distance (at 90°) from the cam flat 17 to the cam axle center of rotation. The cam handle torsion springs 10 return the cam to the engaged position after the removal of the downward pressing force on the frame lever arm. The top plate is retained in the plane parallel to the base 2 by any of well known in the art mechanical designs. The socket contacts 12 extend downward through

the base 2 and extend farther for mounting onto and soldering to printed circuit boards.

Still referring to FIG. 1A and FIG. 1B, the frame lever arm or lid 4 is limited in its upward direction by two stops 26 that are built into the base 2. The lower section 10 of the lid engages a slide pin 8 that travels from the cam handle 5 under the lower section 10 of the lid. The embodiment the pin 8 does not traverse the entire socket, however, there is another pin, not shown, on the corresponding other side of the socket that engages a corresponding lower section of the lid. In another preferred embodiment, mentioned above and not shown, the lid lower section engages the rounded surface 9 of the cam handle 5.

FIG. 3B shows an individual top plate hole with an opening 15 with a BGA package inserted in the engaged position. The holes have walls 21 that have been moved as shown comparing FIG. 3A to FIG. 3B, and as described above, to contact the balls and to move the balls into contact with the socket contacts 12. The force on the balls causes the socket contacts to deflect so as to make reliable electrical connections therebetween and to secure the balls and so the BGA package to the socket. The socket contact deflection is seen by the movement of the surface 20 of the socket electrical contacts movement away from the housing structure 32. The length of the contact is designed along with the details of the size and of the socket contact to ensure proper spring force of the deflected socket contact. These are the only forces on the BGA since, as seen in FIG. 2A, the frame lever arm has moved above and away from the BGA package.

As seen in FIG. 3B the end of the socket electrical contact 21 is cupped 25 such that the portion of the socket contact making contact with the ball is above the imaginary equator of the ball near where the ball is connected to the body of the BGA package itself. This directed pinching action of the ends of the socket contacts and the hole side wall pinches the ball contacts so as to prevent vertical movement of the ball contacts and the BGA package itself.

FIG. 4 is perspective view of a representative socket contact 12. The cupped or angled end 24 is bifurcated or forked. There are sharp edges 23 that penetrate any oxide layer to assure good electrical contact between the ball contacts and the socket contacts.

FIG. 5 shows a top view of the frame lever arm or lid 4. The chamfered guide surfaces 15 engage the corners of the BGA package to guide the ball contacts into alignment with the holes 14 in the slidable top plate 3. The socket is in the open position with the lid 4 flat against the top plate 3. This is evident since the lid has moved away from the stops 26 that limit the upward travel of the lid via the torsional spring action describe before. A force is pressing down on the surface 25 against the torsional springs.

FIG. 6A and 6B are top views of the openings and holes 14 in the slidable top plate 3. FIG. 6A shows the socket in the engaged position and FIG. 6B in the open position. There is a ball contact 16 and a socket contact 12 shown. In FIG. 6A the line 50 represents the position

of the hole side wall surface 21 with the socket in the open position. The distance X is the movement caused by the cam axle rotation as described above. The surface 21 contact the ball and moves the ball into contact with the socket contact 21 and then moves the combination ball and socket contact farther deflecting the socket contact 12. The sharp edges 23 contact the ball making reliable electrical connections.

FIG. 7A show a section drawing of three ball contacts 40, adjacent to the openings of three through holes 42 in the plate 3. The electrical contacts 12 extend through the holes 42 to a point adjacent the ball contacts. The distal ends of the electrical contacts 26 extend through the plate to locations where electrical connections can be made to the test or burn-in equipment (not shown). FIG. 7B shows the plate 3 moved left by an amount 44. In this instance there is a vertical force on the ball contacts 40 that drives the balls into the ends of the electrical contacts 12. The ends 46 of the contacts 12 are counter bent outward to facilitate the balls 40 driving the contacts 12 from the position of the contacts 12 in FIG. 7A to the position of the contacts 12 shown in FIG. 7B. The opening of the holes are enlarged by the amount 44 such that the ball contacts 40 enter the holes, as shown. FIG. 7C shows the final engaged where the ball contacts are retained by the upper cupped edge or lip 30 of the ends of the electrical contacts 12 and the opposing surface 32 of the hole. The electrical contacts 12 make physical contact with the ball contacts 40 establishing electrical conductivity therebetween.

It will now be apparent to those skilled in the art

that other embodiments, improvements, details and uses can be made consistent with the letter and spirit of the foregoing disclosure and within the scope of this patent, which is limited only by the following claims, construed in accordance with the patent law, including the doctrine of equivalents.

