An improved connector assembly (1) particularly useful for testing semiconductor devices of ball grid array ("BGA") structure (10) with a plurality of solder balls (11) formed on the surface thereof. The balls (11) are placed into contact with opposing conductive portions (3a) of the connector assembly. A heat generating member (7), such as a wire, is disposed proximate to the connector assembly conductive portions (3a) and may be selectively energized to generate heat to partially melt the solder balls (11). Reliable connections are effected in this manner.
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BGA CONNECTOR WITH HEAT ACTIVATED CONNECTION AND DISCONNECTION MEANS

**Background of the Invention**

The present invention relates generally to a ball grid array ("BGA") connector used in connecting circuit boards to BGA packages having soldering balls arranged in the form of a lattice, and more particularly, to an improved BGA connector having a heat-activated connection and disconnection means.

Conventional semiconductors or integrated circuits ("IC") are commonly formed as chips, that are referred to in the art as "packages". Conventional packages may have their leads formed on two sides, such as in DIPs or on four sides, such as in QFPs or TCPs. The number of leads connecting to such semiconductors and ICs have been increasing and accordingly, the distance, or pitch, between the leads has been reduced. The reduction of spacing between the leads increases the difficulty with which the closely spaced leads are soldered to a printed circuit board. In the case of the four-sided QFPs and TCPs mentioned above, the leads cannot be easily soldered to a circuit board because of the close lead-to-lead distance.

In order to meet this situation, a lattice-array or grid-array of electrically conductive raised lands are formed on the bottom surface of the semiconductor package in place of the conventional leads on the four sides of the package. These lands typically have balls of soldering material or metal physically connected to them and are referred to in the art as BGA. BGA sockets are known in semiconductor arts.

A conventional BGA connector used to connect a BGA package to a circuit board having soldering balls arranged in the form of lattice includes an insulating board,
includes an insulating board, or an insulative connector base. The connector base typically has a series of metal spring contacts arranged thereon in one-to-one correspondence with the soldering balls of the BGA package as demonstrated in Japanese Patent Application Laid-Open No. 8-330005. A selectively releasable electrical connection is made between the soldering balls of the BGA package and the contacts of the insulating board of the BGA connector by keeping the BGA package pushed against the connector. This requires the BGA connector to have one or more pushing elements that press the BGA package into the socket of the BGA connector. Unfortunately, this structure and the result of the soldering balls of the BGA package abutting the connector is likely to cause the soldering balls to become scarred or deformed because of the great force required to maintain the BGA package in contact with the BGA connector.

To assure that a reliable electric connection is made between the soldering balls of the BGA package and the contacts of the BGA connector, it is necessary with this structure to apply a relatively high pressure to the contact-to-soldering ball interface. Therefore, the connector needs to be equipped with a pushing means for pressing the connector against the BGA package, which may unduly complicate the structure of the connector. The contacts of the BGA connector must also be long enough in order to have a desired resiliency, and accordingly their height is increased. Unfortunately, the inductance of each conductor increases with an increase of its length so that increasing the length of the contacts results in increasing the inductance of the connector.

A need therefore exists for an improved BGA connector that does not require a pressing member which complicates the overall structure of the connector and a BGA connector that may be easily inserted into and removed from a BGA package-receiving socket.

Summary of the Invention
It is therefore a general object of the present invention to provide an improved BGA connector that does not rely upon a pressure contact system in which the connector has the lengths of its contacts maintained at a desired minimum so as not to increase the inductance of the contacts.

Another object of the present invention is to provide a BGA connector which requires no pressing means for pushing the connector against a BGA package, thus guaranteed to be free of damaging the soldering balls of the BGA package.

Another object of the present invention is to provide a BGA connector whose profile is reduced to possible minimum. Still, yet another object of the present invention is to provide an improved BGA connector having a heat-activated means for selectively connecting and disconnecting a BGA package to the BGA connector.

Yet another object of the present invention is to provide an improved BGA connector having a heat-activated connection and disconnection means that eliminates the need for a pressure member to keep a BGA package in contact with a BGA connector, the heat-activated means being disposed on a surface of the BGA connector and further being arranged in a pattern that extends between conductive pads formed on one surface of the BGA connector.

