US009263817B2

(12) **United States Patent**
Palaniappa et al.

(10) **Patent No.: US 9,263,817 B2**
(45) **Date of Patent: Feb. 16, 2016**

(54) **ADAPTER APPARATUS WITH SUSPENDED CONDUCTIVE ELASTOMER INTERCONNECT**

(71) Applicant: **Ironwood Electronics, Inc.**, Eagan, MN (US)

(72) Inventors: **Ilavarasan M. Palaniappa**, Rosemount, MN (US); **Sue Min Huang**, Apple Valley, MN (US)

(73) Assignee: **IRONWOOD ELECTRONICS, INC.**, Eagan, MN (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 212 days.

(21) Appl. No.: **13/916,097**

(22) Filed: **Jun. 12, 2013**

(65) **Prior Publication Data**

US 2014/0370727 A1 Dec. 18, 2014

(51) **Int. Cl.**

H01R 4/58	(2006.01)
H01R 13/24	(2006.01)
H01R 43/20	(2006.01)
H01R 12/71	(2011.01)

(52) **U.S. Cl.**

CPC ***H01R 13/2414*** (2013.01); ***H01R 12/718*** (2013.01); ***H01R 43/205*** (2013.01); *Y10T 29/49147* (2015.01)

(58) **Field of Classification Search**

CPC H01R 13/6215; H01R 13/24; H01R 13/22; H01R 13/2414; H01R 43/0207; H01R 43/205; H01L 23/4006; Y10T 29/49147

USPC 439/86

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,578,288	A	12/1951	Cook
2,951,817	A	9/1960	Myers
3,229,756	A	1/1966	Keresztury
3,728,509	A	4/1973	Shimojo
3,760,342	A	9/1973	Prouty et al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP	0 905 826 A2	3/1999
WO	WO 97/16849	5/1997
WO	WO 99/66599	12/1999

OTHER PUBLICATIONS

Application Notes for Surface Mount Assembly of Amkor's MicroLeadFrame(MLF) Packages. Sep. 2002.

(Continued)

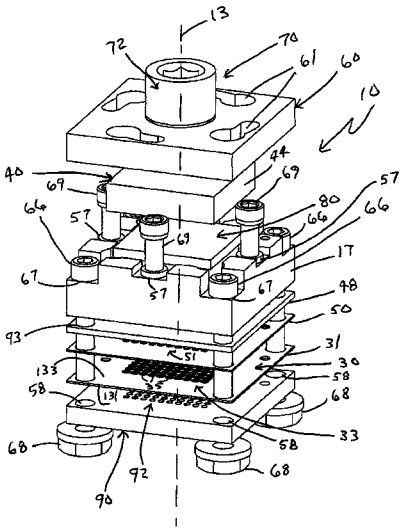
Primary Examiner — Jean F Duverne

(74) *Attorney, Agent, or Firm* — Mueting, Raasch & Gebhardt, P.A.

(57) **ABSTRACT**

An adapter apparatus for receiving a packaged device having a plurality of contact elements disposed on a surface thereof may include a conductive elastomer interconnect. The conductive elastomer interconnect may include a carrier having a plurality of openings defined therethrough from a first side to a second side thereof (e.g., the plurality of openings being arranged to align with the plurality of contact elements of the packaged device) and conductive elastomer suspended in each of the plurality of openings to contact a contact element of a plurality of contact elements of a packaged device when positioned adjacent the second side of the carrier. Further, the adapter apparatus may include one or more adapter wall members used with the conductive elastomer interconnect to define a socket cavity adapted to receive the packaged device.

20 Claims, 8 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

3,870,385	A		3/1975	Avakian et al.
3,971,610	A		7/1976	Buchoff et al.
4,295,699	A		10/1981	DuRocher
4,345,810	A		8/1982	Bakermans
4,460,223	A		7/1984	Brown et al.
4,514,784	A		4/1985	Williams et al.
4,550,959	A		11/1985	Grabbe et al.
4,655,524	A		4/1987	Etzel
4,668,957	A		5/1987	Spohr
4,678,250	A		7/1987	Romine et al.
4,729,166	A		3/1988	Lee et al.
4,754,546	A		7/1988	Lee et al.
4,762,498	A		8/1988	Harting et al.
4,862,076	A		8/1989	Renner et al.
4,878,861	A		11/1989	Kendall et al.
4,923,739	A		5/1990	Jin et al.
5,074,799	A		12/1991	Rowlette, Sr.
5,109,320	A		4/1992	Bourdelaise et al.
5,123,849	A		6/1992	Deak et al.
5,127,837	A	*	7/1992	Shah et al. 439/71
5,129,833	A		7/1992	Rowlette, Sr.
5,137,462	A		8/1992	Casey et al.
5,140,405	A		8/1992	King et al.
5,155,661	A		10/1992	Nagesh et al.
5,163,837	A		11/1992	Rowlette, Sr.
5,286,218	A		2/1994	Sakurai et al.
5,313,099	A		5/1994	Tata et al.
5,318,456	A		6/1994	Mori
5,340,318	A		8/1994	Kunihiro
5,377,900	A		1/1995	Bergmann
5,387,861	A		2/1995	Neiderhofer
5,389,819	A		2/1995	Matsuoka
5,397,240	A		3/1995	Herard
5,397,245	A		3/1995	Roebuck et al.
5,397,919	A		3/1995	Tata et al.
5,418,471	A		5/1995	Kardos
5,432,679	A		7/1995	Grabbe
5,445,526	A		8/1995	Hoshino et al.
5,468,158	A		11/1995	Roebuck et al.
5,473,510	A		12/1995	Dozier, II
5,477,160	A		12/1995	Love
5,528,462	A		6/1996	Pendse
5,548,223	A		8/1996	Cole et al.
5,566,052	A		10/1996	Hughes
5,636,996	A		6/1997	Johnson et al.
5,662,163	A		9/1997	Mira
5,667,870	A		9/1997	McCullough
5,691,041	A		11/1997	Frankeny et al.
5,699,227	A		12/1997	Kolman et al.
5,710,459	A		1/1998	Teng et al.
5,712,768	A		1/1998	Werther
5,730,620	A		3/1998	Chan et al.
5,735,698	A		4/1998	Bakker et al.
5,741,141	A		4/1998	O'Malley
5,742,481	A		4/1998	Murphy et al.
5,745,346	A		4/1998	Ogawa et al.
5,761,050	A		6/1998	Archer
5,766,022	A		6/1998	Chapin et al.
5,770,891	A		6/1998	Frankeny et al.
5,783,461	A		7/1998	Hembree
5,791,914	A		8/1998	Loranger et al.
5,793,618	A		8/1998	Chan et al.
5,805,424	A		9/1998	Purinton
5,810,607	A	*	9/1998	Shih et al. 439/66
5,819,406	A		10/1998	Yoshizawa et al.
5,829,988	A		11/1998	McMillan et al.
5,833,471	A		11/1998	Selna
5,859,538	A		1/1999	Self
5,876,219	A		3/1999	Taylor et al.
5,877,554	A		3/1999	Murphy
5,879,172	A		3/1999	McKenna-Olson et al.
5,892,245	A		4/1999	Hilton
5,893,765	A		4/1999	Farnworth
5,896,037	A		4/1999	Kudla et al.
5,923,176	A		7/1999	Porter et al.
5,973,618	A		10/1999	Ellis
5,982,635	A		11/1999	Menzies et al.
6,007,348	A		12/1999	Murphy
6,325,280	B1		12/2001	Murphy
6,351,392	B1		2/2002	Palaniappa et al.
6,394,820	B1		5/2002	Palaniappa et al.
6,533,589	B1		3/2003	Palaniappa et al.
6,623,280	B2		9/2003	Oldenburg et al.
6,644,981	B2		11/2003	Choy
6,877,993	B2		4/2005	Palaniappa et al.
7,083,434	B1		8/2006	Blossfeld
7,368,814	B1		5/2008	Tully et al.
7,874,880	B2		1/2011	Fedde et al.
8,091,222	B2		1/2012	Fedde et al.

OTHER PUBLICATIONS

Ironwood Electronics, Inc. VLSI Interconnection Specialists Catalog XII (pp. 84, 110) (product on p. 110 available at least as early as Oct. 4, 1998).

Ironwood Electronics, Inc. VLI Interconnection Specialists Product Brochure, Spring 1998. 6 pages.

Herard et al., "Interconnection Technology: Using dendrites to bridge the gaps," *Printed Circuit Fabrication*, 1995;18(9):22-24.

Jarvela R.A., "Module Holder and Actuator," *Technical Disclosure Bulletin*, 1974;16(12):3975-3976.

Lau, John H. ed., "A brief introduction to Ball Grid Array Technologies," *ball Grid Array Technology*, 1995;pp. xii-i-xvi:1-57.