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CLAIMS

What is claimed is:

1. A socket for ball grid array integrated circuit packages comprising:

a housing with a top structure with an opening large enough to allow the grid array package to pass through with the ball contacts facing said socket, the ball contacts defining a first plane,

a slidable top plate with through holes arranged to receive said ball contacts,

a plurality of electrical contacts fixed to said socket with a first end having at least one edge arranged to mate with said ball contacts, and where said first ends extending into said holes in the top plate from a direction opposite the ball contacts, and where the distance between the electrical contact and the edges of the through hole define an opening,

a spring means arranged to provide a force on the top plate in a direction parallel with said plane, where said spring means acts to reduce said opening,

means for driving the top plate to compress said spring means wherein said opening is enlarged for accepting the ball contacts, and wherein with said ball contacts inserted into said openings and with said spring means forces said top plate to reduce said opening said ball contacts are secured between said edges of said socket electrical contacts and the opposing surfaces of said holes thereby retaining the ball grid array package in said socket .

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2. A socket as defined in claim 1 wherein said means for driving the top plate comprises a camming surface and an actuator.

3. A socket as defined in claim 1 wherein said first end of said electrical contact comprises a cupped surface such that a detent action occurs as cupped surfaces engage the top of the ball contacts above the equator of each ball contact such that the ball grid array integrated circuit package is retained in said socket. .

4. A socket as defined in claim 1 wherein said edges on said first end of said electrical contacts comprises a bifurcated or forked extension with two edges arranged to mate with and engage said ball contacts where each of said edges engage said ball on either side of an meridian of each ball.

5. A socket as defined in claim 1 wherein said top structure comprises: a frame arranged on the periphery of the socket such that the frame does not interfere with the open top insertion and extraction of the integrated circuit; and a body where said frame has an edge hinged to said body whereby said hinged frame defines a first position where said grid array package may be inserted into said socket, and a second position where said grid array package is retained in said socket, and where said package is guided and aligned by chamfered surface on said frame in said first position, but when said frame is in said second position , said frame does not contact said package or said ball contacts.

6. A socket for ball grid array integrated circuit packages as defined in claim 5 wherein said means for

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driving said top plate comprises: a cam hinged to said body where said cam defines a first cam position and a second cam position, where said cam in said first position drives said top plate to enlarge said openings allowing the balls to enter, and where said cam in said second position reduces said openings thereby retaining said balls, and where said cam contacts said frame and is actuated by said frame, and where said frame drives said cam such that said frame first position corresponds to said cam first position and said frame second position corresponds to said cam second position.

7. A socket for ball grid array integrated circuit packages comprising:

a body,

a frame hinged to said body and said frame arranged on the periphery of the socket such that the frame does not interfere with the insertion and extraction of the integrated circuit package, and where said hinged frame defines a first position where said integrated circuit package may be inserted into said socket, and a second position where said integrated circuit package is retained in said socket., and where said integrated circuit package is guided and aligned by chamfered surface on said frame in said first position, but, when said frame is in said second position, said frame does not contact said package or said ball contacts, said ball contacts of said inserted package defining a plane,

a slidable top plate with through holes arranged to receive said ball contacts,

a plurality of electrical contacts fixed to said socket with a cupped or angled first bifurcated ends each end having at least two edges adapted to mate with said ball contacts on either side of a meridian, and where each said angled first bifurcated end is adapted to contact said

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ball contact above the equator of said ball contacts, and where said first bifurcated ends extending into said holes in the top plate from a direction opposite the ball contacts, and where the distance between the electrical contact and the edges of the through hole define an opening,

a spring means arranged to provide a force on the top plate in a direction parallel with said plane, where said spring means acts to reduce said opening,

cam axle with a camming surface and actuator for driving the top plate to compress said spring means wherein said opening is enlarged for accepting the ball contacts, and wherein with said ball contacts inserted into said openings and with said spring means forces said top plate to reduce said opening said ball contacts are secured between said edges of said socket electrical contacts and the opposing surfaces of said holes thereby retaining the ball grid array package in said socket .

8. A socket for ball grid array integrated circuit packages comprising:

a housing with a top structure with an opening large enough to allow the grid array package to pass through with the ball contacts facing said socket, the ball contacts defining a first plane,

a top plate with through holes arranged to receive said ball contacts,

a plurality of electrical contacts fixed to said socket with a first end arranged to mate with said ball contacts and said first ends extending into said holes in the top plate from a direction opposite the ball contacts, and where the distance between the electrical contact and the edges of the through hole define an opening,

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a spring means arranged to provide a force on the top plate in a direction parallel with said plane, where said spring means acts to reduce said opening,

means for driving the top plate to compress said spring means wherein said opening is enlarged for accepting the ball contacts, wherein, with said ball contacts inserted into said openings, said spring means forces said top plate such that said ball contacts are secured between said edges of said through holes in said top plate and said mating end of said electrical contacts thereby retaining said ball grid array integrated circuit package in said socket.

9. A socket as defined in claim 8 wherein said means for driving comprises means for driving said ball contacts into said opening to compress said spring means wherein said opening is enlarged by the ball contacts.

10. A socket as defined in claim 9 wherein said tip of the first end of said electrical contacts are chamfered to accept and mate with the ball contact surface, and where the edges of said through hole in said plate are chamfered to accept and mate with the ball contacts surface, said chamfering constructed to allow said ball contacts to drive through and enlarge said opening.

11. A socket as defined in claim 9 wherein the electrical contact comprises a cupped end such that a detent action occurs as the ball is driven through said opening by said cupped end.

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