To attain these objects a low-profiled BGA connector uses a high-resistance heater provided in the vicinity of a plurality of conductive pads disposed on the BGA connector for partially melting a series of solder balls, or preforms, arranged on a contact surface of a BGA package when current is passed through the heater, so that the solder balls are put in a connective, confronting position relative to the conductive pads of the BGA connector.

In one principal aspect of the present invention, the BGA connector of the present invention includes a planar, insulated connector base having a plurality of electrically conductive pads, or lands, provided on front and rear (or top and bottom) opposing surfaces, the conductive
pads being electrically connected together in one-to-one correspondence through via holes formed in the connector base. A plurality of conductive metal balls are provided in association with the rear (bottom) surface of the connector base, such that single balls are provided on single conductive pads. A high-resistance heating means is provided on one surface of the connector, and preferably the front (or top surface) so that the heating means extends on the front surface in a pattern that threads itself between the conductive pads arranged on the front surface.

A BGA connector according to the present invention may also include a plate-like insulative connector base having a plurality of electrically conductive pads provided on opposing top and bottom surfaces of the connector base. The conductive pads on these two opposing surfaces are connected electrically in a one-to-one correspondence by way of conductive via holes that communicate with the conductive pads and which extend through the connector base. A plurality of metal balls are provided on the bottom surface of the connector base, with a single ball being arranged in electrical contact with each of the conductive pads. A high-resistance heating means, preferably in the form of a high-resistance, heat-generating wire is arranged in a pattern proximate to the front surface of the connector base and extending between conductive pads.

By energizing this high-resistance heating means, soldering balls typically associated with a BGA package that abut the conductive pads of the front surface of the connector base, may then be partially melted and soldered to the conductive pads of the connector by supplying electrical current to the high-resistance heater for heating. The high-resistance heating means is positioned proximate to the front surface of the connector base so that the soldering balls of the BGA package may be easily removed from their contact with the conductive pads when the wire is energized. Therefore, the BGA package may be easily connected to and easily removed from its connection with the BGA connector.
The high resistance heater may include one or more high resistance heating wires, such as Nichrome wire, that is stretched close to the front surface of the connector base. One or more coatings of high-resistance heating material may also be applied to the front surface of the connector base. Such coatings can be formed by a suitable vacuum-coating process such as vaporizing or sputtering, or may be formed by way of printing or photolithography.

The soldering balls may be of a conventional soldering material or of copper or any other metal which can be soldered an resoldered to the conductive pads of the connector. The connector base may be of ceramic material, BT resin or any other synthetic resin, or a composite resin containing glass filaments.

The BGA connector structure of the present invention can therefore be fixed to and removed from the BGA package simply by heating the soldering balls of the BGA package with the aid of the high-resistance heater. By using heating alone, the invention prevents the soldering balls from being damaged under relatively intense pressure to which, in the absence of such a heating means, the soldering balls would be subjected. The ball-to-pad soldering assures that the required electric connection is made therebetween without the application of possibly detrimental pressure to the ball-and pad interface. Therefore, no pressing means is required for the BGA connector. The connector-to-package distance can be set equal to the thickness of the connector base, thus permitting the profile of the connector, and hence the intermediate inductance of the contacts to be reduced to a possible minimum.

These and other objects, features and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, wherein like reference numerals refer to like parts.

**Brief Description of the Drawings**
In the course of the following detailed description reference will be made to the attached drawings wherein like reference numerals identify like parts and wherein:

FIG. 1. is an enlarged sectional view of a fragment of a BGA connector according to the present invention; and,

FIG. 2 is a perspective view of the BGA connector, partly in section.

Description of Preferred Embodiments

As mentioned above, the present invention finds its greatest utility in providing connections for semiconductors, or other electronic components, having a BGA-type structure or as shown in FIG. 1, where the semiconductor body, or package 10, has a plurality of conductive raised portions, or preforms 100, formed in a pattern on a lower surface 102 thereof. Although the preforms 100 are illustrated in FIGS. 1 & 2 as raised hemispherical balls 11 and are formed from a solder material, it will be understood that the configuration of the preforms 100 may differ from that shown.