* cited by examiner

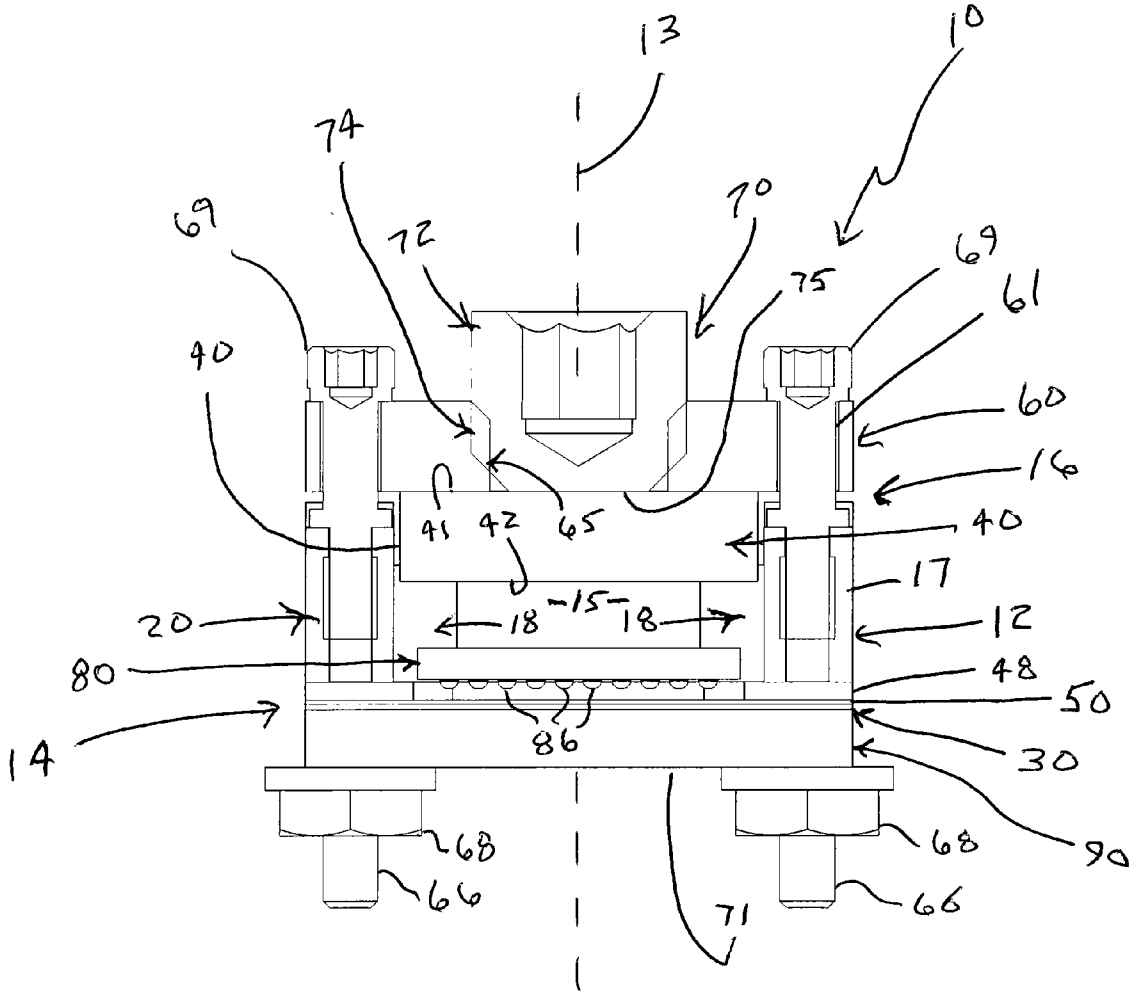

13
10
74
69
72
70
75
69
61
40
60
16
41
42
65
40
17
20
18
15
18
12
80
48
50
14
86
30
90
68
68
66
66
71

FIG. 1

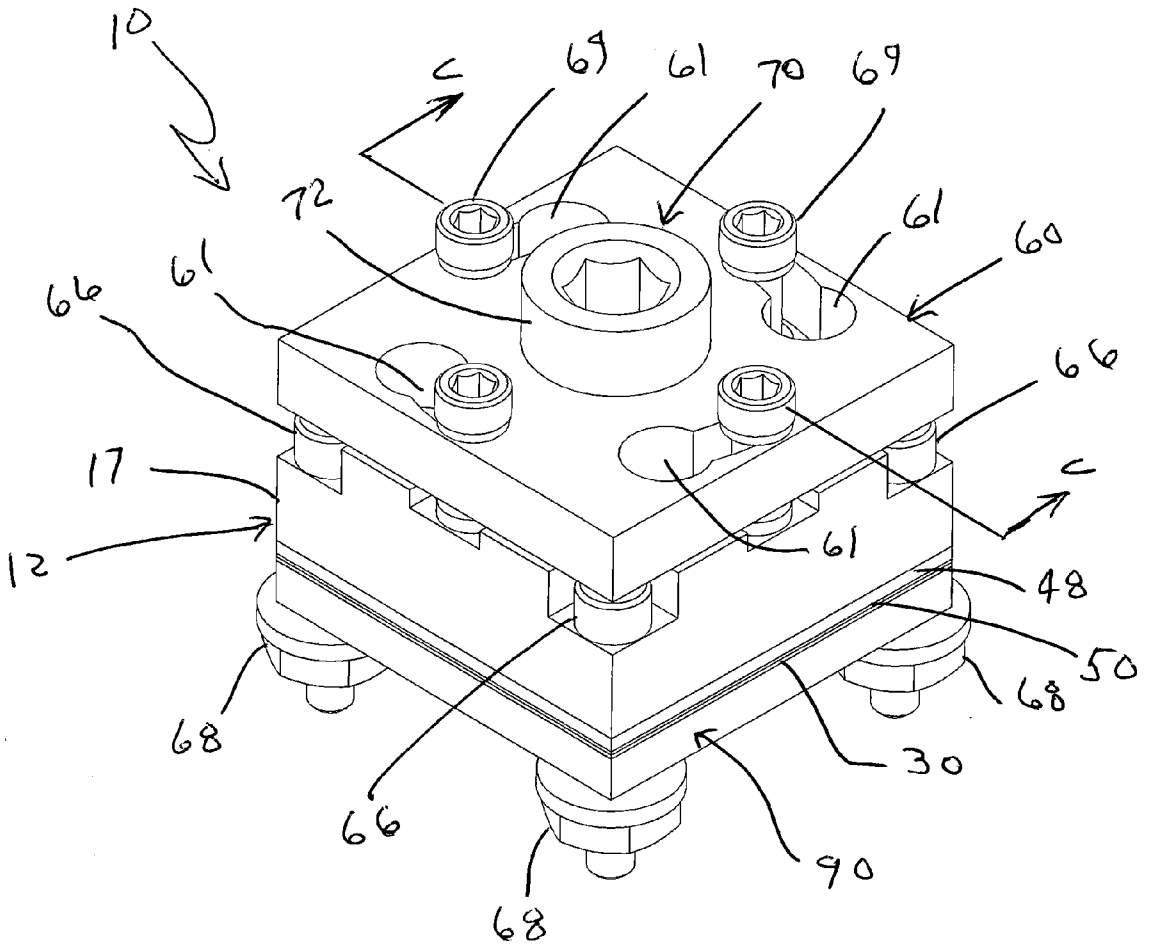


FIG. 2A

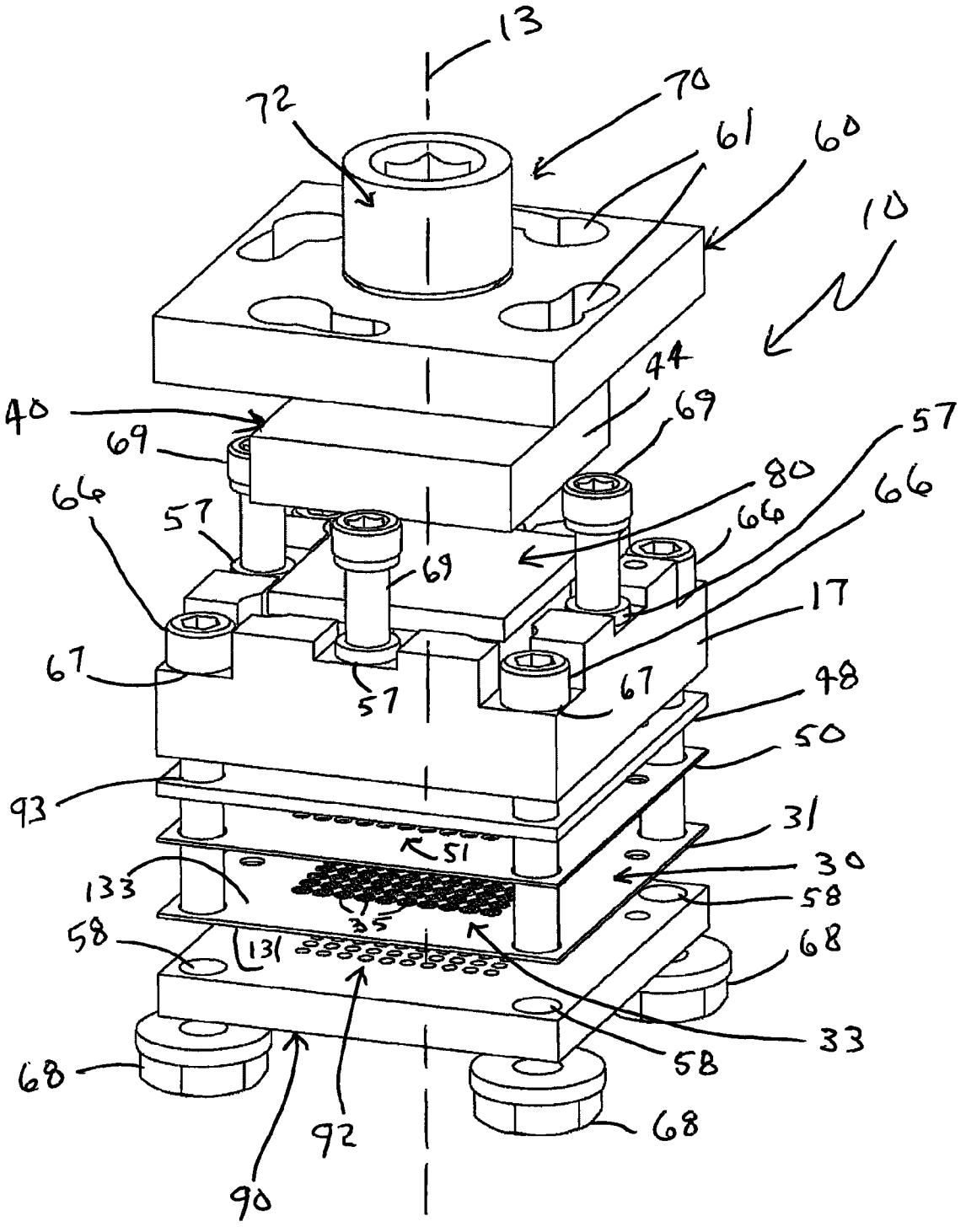

13
72
70
61
60
10
44
40
69
69
57
80
66
66
66
57
69
17
67
67
57
48
50
93
31
51
30
133
58
35
58
131
68
33
58
68
68
92
90

FIG. 2B

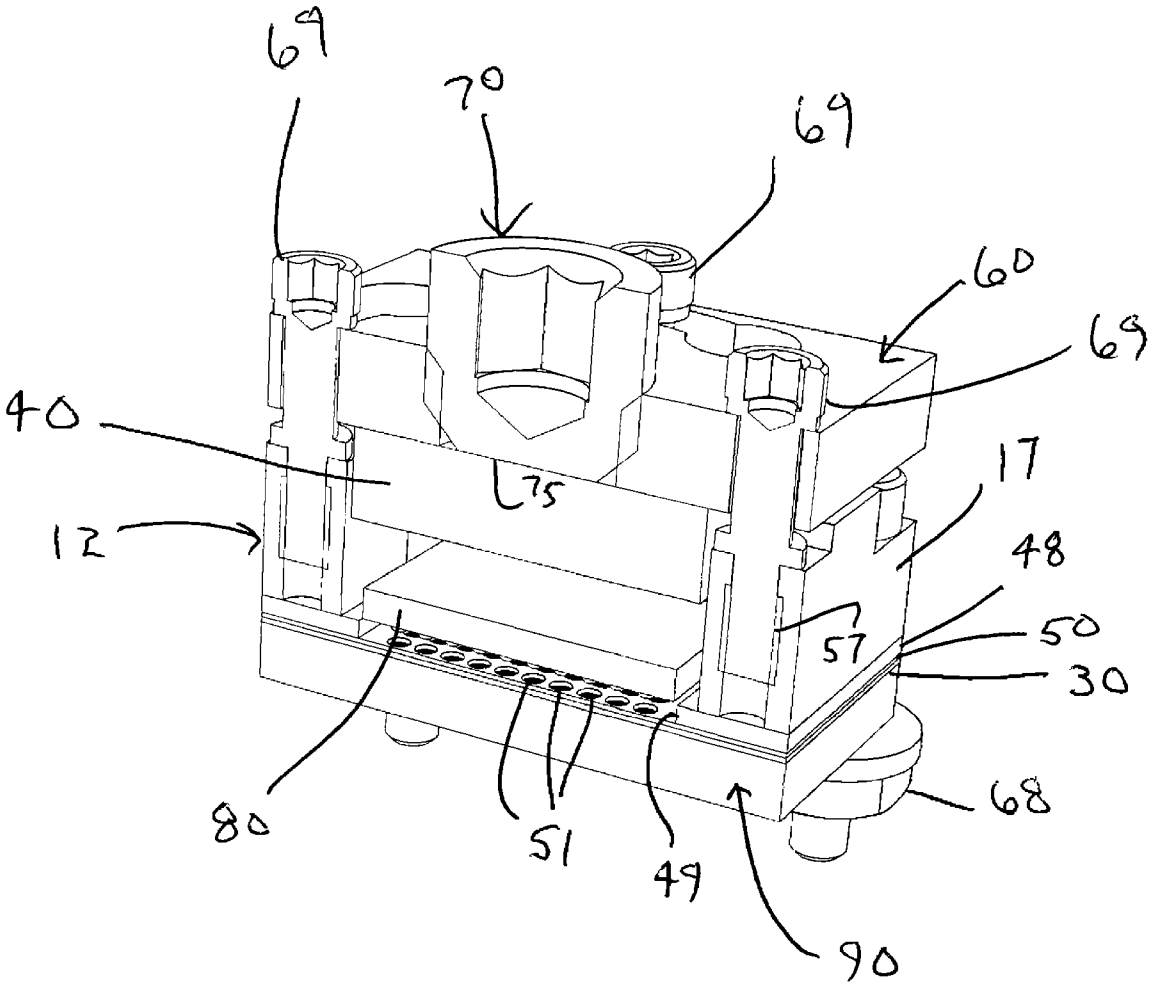


FIG. 2C

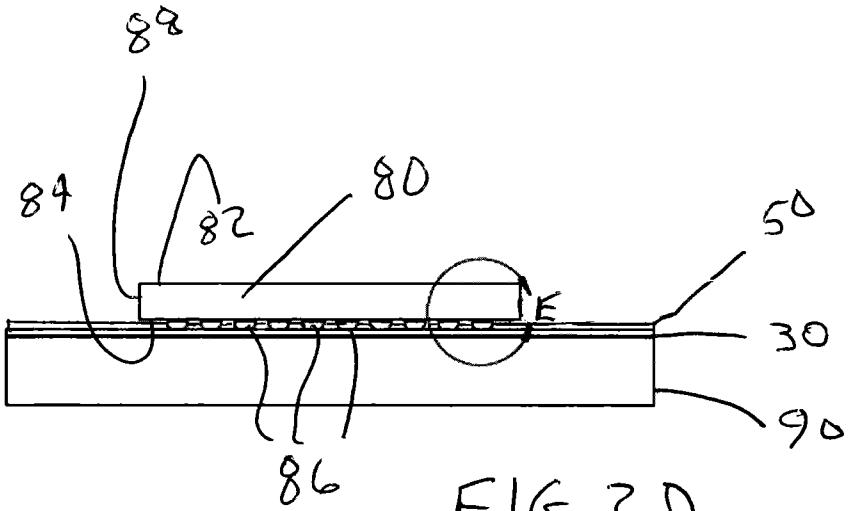

88
84
82
80
50
E
30
90
86

FIG. 2D

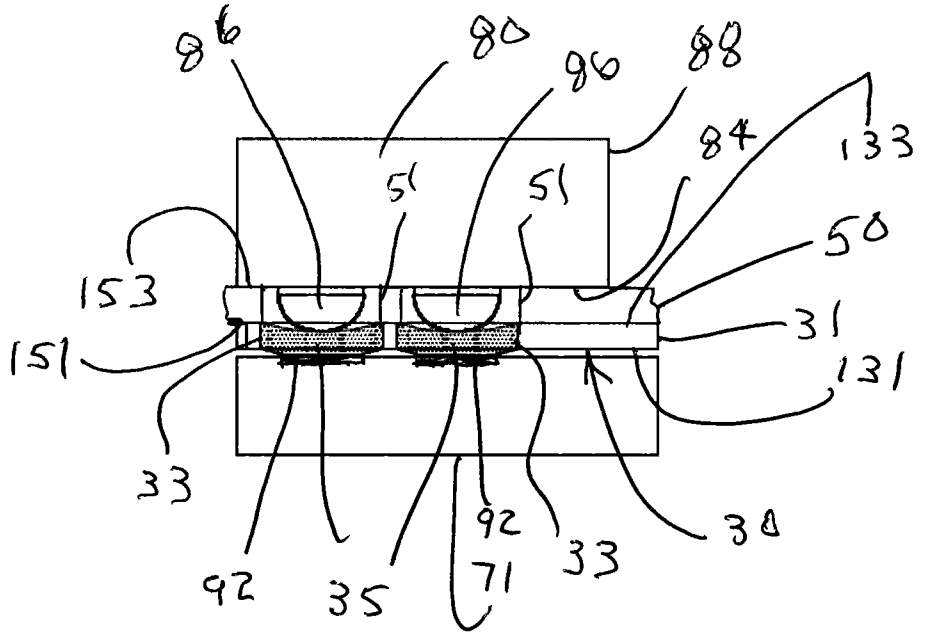

86
80
90
88
84
133
51
51
153
50
31
151
131
33
92
33
34
92
35
71

FIG. 2E

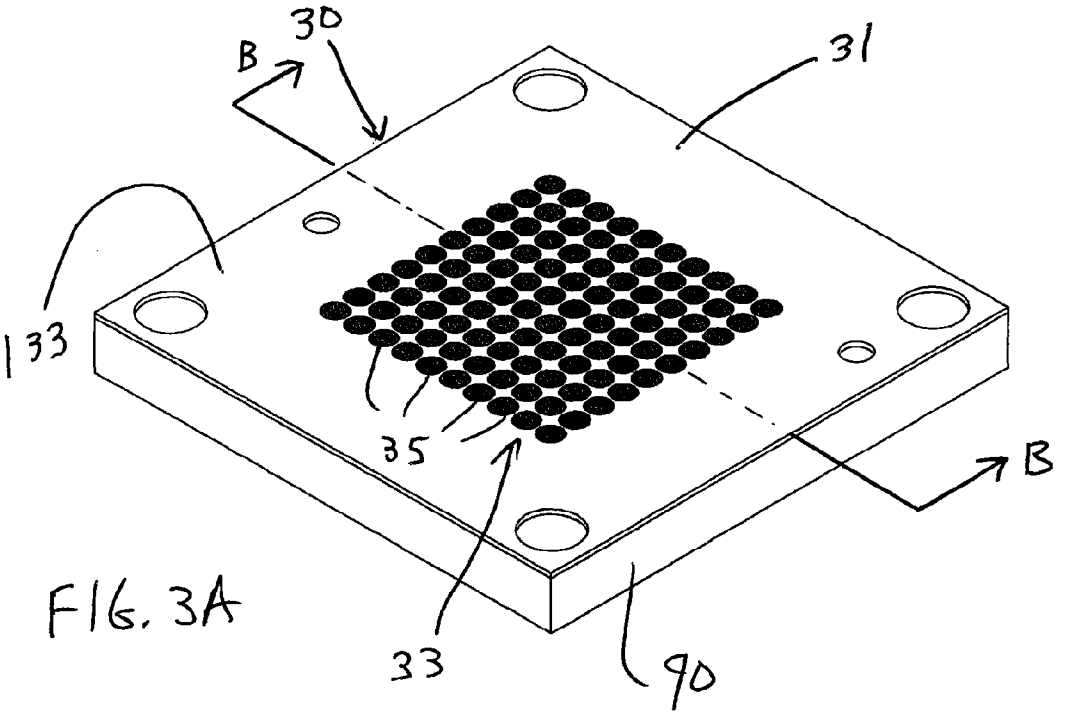


FIG. 3A

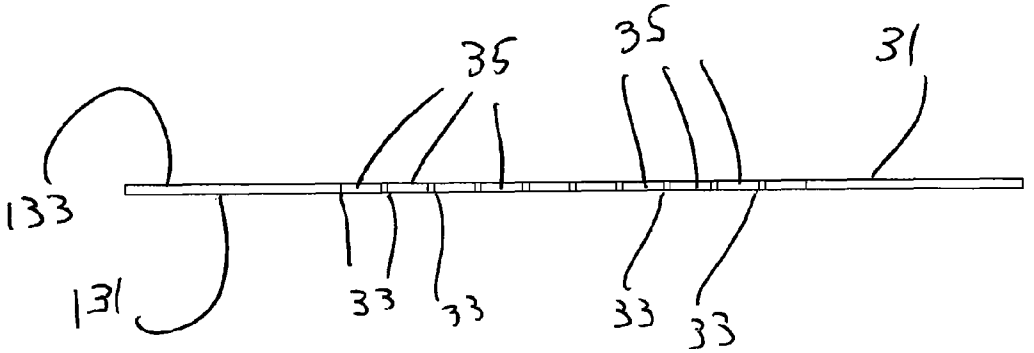


FIG. 3B

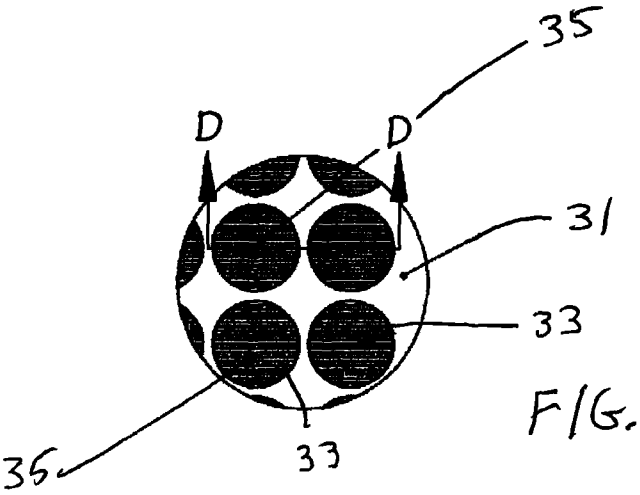


FIG. 3C

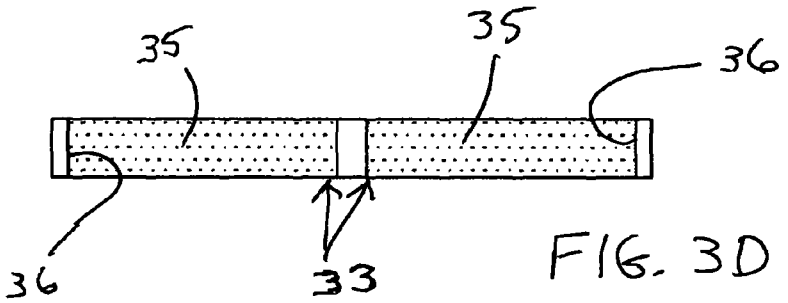


FIG. 3D

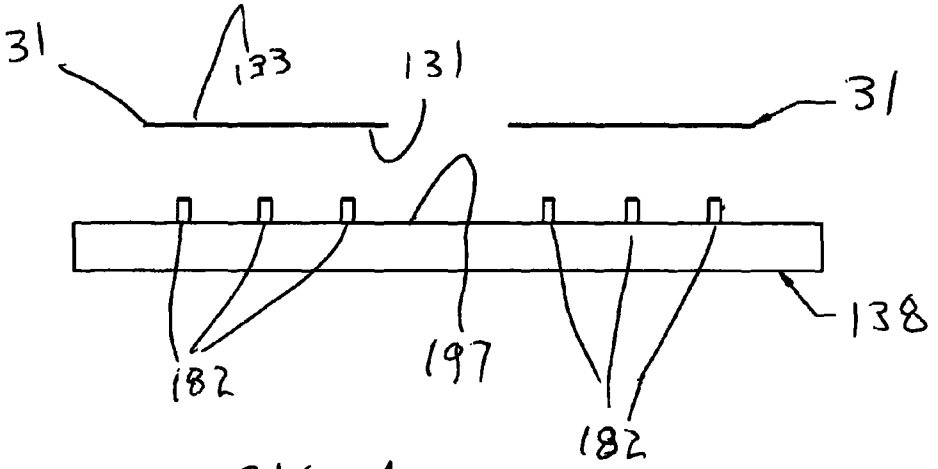


FIG. 4

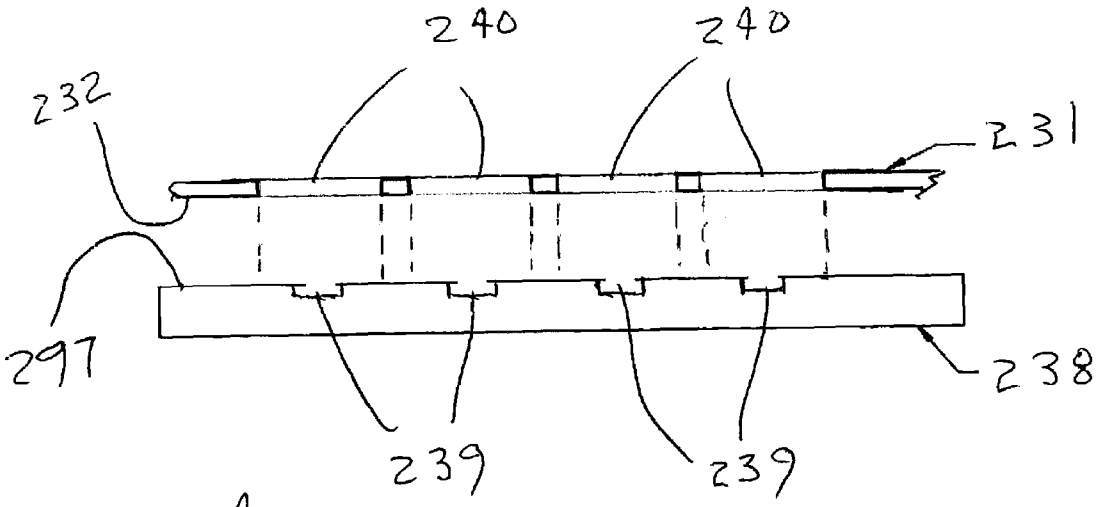


FIG. 5A

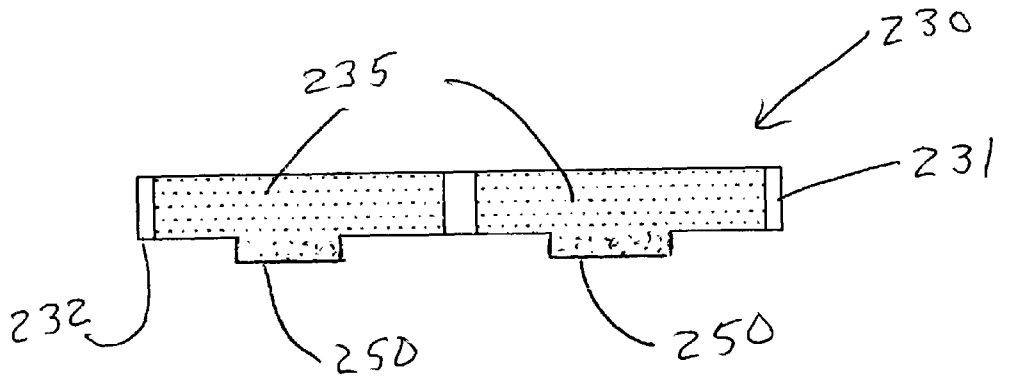


FIG. 5B

ADAPTER APPARATUS WITH SUSPENDED CONDUCTIVE ELASTOMER INTERCONNECT

BACKGROUND

The present disclosure relates generally to electrical adapters and methods related to such adapters. More particularly, the present disclosure pertains to adapters for packaged integrated circuit devices, e.g., ball grid array packages.

Certain types of integrated circuit packages are becoming increasingly popular due to their occupancy area efficiency. In other words, they occupy less area on a target board on which they are mounted while providing a high density of contact terminals. For example, one such high density package type is a ball grid array package (e.g., a micro ball grid array package). Generally, such packages contain an integrated circuit having its die bond pads electrically connected to respective conductive contact elements (e.g., spheres/balls) that are distributed on a surface of the package (e.g., the bottom surface of the package, for example, in an array).

A target printed circuit board upon which the package is to be mounted typically has formed on its surface a corresponding array of conductive pads which are aligned with the conductive contact elements of the packaged device for electrically mounting the package on the target board. The target board typically includes other conductive traces and elements which lead from the array of conductive pads used for mounting the package to other circuitry on the board for connecting various components mounted thereon. To mount such a package to a target board, for example, the package may be positioned with the contact elements thereof adjacent to the corresponding array of conductive pads on the target board and, for example, the resulting structure may be heated until solder melts and fuses the contact elements of the package to the conductive pads of the target board.

Such area efficient packaging, e.g., micro ball grid array packages, provides a high density of terminals at a very low cost. Also, this packaging provides for limited lead lengths (e.g., short leads). The limited lead lengths may reduce the risk of damage to such leads of the package, may provide for higher speed product, etc.

Generally, circuit boards and/or components mounted thereon are tested by designers as the circuit boards are being developed. For example, for a designer to test a circuit board and/or a package mounted thereon, the designer must first electrically connect the package to the target circuit board.

As described herein, this may include mounting the package on the target board and heating to fuse the contact elements of the package to the conductive pads of the target board. Therefore, the package may be prevented from being used again. It is desirable for various reasons to use package adapters for mounting the packages and reuse such packages after testing. For example, such device packages may be relatively expensive. Further, for example, once attached, the contacts may not be accessible for testing. In addition, it is often difficult to rework the circuit board with the packages soldered thereon.