Referring to the drawings, a BGA connector 1 comprises a plate-like connector base 2 of insulating material having a plurality of electrically conductive pads, or lands 3a and 3b, arranged in the form of lattice on its front and rear (or top and bottom) surfaces 2a and 2b. The electrically conductive pads 3a and 3b of the connector are electrically connected in one-to-one correspondence by way of through, or via holes 4, as a result of conventional plating 101 that extends around the interior of the via holes 4.

As seen from FIG. 1, a corresponding plurality of soldering balls 5 are provided on the electrically conductive pads 3b on the rear surface 2b of the plate-like connector base 2. A length of Nichrome wire 6 is extended over the front surface 2a of the plate-like connector base 2 in a pattern that threads between the electrically conductive pads 3a. The wire 6 is used as a high-
resistance heater 7, and is supplied with electric current from a power source (not shown) to
generate heat in the vicinity of the surface 2a of the connector base 2. The wire, as shown,
passes through holes in the connector base 2 so as to permit it to run through pairs of adjacent
rows 104 of the conductive pads 3a.

As seen from FIG. 1, the BGA connector 1 when used, is laid over or on a circuit member
in the form of a circuit board 8, which may be the base circuit board of an IC testing socket for
testing the BGA package 10. The circuit board 8 has a corresponding plurality of electrically
conductive pads 9 provided thereon in one-to-one corresponding relation relative to the soldering
balls 5 located on the rear surface 2b of the connector base 2. When the BGA connector 1 is
used, the soldering balls 5 are soldered to the electrically conductive pads 9. The BGA package
10 is then laid on the front surface 2a of the connector base 2 with the soldering balls 11
confronting the conductive pads 3a on the top surface 2a in one-to-one correspondence. Then,
the high-resistance heater 7 is energized to generate heat in the vicinity of the surface 2a of the
connector base 2 and, more importantly, in the vicinity of the BGA soldering balls 11. (FIG. 1.)

Once the heater 7 is energized, the soldering balls 11 of the BGA package 10 will at least
partially melt and fix themselves to the conductive pads 3a of the front surface 2a of the BGA
connector 1 to provide a connection between the BGA package 10 and the circuit board 8 via the
BGA connector 1. The surface tension of the soldering balls 11 will tend to retain their shape
and effect a reliable contact between the BGA package 10 and the connector first contacts 3a.
The interior conductive plating 101 of the via holes 4 provides a connection to the second
contacts 3b and the conductive traces 9 of the circuit board 8.

When the BGA package 10 must be removed from the socket, the high-resistance heater
7 is again energized to generate heat in the vicinity of the surface 2a of the connector base 2.
Then, the soldering balls 11 of the BGA package 10 are again partially melted to permit the
removal and disconnection of the BGA package 10 from the BGA connector 1. The surface
tension of the solder balls 11 keeps them from substantially losing their shape when melted and
facilitates repeated connections in this manner.

The high-resistance heater 7 may be formed from a Nichrome wire, as illustrated in the
FIG. 2, but it may also be formed from tantalum wire or any other appropriate high-resistance
heating wire. Alternatively, the heating means may take the form of a conductive high-resistance
coating, which may be formed on the front surface 2a of the connector base 2 by a vacuum-
coating method such as vaporizing or sputtering, or formed directly on the front surface 2a of the
connector base 2 by way of a photolithography process or by acid-resist etching. In these latter
instances, the coating on the front surface 2a of the connector base 2, as illustrated generally in
FIG. 1, can be advantageously effected simultaneously with the forming of conductive pads 3a on
the front surface 2a of the connector base 2.

In instances where the heating means rests on the top surface 2a of the connector base 2,
it is preferred that it be arranged in a pattern that extends between the conductive pads 3a, such
as in a serpentine pattern, without contacting the conductive pads 3a so as to prevent shorting of
the conductive pads 3a and the BGA circuits. This contact is avoided when the heating means is
located close to, but spaced apart from and above the conductive pads. As illustrated in FIG. 2,
the heating means 7, when it takes the form of a wire 6, is threaded between adjacent rows 104 of
conductive pads 3a and may further pass through openings 106 formed in the circuit board 8 at
the ends of the rows 104.