Various adapters are available to electrically connect a package to a target printed circuit board without requiring that the contact elements on the package be fused to the target board. However, the high density of terminals for certain packages, e.g., micro ball grid array packages, leads to various interconnect problems for adapters being used with such packages. For example, alignment of the contact elements of the packaged device to the contact pads of the target board may be problematic when an electrical adapter is used. Further, providing effective contact with minimal adaptive structure may be difficult. Various adapters have been described for electrically connecting high density packaged devices to a target printed circuit board, such as, for example, U.S. Pat. No. 6,877,993 to Palaniappa et al., issued 12 Apr. 2005, entitled "Packaged Device Adapter Assembly with Alignment Structure and Methods Regarding Same," and U.S. Pat. No. 6,394,820 to Palaniappa et al., issued 28 May 2002, entitled "Packaged Device Adapter Assembly and Mounting Apparatus," describe adapter apparatus that use a conductive elastomer layer to provide electrical contact.

SUMMARY

The disclosure herein provides packaged device adapter assemblies useable for high density integrated circuit packages, e.g., micro ball grid array packages, etc.

One exemplary adapter apparatus disclosed herein for receiving a packaged device having a plurality of contact elements disposed on a surface thereof may include a conductive elastomer interconnect. The conductive elastomer interconnect may include a carrier having a plurality of openings defined therethrough from a first side to a second side thereof (e.g., the plurality of openings may be arranged to align with the plurality of contact elements of the packaged device) and conductive elastomer suspended in each of the plurality of openings to contact a contact element of a plurality of contact elements of a packaged device when positioned adjacent the second side of the carrier. Further, the adapter apparatus may include one or more adapter wall members along an adapter axis between a first end region of the adapter apparatus and a second end region of the adapter apparatus. The conductive elastomer interconnect may be positioned at the first end region of the adapter apparatus orthogonal to the adapter axis and the one or more adapter wall members and the conductive elastomer interconnect may define a socket cavity adapted to receive the packaged device with the plurality of contact elements thereof adjacent the conductive elastomer suspended in each of the plurality of openings.

Another exemplary adapter apparatus for use in an adapter configured to receive a packaged device having a plurality of contact elements disposed on a surface thereof may include a conductive elastomer interconnect that includes a carrier having a plurality of openings defined therethrough from a first side to a second side thereof (e.g., the plurality of openings are arranged to align with the plurality of contact elements of the packaged device) and conductive elastomer suspended in each of the plurality of openings to contact a contact element of a plurality of contact elements of a packaged device when positioned adjacent the second side of the carrier.

One or more embodiments of such adapter apparatus may include one or more of the following features: the first and second sides of the carrier may be free of conductive elastomer; the packaged device may include a ball grid array having a plurality of balls; each opening of the plurality of openings defined through the carrier may be a cylindrical opening having a diameter sized to receive a ball of the plurality of balls of the ball grid array; the conductive elastomer suspended in each of the plurality of openings may include a curable conductive elastomer material (e.g., a curable conductive elastomer material that includes a plurality of conductive particles); the conductive elastomer suspended in each of the plurality of openings may include a concave surface at the second side of the carrier for electrical contact with the contact elements of the packaged device; the conductive elastomer suspended in each of the plurality of openings may include a contact projection extending beyond the

first side of the carrier for electrical contact with a contact pad of a plurality of contact pads of a target board when the target board is positioned adjacent the first side of the carrier; the one or more wall members may include alignment structure positioned at the first end region to align the packaged device within the socket cavity (e.g., the alignment structure may include at least an alignment plate positioned orthogonal to the adapter axis; the alignment plate may include a plurality of openings arranged to align with the plurality of contact elements of the packaged device and adapted to allow contact elements of the packaged device to be in electrical contact with the conductive elastomer suspended in each of the plurality of openings defined in the carrier layer, etc.); and an actuator apparatus including a floating member movable in the socket cavity and an actuator element (e.g., the actuator element may be operable to provide a force on the floating member resulting in a corresponding force being distributed to the packaged device when received in the socket cavity such that the plurality of contact elements are in electrical contact with the suspended conductive elastomer in each of the plurality of openings defined in the carrier, the suspended conductive elastomer in each of the plurality of openings defined in the carrier may be flexed towards the first side of the carrier when the force is applied, etc.).

One exemplary embodiment of a method of providing an adapter apparatus adapted to receive a packaged device having a plurality of contact elements disposed on a surface thereof (e.g., the adapter apparatus mountable to a target board to electrically connect the plurality of contact elements to a plurality of contact pads of the target board) may include providing a conductive elastomer interconnect such as described herein including, for example, a carrier and conductive elastomer suspended in each of a plurality of openings defined therethrough. The method may further include providing one or more adapter wall members along an adapter axis between a first end region and a second end region of the adapter apparatus and positioning the conductive elastomer interconnect at the first end region of the adapter apparatus orthogonal to the adapter axis to define a socket cavity of the adapter apparatus adapted to receive a packaged device such that the plurality of contact elements of the packaged device are adjacent the conductive elastomer suspended in each of the plurality of openings.

In one embodiment of the exemplary method, providing a conductive elastomer interconnect may include positioning the first side of the carrier adjacent a formation surface to close the plurality of openings defined through the carrier, providing conductive elastomer at least within the plurality of openings defined through the carrier, and curing the conductive elastomer within the plurality of openings to provide the suspended conductive elastomer in each of the plurality of openings. For example, the formation surface may be a planar surface or a nonplanar surface (e.g., a formation surface having at least one surface deformation defined therein corresponding to each of the plurality of openings defined through the carrier, wherein the at least one surface deformation forms a contact projection of the suspended conductive elastomer extending beyond the first side of the carrier for electrical contact with a contact pad of a plurality of contact pads of a target board when the target board is positioned adjacent the first side of the carrier).

In another embodiment of the exemplary method, the method may further include providing an actuator apparatus that includes a floating member movable in the socket cavity and an actuator element (e.g., the actuator element may be operable to provide a force on the floating member such that a corresponding force is distributed to a packaged device when received in the socket cavity) and providing electrical contact between the plurality of contact elements of the packaged device and the suspended conductive elastomer in each of the plurality of openings defined in the carrier via the force provided on the floating member (e.g., the suspended conductive elastomer in each of the plurality of openings defined in the carrier may be flexed towards the first side of the carrier when the force is applied).

The above summary of the present disclosure is not intended to describe each embodiment or every implementation thereof. Advantages, together with a more complete understanding of the disclosure, will become apparent and appreciated by referring to the following detailed description and claims taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional side view of an exemplary packaged device adapter assembly mounted on a target board.

FIG. **2**A is a perspective view of a packaged device adapter assembly including features shown in FIG. **1**, FIG. **2**B is a top exploded perspective view of the packaged device adapter assembly of FIG. **2**A, FIG. **2**C is a cross-section of the packaged device adapter assembly of FIG. **2**A taken along line CC, FIG. **2**D is a side view of a portion of the packaged device adapter assembly showing a compressed state, and FIG. **2**E is a more detail view of a portion of FIG. **2**D.

FIG. **3**A is a top perspective view of one exemplary embodiment of a conductive elastomer interconnect on a target board for use in a packaged device adapter assembly such as that shown in FIGS. **1-2**, FIG. **3**B is cross-sectional side view of the conductive elastomer interconnect shown in FIG. **3**A taken along line BB, FIG. **3**C is a plan view of a portion of the conductive elastomer interconnect of FIGS. **3**A-**3**B, and FIG. **3**D is a cross-section side view of a portion of the conductive elastomer interconnect shown in FIG. **3**C taken along line DD.

FIG. **4** is a side view for use in illustrating the formation of an exemplary conductive elastomer interconnect such as shown in FIGS. **1-3**.

FIG. **5**A is a side view for use in illustrating the formation of a portion of another exemplary conductive elastomer interconnect, and FIG. **5**B shows an illustrative cross-section of a portion of the exemplary conductive elastomer interconnect formed as illustrated in FIG. **5**A.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

In the following detailed description of illustrative embodiments, reference is made to the accompanying figures of the drawing which form a part hereof, and in which are shown, by way of illustration, specific embodiments which may be practiced. It is to be understood that other embodiments may be utilized and structural changes may be made without departing from (e.g., still falling within) the scope of the disclosure presented hereby.

Generally, packaged device adapter assemblies for use with packaged devices, e.g., high density devices, such as ball grid array packages, along with methods of using and forming such assemblies or portions thereof, shall be described herein. An illustrative packaged device adapter assembly **10** according to the present invention shall be described with reference to illustrative FIGS. **1-3**. Other features and or illustrations

relating to packaged device adapter assemblies, including methods of forming such features, shall be described with reference to FIGS. **4-5**.

In other words, exemplary adapter apparatus and methods for providing and using such adapters shall generally be described with reference to FIGS. **1-5**. It will be apparent to one skilled in the art that elements from one embodiment may be used in combination with elements of the other embodiments, and that the possible adapter apparatus embodiments using features set forth herein is not limited to the specific embodiments described (e.g., various illustrative embodiments described may include some features or elements included in other illustrative embodiments and/or exclude other features). For example, as will be readily apparent from the description herein, various types of alignment structure, wall members used to form socket cavities, actuator structure, covers, etc., may be used in combination with each of the various embodiments of adapter assemblies described herein, and further other adapter assemblies may benefit from features described herein (e.g., adapter assemblies that may not be described herein). Further, it will be recognized that the embodiments described herein may include many elements that are not necessarily shown to scale. Further, it will be recognized that the size and shape of various elements herein may be modified without departing from the scope of the present disclosure, although one or more shapes and sizes may be advantageous over others.

FIGS. **1-3** show a cross-section side view and various other views, including an exploded perspective view in FIG. **2**B, of an illustrative and exemplary packaged device adapter assembly **10** for use with a packaged device **80** according to the present invention. Generally, the packaged device adapter assembly **10** is for mounting on a target board **90**. The packaged device adapter assembly **10** includes one or more wall members **12** (e.g., perimeter wall members, base socket member **17**, etc.) having a length along an adapter axis **13**. Generally, the length of the one or more wall members **12** extends between a first end region **14** of the packaged device adapter assembly **10** and a second end region **16** of the packaged device adapter assembly **10**. The one or more wall members **12** may include an inner surface region **18** facing towards the adapter axis **13** (e.g., used to form socket cavity **15**) and an opposing outer surface region **20** facing away from the adapter axis **13**.

The packaged device adapter assembly **10** further includes a conductive elastomer interconnect **30**. In at least one embodiment, the conductive elastomer interconnect **30** includes a carrier **31** including a plurality of openings **33** defined therethrough from a first side **131** to a second side **133** thereof. The plurality of openings **33** are arranged to align with a plurality of contact elements **86** of the packaged device **80**. In one or more embodiments, conductive elastomer **35** may be suspended in each of the plurality of openings **33** to contact a contact element of the plurality of contact elements **86** of the packaged device **80** when the packaged device **80** is positioned adjacent the second side **133** of the carrier **31**.

The one or more wall members **12** (e.g., various structure along the adapter axis **13** between the first end region **14** and second end region **16** of the adapter assembly **10**) and the conductive elastomer interconnect **30** (e.g., positioned at the first end region **14** of the adapter assembly **10** orthogonal to the adapter axis **13**) may define a socket cavity **15** sized or otherwise configured to receive the packaged device **80**. The socket cavity **15** is adapted to receive the packaged device **80** with each contact element of the plurality of contact elements **86** adjacent a corresponding conductive elastomer **35** suspended in an opening of the plurality of openings **33**.

In one or more embodiments, for example, as shown in FIGS. **2**D-**2**E, the packaged device **80** may include an upper surface **82** and a lower surface **84** in addition to one or more side surfaces **88** extending therebetween at the perimeter of the packaged device **80**. A plurality of contact elements **86** (e.g., balls/spheres of a ball grid array) may be disposed at least at the lower surface **84**. For example, the contact elements **86** may be distributed in an array along x and y axes orthogonal to the adapter axis **13** or the contact elements (e.g., spheres or balls, etc.) may be distributed along the outer portions of the lower surface **84** proximate the perimeter thereof. However, any arrangement of contact elements **86** may be accommodated according to the present disclosure.

The packaged device **80** may be any packaged device having a plurality of contact elements **86** disposed on a surface thereof suitable for electrical connection with conductive elastomer **35** suspended within the plurality of openings **33** of the conductive elastomer interconnect **30**. In one or more embodiments, the packaged device may be a device having a high density of contact terminals, e.g., lands, solder spheres, bumps, contact pads, leads, etc., disposed on a surface thereof. For example, the high density packaged device may be a micro lead frame package, a micro lead chip carrier, a quad flat no lead package, a micro ball grid array package, or any other type of package such as a ball grid array package, a chip scale package, a flip chip package, a flat package, a quad flat package, a small outline package, a land grid array package, or any other package having contact elements disposed on a surface thereof suitable for electrical connection with conductive elastomer **35** suspended within the plurality of openings **33** of the conductive elastomer interconnect **30**.

In at least one embodiment, the packaged device **80** includes a ball grid array package device having contact elements **86** in the form of spheres or balls on the lower surface **84**. However, adapter assemblies and adapter concepts described herein may be used with any other packaged device having contact elements disposed on a surface thereof which would benefit from the use of the conductive elastomer interconnect **30**. Further, any number of different sizes and/or configurations of packaged devices may benefit from features described herein (e.g., packaged devices with only one planar surface having contact elements disposed thereon, packaged devices having upper and lower surfaces that are parallel to one another, packaged devices having upper and lower surfaces that are not parallel to one another, etc.).