The soldering balls 5 on the rear side 2b of the connector base 2 can be of copper or any
other metal or alloy which can be soldered both to the electrically conductive pads 3b of the rear
surface 2b of the connector base 2 and to the conductive pads 9 of the circuit board 8.

The connector base 2 may be made of a thin, planar sheet of tough insulating material,
such as a BT resin used in the field of plastic BGA connectors, a composite resin-containing glass fibers, etc. The connector base 2 of such a composite resin may also have a laminated structure that includes a signal-conveying layer, a grounding layer, a Vcc layer, a wiring layer and the like.

The electrically conductive pads 3a and 3b are illustrated as being provided in the form of a lattice having distinct rows 104, but it will be understood that these conductive pads 3a and 3b can be provided on the top surface 2a of the connector base 2 in a concentric or radial pattern.

As may be understood from the above, a BGA connector according to the present invention has a high-resistance heater provided on the front (or top) surface of its base, thereby permitting the soldering balls of a BGA package to be partially melted and remelted for fixing to or removing from an associated circuit board via the intervening connector 2.

While the preferred embodiments of the invention have been shown and described, it will be apparent to those skilled in the art that changes and modifications may be made therein without departing from the spirit of the invention, the scope of which is defined by the appended claims.
What is Claimed:

1. A connector assembly for establishing an electrical connection between an electronic component of ball grid array (BGA) structure and a circuit member, the electronic component having a base portion with a plurality of raised, conductive, solder balls extending out therefrom, said BGA solder balls being arranged thereon in a first preselected pattern, said BGA solder balls being subject to melting when heated by a heating source, said circuit member having a plurality of conductive traces disposed thereon in a second preselected pattern, said connector assembly comprising:

   a planar substrate for providing a connective-interface between said BGA and said circuit member, the substrate having a predetermined thickness extending between opposing first and second surfaces of said substrate,

   the substrate first surface having a plurality of conductive first contacts disposed thereon, also in said first preselected pattern, so that when said BGA component is placed into contact with said connector, said solder balls are aligned with and contact said substrate first contacts, the substrate second surface having a plurality of conductive second contacts disposed thereon also in the second preselected pattern,

   said substrate further including a plurality of via holes extending through said substrate, each of said via holes providing a conductive passage extending through said substrate between said substrate first and second surfaces that conductively interconnects said substrate first and second contacts together, said substrate second contacts being placed into conductive contact with said circuit member conductive traces when said connector is placed into contact with said circuit member,

   a heating source including means for selectively generating heat in proximity to said substrate first surface, the heat-generating means being further disposed in proximity
to said substrate first contacts so that when said BGA component is placed into said contact with said connector, and when said heat generating means is energized, heat is generated thereby to at least partially melt said solder balls to effect an electrical connection between said solder balls and said substrate first contacts.

2. The connector assembly as set forth in claim 1, wherein said heat-generating means is arranged in a serpentine pattern proximate to said substrate first surface.

3. The connector assembly as set forth in claim 1, wherein said substrate first contacts are arranged on said substrate first surface in at least two rows, said heat-generating means being disposed between adjoining rows of said substrate first contacts.

4. The connector assembly as set forth in claim 1, wherein said heat-generating means includes a length of high-resistance wire.

5. The connector assembly as set forth in claim 4, wherein high-resistance wire includes nichrome wire.

6. The connector assembly as set forth in claim 4, wherein said high-resistance wire is spaced close to, but apart from said substrate first surface.

7. The connector assembly as set forth in claim 1, wherein said heat-generating means is spaced close to, yet spaced apart from said substrate first surface.
8. The connector assembly as set forth in claim 1, wherein said heat-generating means is disposed on said substrate first surface in proximity to said substrate first contacts.

9. The connector assembly as set forth in claim 1, wherein said substrate first contacts are arranged on said substrate first surface in said first preselected pattern in a series of distinct rows and said heat-generating means extends between adjacent rows of said substrate first contacts.