Further, the packaged device adapter assembly **10** may include a cover member **60** positioned at the second end **16** of the one or more wall members **12** (e.g., adjacent the socket base member **17** along axis **13**) to close the socket cavity **15**. The cover member **60** may be movable, e.g., removable via fastening devices **69** as shown in FIGS. **1-2**. However, the cover member may also be moveable about a hinge axis (not shown), or any other manner of removing or moving the cover to open the socket cavity for allowing a packaged device to be received therein. In other words, one or more cover member configurations may allow the packaged device **80** to be removed from the socket cavity **15** and another packaged device placed therein. The packaged device adapter assembly **10** is generally used to provide electrical contact between the contact elements **86** of the packaged device **80** and contact pads **92** of the target board **90** via the conductive elastomer interconnect **30** when the packaged device **80** is positioned in the socket cavity **15**.

The one or more wall members **12** may include any number of different structures (e.g., along the adapter axis **13**) between the first end region **14** and second end region **16** of the adapter assembly **10**. For example, the one or more wall

members **12** may include a socket base member **17** extending from a first end located towards the first end region **14** of the adapter assembly **10** to a second end location towards the second end region **16**. For example, in one or more embodiments, such a socket base member **17** may define an opening therethrough along axis **13** (e.g., providing, at least in part, the inner surface region **18** of adapter assembly **10**) to form at least a part of the defined socket cavity **15** sized or otherwise configured to receive the packaged device **80**.

Further, for example, the one or more wall members **12** may include one or more types of alignment structure positioned at the first end region **14** (e.g., adjacent the first end of socket base member **17**) to align the packaged device **80** within the socket cavity **15**. For example, in one or more embodiments, the alignment structure may include an alignment plate **48** positioned orthogonal to the adapter axis **13**. For example, the alignment plate **48** may define an opening therethrough along axis **13** (e.g., providing, at least in part, the inner surface region **18** of adapter assembly **10**) to form at least a part of the defined socket cavity **15** sized or otherwise configured to receive the packaged device **80**. For example, the alignment plate **48** may include an inner surface **49** defining the opening along axis **13** (e.g., the opening being sized to align the packaged device **80** within the socket cavity **15** for effective electrical contact of the plurality of contact elements **86** of the packaged device **80** and the conductive elastomer **35** suspended in each of the plurality of openings **33**; each opening **33** of the conductive elastomer interconnect **30** corresponding to a particular contact element **86**). Such alignment structure may be of any configuration suitable to provide alignment within the socket cavity **15**. For example, alignment structure may include a single surface defining an opening to provide the alignment function or may be as described in U.S. Pat. No. 6,877,993 B2 to Palaniappa et al., issued 12 Apr. 2005, and entitled "Packaged Device Adapter Assembly Alignment Structures and Methods Regarding Same."

One will recognize that the one or more wall members **12** may use any number of structures to provide an opening into which the packaged device **80** is received. Such structures may take any shape and/or form suitable to provide a socket cavity for receiving the packaged device **80** and the present disclosure is not limited to any particular configuration of such one or more wall members **12** (e.g., not limited to any number and/or shape described herein).

The packaged device adapter assembly **10** further includes actuator apparatus, such as, for example, a floating member **40** (e.g., a compression plate for providing a force on the packaged device **80**) as shown in FIGS. **1-2**. The floating member **40** may be used in combination with other actuator apparatus, including, for example, an actuator element **70**, to provide a distributed force on the packaged device **80** when received in the socket cavity **15** such that the contact elements **86** disposed on the lower surface **84** of the packaged device **80** are in effective electrical contact with the conductive elastomer **35** suspended in the openings **33** of the conductive elastomer interconnect **30**. In FIG. **1**, the floating member **40** is shown spaced apart from the packaged device **80**, as is the conductive elastomer interconnect **30**.

At least in one embodiment, the floating member **40** includes an upper surface **41** that is generally planar and orthogonal to the adapter axis **13** when the floating member **40** is positioned in the socket cavity **15**. Further, at least in one embodiment, the floating member **40** includes a lower surface **42** that is configured as a function of the upper surface **82** of the packaged device **80**. For example, as shown in FIG. **1**, lower surface **42** of the floating member **40** is generally planar for direct contact with the planar upper surface **82** of a packaged device **80**. However, the lower surface of the floating member **40** may be configured in any manner and need not be planar. Further, the floating member may be formed of any number of different components. However, in at least one embodiment, at least a portion of the lower surface **42** of the floating member **40** is in direct contact with the upper surface **82** of the packaged device **80**. The floating member **40** as shown in FIGS. **1-2** includes an edge surface **44** extending between the upper surface **41** and the lower surface **42** at the perimeter of the floating member **40**. The edge surface **44** lies adjacent, and may even be in contact with, the inner surface region **18** defined, for example, by the one or more wall members **12**, and is moveable relative thereto within the socket cavity **15**.

The actuator element **70** may be any actuator element operable to apply a force on the upper surface **41** of the floating member **40**. As a force is applied by the actuator element **70** to the upper surface **41** of the floating member **40**, the force is distributed generally equally along the upper surface **82** of the packaged device **80**. As such, an equivalent force is provided at each contact element **86**, e.g., ball or sphere, for effective contact between each contact element **86** and the suspended conductive elastomer **35** within a corresponding opening of the plurality of openings **33** defined in carrier **31** of the conductive elastomer interconnect **30**. Such a distributed force across the entire packaged device **80** reduces the potential application of excessive force on one part of the packaged device **80** versus another part thereof, e.g., the center versus the perimeter.

Generally, in one or more embodiments, the actuator element **70** is an element associated with the cover member **60**. For example, the actuator element may be a spring element, a leaf spring, or any other flexible element capable of applying a force to the floating member **40** via the association with the cover member **60**. Further, the cover member **60** itself may be used to apply a force to the floating member **40** such as by tightening the cover member directly down on the floating member **40** by fastening elements, e.g., screws.

At least in one embodiment as shown in FIG. **1**, the actuator element **70** may be a threaded element that includes an upper region **72** with a threaded portion **74** extending therefrom. Further, in such an embodiment, the cover member **60** includes a threaded insert **65** positionable along the axis **13** of the adapter assembly **10** for mating with the threaded portion **74** of the actuator element **70**. The threaded portion **74** may terminate in a generally planer surface **75**.

With the packaged device **80** in the socket cavity **15**, the planer surface **75** is placed in direct contact with the upper surface **41** of the floating member **40** by turning the actuator element **70**. As such, the actuator element **70** is adjustable to provide an effective force to the upper surface **41** of floating member **40** such that the distributed force is applied for effective electrical coupling of the contact elements **86** to the suspended conductive elastomer **35** of conductive elastomer interconnect layer **30**. With use of the actuator element **70** and the floating member **40**, a suitable distributed force on the packaged device **80** can be achieved. The minimized load applied to the packaged device **80** and thus to the conductive elastomer **35** suspended in the openings **33** of the conductive elastomer interconnect **30** allows for operation of the adapter assembly **10** over many insertion cycles as the conductive elastomer interconnect **30** is not unnecessarily damaged by the force applied to the packaged device **80** to achieve contact between all of the contact elements **86** and suspended conductive elastomer **35**.

In one or more embodiments, the floating member **40** may be formed of a heat conductive material, e.g., aluminum, to

provide heat sinking capability. Further, actuator element **70** and the one or more wall members **12** and cover **60** may be formed of such heat sinking material. In such a manner, the elements that form the socket cavity **15** which provide electrical coupling of the packaged device **80** to a target board **90** also function to dissipate heat away from the packaged device **80** when the packaged device **80** is operable. This is particularly beneficial for high density packaged devices in that such packaged devices tend to operate with greater heat output.

As can be seen from FIG. **1**, the floating member **40** may be sized and configured such that edge **44** thereof is in moveable contact with inner surface region **18** provided, at least in part, by the one or more wall members **12** which allows heat conduction therethrough and away from the packaged device **80**. Likewise, the contact between the actuator element **70** and the floating member **40**, such as provided by a screw formed of aluminum, may allow for heat conduction from the threaded portion **74** (which is in direct contact with the floating member **40**) to the exterior of the socket cavity **15**.

It will be recognized that various elements or portions of the adapter assembly **10** may be formed of multiple layers or components or as single piece elements. For example, it will be recognized that the one or more wall members **12** may include multiple pieces or it may be formed as a single piece element. Further, for example, the floating member **40** may be formed of one or more layers or components.

The adapter assemblies as described herein may be mounted relative to various target boards as illustrated generally in FIG. **1** by target board **90** and may be mounted to the target board **90** in any number of different manners, many of which would be readily known by one skilled in the art. For example, such mounting may be performed as described in U.S. Pat. No. 6,394,820 issued 28 May 2002, entitled "Packaged Device Adapter Assembly and Mounting Apparatus," which is incorporated herein by reference.

The target board **90** may be any substrate including contact pads or other conductive elements arranged thereon for electrical connection with the adapter assembly **10**. For example, the target board may be a printed circuit board including various other components mounted thereon or may be a surface mountable substrate (e.g., an interconnect board that may be used with printed circuit boards that do not have mounting holes therein or when it is undesirable to provide mounting holes in the target board **90**).

As shown in FIG. **1**, the adapter assembly **10** may be mounted relative to target board **90** (e.g., a printed circuit board) in a manner using fastening devices (e.g., a threaded bolt **66** and washer/nut **68**). Target board **90** includes openings **58** defined therein for use in attachment of the adapter assembly **10** to the target board **90** using the fastening devices. The threaded bolts **66** extend through openings **67**, **93** defined in the one or more wall members **12** (e.g., such as socket base **17**, alignment plate **48**, etc.) and which further extend through openings **58** and beyond the lower surface **71** of the target board **90**. A mating device, e.g., washer/nut **68**, may then be coupled to the threaded bolts **66** which can be tightened to hold the assembly **10** in position relative to the target board **90**.

It will be recognized that the adapter assemblies as described herein may be mounted relative to various configurations of target boards, including but clearly not limited to those described herein (e.g., a surface mountable board, a printed circuit board, etc.). Further, such mounting of the adapter assemblies relative to such target boards may be accomplished in any manner, including but clearly not limited to those described herein (e.g., adhesive, fastening devices including bolts and nuts, threaded inserts, etc.).

The adapter assembly **10**, as shown in FIGS. **1-2**, is formed in a substantially square configuration. However, one skilled in the art will recognize that the elements used in forming the packaged device adapter assembly **10** may include elements for forming an adapter assembly configured as a rectangle, a circle, or any other configuration sized to accommodate a packaged device received in a socket cavity therein. As such, one skilled in the art will recognize that the present disclosure is not limited to any particular shape of adapter assembly, but is limited only as described in the appended claims.

As described herein, the cover member **60** of the packaged device adapter assembly **10** may be configured in various manners. The cover member **60** is used to close the socket cavity **15** and may include various other elements associated therewith for facilitating other functionality. For example, as previously described herein, in one embodiment as shown in FIG. **1**, cover member **60** may be integrated with threaded insert **65** for receiving the threaded portion **74** of the actuator element **70** (e.g., a compression screw) used in applying a direct force to floating member **40** (e.g., a compression plate). Further, cover member **60** as shown in FIG. **1** may include openings **61** for receiving corresponding fastening elements **69**, e.g., screws or threaded bolts, to affix cover member **60** to the one or more wall members **12** (e.g., socket base member **17**). In such an embodiment, the one or more wall members **12** may include inserts **57** for receiving the fastening elements **69** therein. For example, as shown in FIG. **1**, inserts **57** may be threaded inserts for retaining threaded screw portions of screws **69** to attach cover member **60** to the socket base member **17**.

However, in another embodiment, the cover member **60** may also be configured as a latchable hinge cover as shown and described in U.S. Pat. No. 6,394,820, e.g., a ZIF type or clam-type lid. Although several cover members are described herein, the present invention is not limited to only such configurations as various other configurations may provide suitable closure function for the adapter.

Further, with reference to FIGS. **1-2**, and also with reference to FIGS. **3A-3D**, the conductive elastomer interconnect **30** includes the carrier **31** through which a plurality of openings **33** are defined from the first side **131** to the second side **133** thereof. The carrier **31**, at least in one embodiment, includes parallel first and second sides **131**, **133** and has a thickness in the range of about 0.004 inches to about 0.010 inches. Further, for example, the thickness may be greater than about 0.002 inches or less than about 0.012 inches. By providing such a short contact between the target board contact pads **92** and the contact elements **86** of the packaged device **80** (e.g., the short contact being the thin layer of suspended conductive elastomer in the opening defined in the thin carrier layer), the adapter assembly **10** may be effective for high bandwidth applications.

Further, the carrier **31** may be formed of one or more layers and/or portions of any suitable material. For example, the carrier may be formed of one or more polymers, non-conductive high temperature material that can be exposed to reflow temperatures, etc. Further, for example, the carrier may be formed of Kapton polyimide, cirlex, FR4, etc.

The plurality of openings **33** defined through the carrier **31** are arranged such that each opening aligns with a corresponding contact element **86** (e.g., ball or sphere of a ball grid array) of the packaged device **80**. As such, for example, the plurality of openings **33** may be arranged and/or distributed in an array along x and y axes orthogonal to the adapter axis **13** to correspond to contact elements **86** distributed in such a manner or the plurality of openings **33** may be arranged and/or distributed along a region distal from the center of the carrier

31 to correspond to contact elements 86 distributed in such a manner at the perimeter of the package device 80. However, any arrangement of contact elements 86 may be accommodated according to the present disclosure with use of an arrangement of the plurality of openings 33 which are aligned therewith.

Further, in one or more embodiments, each opening of the plurality of openings 33 defined through the carrier 31 is sized for contact with a corresponding contact element 86. For example, where the packaged device 80 includes a ball grid array having a plurality of balls or spheres 86 at the lower surface 84 thereof, each of the plurality of openings 33 defined through the carrier 31 may be a cylindrical opening having a diameter sized to receive a ball/sphere of the packaged device 80. For example, the diameter of such openings 33 may be in the range of about 0.006 inches to about 0.045 inches depending on the pitch of the openings (i.e., the distance between adjacent openings). In other words, at least in one embodiment, the conductive elastomer 35 is a flexible cylindrical suspended pad within the opening 33.

Within each of the plurality of openings 33, conductive elastomer 35 is suspended therein. For example, in one or more embodiments, the conductive elastomer 35 is suspended such that the first and second sides 131, 133 are free of any conductive elastomer. In other words, the conductive elastomer 35 is attached (e.g., by thermal bonding, UV curing, atmospheric curing, etc.) to the inner walls 36 defining the openings 33 as shown, for example, in FIG. 3D. For example, such conductive elastomer 35 may be described as being suspended in an array of holes or openings provided in a matrix form.

The conductive elastomer 35 may be any suitable conductive elastomer material including, for example, any conductive polymer, any conductive flowable material having a plurality of conductive particles distributed therein, silver particle conductive epoxy, gold particle conductive epoxy, etc. In at least one embodiment, the conductive elastomer material may include a flexible epoxy having a plurality of conductive particles distributed therein (e.g., silver particles or balls, gold particles or balls, etc.; having a particle size in the range of about 3 microns to about 10 microns), electrically conductive RTV silicone, or any like conductive epoxy having a certain degree of flexibility (e.g., to provide certain degree of movement from its normal state when suspended in the opening).

Further, in one or more embodiments, the conductive elastomer 35 suspended in each of the plurality of openings 33 may include a curable conductive elastomer material. For example, the elastomer material may be flowable such that it can be provided within each of the plurality of openings 33 and then cured therein (e.g., such as by thermal, chemical, or other curing processes). Such curing may result in the suspended conductive elastomer 35 having a concave surface at the second side 133 of the carrier 31 (e.g., which may more effectively receive a sphere/ball of a ball grid array).

At least in one embodiment, conductive elastomer 35 suspended in each of the plurality of openings 33 is a flexible conductive material such that the suspended conductive elastomer 35 in each of the plurality of openings 33 is flexed towards the first side 131 of the carrier 31 when a force is applied to the packaged device 80 (e.g., such as with use of floating member 40). In other words, at least in one embodiment, when the contact element 86 (e.g., a ball/sphere) is in contact with the suspended conductive elastomer 35 as shown in FIG. 2E and the force is applied to the packaged device 80, a compression force is also applied to the suspended conductive elastomer 35 resulting in the flexing of the suspended conductive elastomer 35 beyond the first side 131 of the carrier 31 and providing effective contact for the contact element 86 through the conductive elastomer 35 to the contact pad 92 of the target board 90 (e.g., moved from its normal state to a flexed state due to the compression force being applied, and then returning to its normal state when the compression force is removed). In such a case when compression is applied (e.g., in its flexed state), for example, the suspended conductive elastomer 35 may take the form of a concave shape at the second side 133 of the carrier 31 and a convex shape at the first side 131 of the carrier 31. By providing a highly resilient elastomer, thousands of compression cycles can be accommodated.

Further, as shown in FIGS. 1-2, the adapter assembly 10 may further include additional guiding and/or alignment apparatus such as a ball guide 50 adjacent conductive elastomer interconnect 30 (e.g., along axis 13) and upon which the packaged device 80 may be received within socket cavity 15. In at least one embodiment, the ball guide 50 may include a plurality of openings 51 defined from the first side 151 thereof adjacent carrier 31 to a second side 153 adjacent a received package device 80. The ball guide 50, at least in one embodiment, may include parallel first and second sides and have a thickness in the range of about 0.002 inches to about 0.007 inches. Further, the ball guide 50 may be formed of one or more layers of any suitable material (e.g., non-conductive material). For example, the ball guide may be formed of one or more polymers or any other electrically non-conductive material or insulative material. Further, for example, the ball guide may be formed of Kapton polyimide, FR4, etc.

Providing such a ball guide 50 may prevent too large of a compression force being applied to the suspended conductive elastomer 35 in the openings 33 of the carrier 31. For example, as shown in FIG. 2E, the thickness of the ball guide 50 may be such (e.g., depending on the size of the ball/sphere 86) that, when the first side 151 of the ball guide 50 contacts the second side 133 of the carrier 31 and the second side 153 of the ball guide 50 contacts the lower surface 84 of the packaged device 80, over compression on the suspended conductive elastomer 35 in the opening 33 is prevented.

The plurality of openings 51 defined through the ball guide 50 are arranged such that each opening aligns with a corresponding contact element 86 (e.g., ball or sphere of a ball grid array) of the packaged device 80. As such, for example, the plurality of openings 51 may be arranged and/or distributed in an array along x and y axes orthogonal to the adapter axis 13 to correspond to contact elements 86 distributed in such a manner or the plurality of openings 51 may be arranged and/or distributed along a region distal from the center of the ball guide to correspond to contact elements 86 distributed in such a manner at the perimeter of the package device 80. However, any arrangement of contact elements 86 may be accommodated according to the present disclosure with use of an arrangement of the plurality of openings 51 which are aligned therewith.

In at least one embodiment, the ball guide 50 may take form of the carrier 31 without the conductive elastomer suspended in the openings thereof. Further, for example, in one or more embodiments, each opening of the plurality of openings 51 defined through the ball guide 50 may be sized for allowing a corresponding contact element 86 to pass therethrough and contact the suspended conductive elastomer 35 in the opening 33 of the carrier 31. For example, where the packaged device 80 includes a ball grid array having a plurality of balls or spheres 86 at the lower surface 84 thereof, each of the plurality of openings 51 defined through the ball guide 50 may be a cylindrical opening having a diameter sized to allow a ball/

sphere of the packaged device **80** to pass therethrough. For example, the diameter of such openings **51** may be in the range of about 0.005 inches to about 0.045 inches.

As described herein, the conductive elastomer interconnect **30** for the adapter assembly **10**, at least in one embodiment, may be positioned at the first end region **14** of the adapter assembly **10** orthogonal to the adapter axis **13** to define the socket cavity **15** with the one or more wall numbers **12**. The conductive elastomer interconnect **30** may be formed in any suitable manner before being assembled to form the socket cavity **15**. In one embodiment, as shown in FIG. **4**, the conductive elastomer interconnect **30** may be formed by positioning the first side **131** of carrier **31** adjacent a formation surface **197** of a fill plate **138**. For example, one or more alignment pins **182** may be used to position multiple carriers **31** on the formation surface **197**. At least in one embodiment, the formation surface **197** is a planar surface which closes the plurality of openings **33** defined through the carrier **31**. A flowable conductive elastomer is then provided within the plurality of openings **33** defined through the carrier **31**. The conductive elastomer within the plurality of openings **33** may then be cured (e.g., by thermal curing, UV curing, atmospheric curing, etc.) to provide the suspended conductive elastomer **35** in each of the plurality of openings **33**. In such a manner, for example, the conductive elastomer **35** fills the defined opening **33** with the conductive elastomer **35** having a surface that is flush with the first side **131** of the carrier **31** as shown in FIG. **3**D.

At least in one embodiment, silver particles are dispersed in silicone paste to provide the conductive elastomer (e.g., a two part composition including a base material and a catalyst). When the material is to be provided into the openings **33** in the carrier **31**, the base material and catalyst are added together and mixed (e.g., with centrifugal movement) to make a consistent paste. The paste may then be provided onto the carrier **31** (e.g., screened onto the carrier **31**). For example, a flexible member (e.g., a rubber member or squeegee) may be used to force the paste into the openings **33** such that they are filled equally. The flexible member may be moved left to right and top to bottom several times to provide the fill in the openings **33** and to remove any excess paste. The carrier **31** may then be cured (e.g., thermally cured in an oven, for example, at 150 degrees C. for 30 minutes; or at room temperature, for example, for one day).