10. The connector assembly as set forth in claim 1, wherein said substrate has a planer configuration.

11. A BGA connector assembly for establishing a connection between a semiconductor and a circuit member, the semiconductor having a ball grid array ("BGA") disposed on a contact surface thereof, the BGA including a plurality of solder preforms disposed on the contact surface in a first pattern and extending out from said semiconductor contact surface, the circuit member having a plurality of conductive traces disposed thereon, said BGA connector assembly comprising:

   an insulative connector body in the form of a planar substrate, the substrate including individual first conductive land portions disposed on a first surface and individual second conductive land portions disposed on a second surface thereof, said first conductive land portions being disposed on said substrate first surface in at least two distinct rows with a predetermined spacing between said rows, said first conductive land portions further being arranged in a pattern that matches said first pattern of said solder preforms, such that each first conductive land portion opposes a single solder preform.
when said semiconductor is placed into contact with said connector body;

said substrate having a plurality of through holes formed therein that define

passages through said substrate, the through holes being arranged in one-to-one

correspondence with said first and second conductive land portions, said through holes

including conductive portions that electrically interconnect said first and second

conductive land portions together;

said connector body further including a heat-generating member disposed in

proximity to said first conductive land portions and between adjacent rows thereof, such

that when said semiconductor is placed into contact with said connector body and said

heat-generating means, heat is generated thereby to at least partially melt said solder

preforms to effect an electrical connection between said solder preforms and said first

conductive land portions.

12. The BGA connector assembly of claim 11, wherein said solder preforms include solder

balls.

13. The BGA connector assembly of claim 11, wherein said heat-generating means includes a

high-resistance wire.

14. The BGA connector assembly of claim 11, wherein said heat-generating means is spaced

apart from said substrate first surface.

15. A BGA socket for effecting a connection with a semiconductor having a plurality of leads

extending therefrom in the form of a ball grid array, the ball grid array including a plurality
of conductive solder preforms extending from a surface of said semiconductor, the solder preforms being meltably when subjected to heat, said solder preforms being arranged in a first pattern on said semiconductor surface, the socket comprising:

5 a circuit board having a plurality of conductive traces disposed thereon;

a connection substrate having opposing first and second surfaces, the substrate first surface having a plurality of first conductive portions disposed thereon and the substrate second surface having a plurality of second conductive portions disposed thereon, said first conductive portions also being arranged in said a pattern that matches that of said solder preform first pattern such that when said semiconductor is placed within said socket, a single solder preform opposes a single first conductive portion, the substrate having a plurality of through holes formed therein that extend through said substrate between said first and second surfaces thereof, and in alignment with said first and second conductive portions;

10 the through holes further having conductive portions associated therewith to define electrically conductive paths between said substrate first and second surfaces, interconnecting said first and second conductive portions; and,

an elongated heat source for generating a predetermined amount of heat to selectively effect a connection and disconnection between said semiconductor and said first conductive portions by at least partially melting said solder preforms causing them to selectively attach and unattach themselves to said first substrate conductive portions.

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The BGA socket of claim 15, wherein said substrate first conductive portions are arranged in a plurality of rows separated by intervening spaces and said heat source extends lengthwise in said intervening spaces between adjacent rows.
17. The BGA socket of claim 15, wherein said heat source includes a high-resistance wire arranged in a serpentine pattern.

18. The BGA socket of claim 16, wherein said heat source includes a length of high-resistance wire.

19. The BGA socket of claim 15, wherein said heat source is close to but apart from said substrate first surface.

20. The BGA socket of claim 15, wherein said heat source is spaced close to but apart from said substrate first surface and said first conductive portions.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H01L23/498 H05K3/34

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H01L H05K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tr>
<td>Y</td>
<td>US 5 615 824 A (FJELSTAD JOSEPH ET AL) 1 April 1997 see column 4, line 56 - column 7, line 54; figure 3</td>
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<td>A</td>
<td>US 5 093 987 A (SCHOLZ JAMES P) 10 March 1992 see column 10, line 9 - column 13, line 37; figures 11,15</td>
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Further documents are listed in the continuation of box C.

| Patent family members are listed in annex. |

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"&" document member of the same patent family

Date of the actual completion of the international search
29 March 1999

Date of mailing of the international search report
09/04/1999

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European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HN Rijswijk
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Authorized officer
Edmeades, M
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