FIGS. **5**A-**5**B show an alternate process of forming a conductive elastomer interconnect **230** including conductive elastomer **235** suspended in a plurality of openings **240** of a carrier **231**. For example, a first side **232** of carrier **231** is positioned adjacent a fill plate **238**. However, unlike the fill plate **138** shown in FIG. **4**, fill plate **238** includes at least one surface deformation **239** defined in formation surface **297** (e.g., using a mask and etch process, or in any other manner, physical or chemical) corresponding to each of the plurality of openings **240** defined through the carrier **231**. When flowable elastomer material fills the opening **240**, the deformation **239** is also filled. When cured, the elastomer material in the at least one surface deformation **239** forms a contact projection **250** of conductive elastomer extending beyond the first side **232** of the carrier **231**. The contact projection **250** may provide more effective electrical contact between the conductive elastomer **235** and a contact pad of the plurality of contact pads **92** of the target board **90** when the target board **90** is positioned adjacent to the first side **232** of the carrier **231**. In other words, the formation surface **297** is a nonplanar formation surface configured to provide contact projections **250**.

One will recognize that various processing steps may be used in the formation of the conductive elastomer interconnects described herein. For example, overfilling holes may be permitted with subsequent planarization or other processes to remove undesirable material, varies masking and etching processes may be used to form openings and or deformations in surfaces, openings may be formed by mechanical drilling or laser drilling, etc.

All patents, patent documents, and references cited herein are incorporated in their entirety as if each were incorporated separately. This disclosure has been described with reference to illustrative embodiments and is not meant to be construed in a limiting sense. As described previously, one skilled in the art will recognize that various other illustrative adapter assembly embodiments may be provided which utilize various combinations of the elements described herein. Various modifications of the illustrative embodiments, as well as additional embodiments of the disclosure and combinations of various elements herein, will be apparent to persons skilled in the art upon reference to this description. It is therefore contemplated that the patented claims will cover any such modifications or embodiments that may fall within the scope of the present disclosure as defined by the accompanying claims.

What is claimed is:

1. An adapter apparatus for receiving a packaged device having a plurality of contact elements disposed on a surface thereof, the adapter apparatus comprising:

a conductive elastomer interconnect comprising:

a carrier comprising a plurality of openings defined therethrough from a first side to a second side thereof by inner walls, wherein the plurality of openings are arranged to align with the plurality of contact elements of the packaged device, and

conductive elastomer suspended in each of the plurality of openings by attachment to the inner walls to contact a contact element of a plurality of contact elements of a packaged device when positioned adjacent the second side of the carrier; and

one or more adapter wall members along an adapter axis between a first end region of the adapter apparatus and a second end region of the adapter apparatus, wherein the conductive elastomer interconnect is positioned at the first end region of the adapter apparatus orthogonal to the adapter axis, and further wherein the one or more adapter wall members and the conductive elastomer interconnect define a socket cavity adapted to receive the packaged device with the plurality of contact elements thereof adjacent the conductive elastomer suspended in each of the plurality of openings.

2. The adapter apparatus of claim **1**, wherein the first and second sides of the carrier are free of conductive elastomer.

3. The adapter apparatus of claim **1**, wherein the packaged device comprises a ball grid array comprising a plurality of balls, and further wherein each opening of the plurality of openings defined through the carrier is a cylindrical opening having a diameter sized to receive a ball of the plurality of balls of the ball grid array.

4. The adapter apparatus of claim **1**, wherein the conductive elastomer suspended in each of the plurality of openings comprises a curable conductive elastomer material, wherein the curable conductive elastomer material comprises a plurality of conductive particles.

5. The adapter apparatus of claim **1**, wherein the conductive elastomer suspended in each of the plurality of openings comprises a concave surface at the second side of the carrier for electrical contact with the contact elements of the packaged device.

6. The adapter apparatus of claim 1, wherein the conductive elastomer suspended in each of the plurality of openings comprises a contact projection extending beyond the first side of the carrier for electrical contact with a contact pad of a plurality of contact pads of a target board when the target board is positioned adjacent the first side of the carrier.

7. The adapter apparatus of claim 1, wherein the one or more wall members comprise alignment structure positioned at the first end region to align the packaged device within the socket cavity, wherein the alignment structure comprises at least an alignment plate positioned orthogonal to the adapter axis, wherein the alignment plate comprises a plurality of openings arranged to align with the plurality of contact elements of the packaged device and adapted to allow contact elements of the packaged device to be in electrical contact with the conductive elastomer suspended in each of the plurality of openings defined in the carrier layer.

8. The adapter apparatus of claim 1, wherein adapter apparatus further comprises an actuator apparatus comprising a floating member movable in the socket cavity and an actuator element, wherein the actuator element is operable to provide a force on the floating member resulting in a corresponding force being distributed to the packaged device when received in the socket cavity such that the plurality of contact elements are in electrical contact with the suspended conductive elastomer in each of the plurality of openings defined in the carrier, wherein the suspended conductive elastomer in each of the plurality of openings defined in the carrier is flexed towards the first side of the carrier when the force is applied.

9. An apparatus for use in an adapter configured to receive a packaged device having a plurality of contact elements disposed on a surface thereof, the apparatus comprising a conductive elastomer interconnect comprising:

a carrier comprising a plurality of openings defined therethrough from a first side to a second side thereof by inner walls, wherein the plurality of openings are arranged to align with the plurality of contact elements of the packaged device; and

conductive elastomer suspended in each of the plurality of openings by attachment to the inner walls to contact a contact element of a plurality of contact elements of a packaged device when positioned adjacent the second side of the carrier.

10. The apparatus of claim 9, wherein the first and second sides of the carrier are free of conductive elastomer.

11. An apparatus for use in an adapter configured to receive a packaged device having a plurality of contact elements disposed on a surface thereof, the apparatus comprising a conductive elastomer interconnect comprising:

a carrier comprising a plurality of openings defined therethrough from a first side to a second side thereof, wherein the plurality of openings are arranged to align with the plurality of contact elements of the packaged device; and

conductive elastomer suspended in each of the plurality of openings to contact a contact element of a plurality of contact elements of a packaged device when positioned adjacent the second side of the carrier, wherein the packaged device comprises a ball grid array comprising a plurality of balls, and further wherein each opening of the plurality of openings defined through the carrier is a cylindrical opening having a diameter sized to receive a ball of the plurality of balls of the ball grid array.

12. The apparatus of claim 9, wherein the conductive elastomer suspended in each of the plurality of openings comprises a curable conductive elastomer material, wherein the curable conductive elastomer material comprises a plurality of conductive particles.

13. The apparatus of claim 9, wherein the conductive elastomer suspended in each of the plurality of openings comprises a concave surface at the second side of the carrier for electrical contact with the contact elements of the packaged device.

14. An apparatus for use in an adapter configured to receive a packaged device having a plurality of contact elements disposed on a surface thereof, the apparatus comprising a conductive elastomer interconnect comprising:

a carrier comprising a plurality of openings defined therethrough from a first side to a second side thereof, wherein the plurality of openings are arranged to align with the plurality of contact elements of the packaged device; and

conductive elastomer suspended in each of the plurality of openings to contact a contact element of a plurality of contact elements of a packaged device when positioned adjacent the second side of the carrier, wherein the conductive elastomer suspended in each of the plurality of openings comprises a contact projection extending beyond the first side of the carrier for electrical contact with a contact pad of a plurality of contact pads of a target board when the target board is positioned adjacent the first side of the carrier.

15. An apparatus for use in an adapter configured to receive a packaged device having a plurality of contact elements disposed on a surface thereof, the apparatus comprising a conductive elastomer interconnect comprising:

a carrier comprising a plurality of openings defined therethrough from a first side to a second side thereof, wherein the plurality of openings are arranged to align with the plurality of contact elements of the packaged device; and

conductive elastomer suspended in each of the plurality of openings to contact a contact element of a plurality of contact elements of a packaged device when positioned adjacent the second side of the carrier, wherein the suspended conductive elastomer in each of the plurality of openings defined in the carrier is flexed towards the first side of the carrier when a force is applied via a packaged device positioned adjacent the second side of the carrier.

16. A method of providing an adapter apparatus adapted to receive a packaged device having a plurality of contact elements disposed on a surface thereof, the adapter apparatus mountable to a target board to electrically connect the plurality of contact elements to a plurality of contact pads of the target board, wherein the method comprises:

providing a conductive elastomer interconnect, the conductive elastomer interconnect comprising:

a carrier comprising a plurality of openings defined therethrough from a first side to a second side thereof by inner walls, wherein the plurality of openings are arranged to align with the plurality of contact elements of the packaged device, and

conductive elastomer suspended in each of the plurality of openings by attachment to the inner walls to contact a contact element of a plurality of contact elements of a packaged device when positioned adjacent the second side of the carrier; and

providing one or more adapter wall members along an adapter axis between a first end region and a second end region of the adapter apparatus; and

positioning the conductive elastomer interconnect at the first end region of the adapter apparatus orthogonal to

the adapter axis to define a socket cavity of the adapter apparatus adapted to receive a packaged device such that the plurality of contact elements of the packaged device are adjacent the conductive elastomer suspended in each of the plurality of openings.

17. The method of claim **16**, wherein providing a conductive elastomer interconnect comprises:

positioning the first side of the carrier adjacent a formation surface to close the plurality of openings defined through the carrier; and

providing conductive elastomer at least within the plurality of openings defined through the carrier; and

curing the conductive elastomer within the plurality of openings to provide the suspended conductive elastomer in each of the plurality of openings.

18. The method of claim **17**, wherein the formation surface is planar.

19. The method of claim **17**, wherein the formation surface comprises a least one surface deformation defined therein corresponding to each of the plurality of openings defined through the carrier, wherein the at least one surface deformation forms a contact projection of the suspended conductive elastomer extending beyond the first side of the carrier for electrical contact with a contact pad of a plurality of contact pads of a target board when the target board is positioned adjacent the first side of the carrier.

20. The method of claim **16**, wherein the method further comprises:

providing an actuator apparatus comprising a floating member movable in the socket cavity and an actuator element, wherein the actuator element is operable to provide a force on the floating member such that a corresponding force is distributed to a packaged device when received in the socket cavity; and

providing electrical contact between the plurality of contact elements of the packaged device and the suspended conductive elastomer in each of the plurality of openings defined in the carrier via the force provided on the floating member, wherein the suspended conductive elastomer in each of the plurality of openings defined in the carrier is flexed towards the first side of the carrier when the force is applied.

* * * * *