(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 March 2008 (27.03.2008)

PCT

(10) International Publication Number
WO 2008/034233 A1

(51) International Patent Classification:
B81B 7/02 (2006.01) *B81C 5/00* (2006.01)

(21) International Application Number:
PCT/CA2007/001660

(22) International Filing Date:
18 September 2007 (18.09.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
11/532,676 18 September 2006 (18.09.2006) US

(71) Applicant *(for all designated States except US)*: **SIMPLER NETWORKS, INC.** [CA/CA]; 1840 Transcanada, Suite 100, Dorval, Québec H9P 1H7 (CA).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **LU, Jun** [CA/CA]; 694 Avenue Allison, Lasalle, Québec H8P 2C7 (CA). **MÉNARD, Stéphane** [CA/CA]; 119 Chateau Kirkland, Kirkland, Québec H9J 3Z9 (CA).

(74) Agent: **OGILVY RENAULT LLP/S.E.N.C.R.L., S.R.L.**; Suite 1600, 1981 McGill College Avenue, Montreal, Québec H3A 2Y3 (CA).

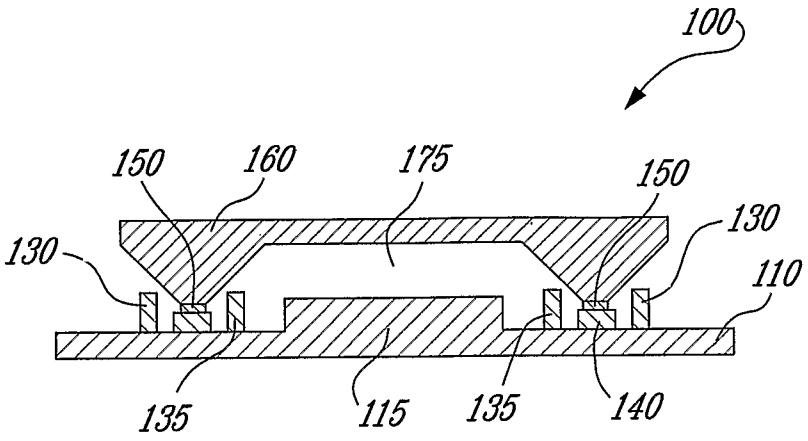
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:
— *with international search report*

(54) **Title:** INTEGRATED MEMS PACKAGING



(57) **Abstract:** The microelectromechanical system (MEMS) package includes a substrate onto which is disposed or otherwise formed an active MEMS device, a cap for hermetically sealing the MEMS package and a pair of barrier walls for preventing bonding material for the cap from contaminating unintended areas of the substrate.

WO 2008/034233 A1

INTEGRATED MEMS PACKAGING

The field of invention relates to integrated circuit packaging and in particular to an integrated package for chip level MEMS devices.

With microelectromechanical systems (MEMS), the packaging is an important aspect as oftentimes it must provide for the isolation of a functional element, such as a circuit or actuator, from the surrounding environment. More particularly, because MEMS devices tend to have moving parts, they cannot be packaged in the same manner used for purely electronic components. Instead, a hermetically sealed enclosure or cavity is oftentimes needed around the MEMS devices.

One challenge in creating MEMS packages therefore, is to create a hermetically sealed cavity and provide one or more external electrical connections thereto while, at the same time, not damaging the microelectromechanical structures it contains. The improvements presented herein address this challenge.

In one aspect, there is provided a microelectromechanical system (MEMS) package comprising: a substrate provided with a MEMS device thereon; a first barrier wall disposed upon the substrate and surrounding the MEMS device; a second barrier wall disposed upon the substrate and surrounding the first barrier wall, the first and the second barrier wall being spaced apart from each other; and a cap disposed over the substrate, the cap having an underside sealingly attached to the substrate between the first and the second barrier wall.

In another aspect, there is provided a microelectromechanical system (MEMS) package having a MEMS device provided on a substrate, the package comprising: means for hermetically covering the MEMS device; and means for preventing bonding material leakage during assembly of the means for hermetically covering the MEMS device.

In another aspect, there is provided a method of attaching a cap over a microelectromechanical system (MEMS) device provided on a substrate, the method comprising: providing a bonding material on an underside of the cap; bringing the underside of the cap and the substrate together so as to cover the MEMS device; and

preventing the bonding material from flowing to unintended areas before the bonding material solidifies.

In the appended figures:

FIG. 1 is an isometric view of an example of an improved MEMS package before assembly of the cap;

FIG. 2 is an exploded isometric view of the MEMS package of FIG. 1;

FIG. 3 is an exploded cross-sectional side view of the MEMS package of FIG. 1 ;

FIG. 4 is a cross-sectional side view of the improved MEMS package of FIG. 1 during the assembly of the cap;

FIG. 5 is a view similar to FIG. 4, showing the improved MEMS package of FIG. 1 after the assembly of the cap;

FIG. 6 is an isometric view of the MEMS package of FIG. 1 after the assembly of the cap;

FIG. 7 is a cross-sectional side view of another example of an improved MEMS package before assembly of the cap; and

FIG. 8 is a view similar to FIG. 7, showing the improved MEMS package of FIG. 7 after the assembly of the cap.

FIG. 1 is an isometric view of an example of an improved MEMS package 100 before the assembly of the cap 160. FIG. 2 is an exploded isometric view of that same package 100. With simultaneous reference to FIGS. 1 and 2, there is shown a MEMS device 115 provided on a substrate 110, namely disposed upon an upper surface of, or alternatively formed as part of the substrate 110. MEMS device 115 can include one or more switches. An outer barrier wall 130 and an inner barrier wall 135 are concentrically disposed upon the upper surface of the substrate 110. The inner barrier wall 135 completely surrounds the perimeter of the MEMS device 115. Similarly, the outer barrier wall 130 completely surrounds the perimeter of the inner barrier wall

135. The walls 130, 135 are spaced apart from each other. The relative position of the two barrier walls 130, 135 define a "gap" or "moat" 132 between them.

Disposed within the moat 132 of the illustrated example is a bonding block 140 to which the underside of a package cap 160 will be bonded through the effect of bonding material 150 that can be initially provided on the underside of the cap 160. A perimeter seal will then be created as the cap 160 is bonded by the bonding material 150 to the bonding block 140, thus to the substrate 110 to which the bonding block 150 is attached. The bonding block 140 and the bonding material 150 are more clearly visible in FIG. 3, which figure is a cross-sectional view of what is shown in FIG. 2. The bonding material 150 is designed to seal the interior of the package 100 permanently. The bonding material 150 can be an eutectic.

The two barrier walls 130, 135 serve to contain the bonding material 150 within the moat 132 as the cap 160 is pressed into place. As can be appreciated, placing the cap 160 onto the bonding block 140 acts to squeeze or compress some of the bonding material 150 while in a molten state, for instance after being heated. Absent one or both of the barrier walls 130, 135 the bonding material so squeezed would tend to run or otherwise possibly foul the surface of the substrate 110 or other unintended areas, such as the MEMS device 115 itself. The bonding block 140 is provided all around the inner barrier wall 135 but has a width that is smaller than the distance between the two barrier walls 130, 135. Excess of bonding material can fall on each side of the bonding block 150 and eventually solidifies with the rest of the bonding material 140.

FIGS. 5 and 6 show how the underside of the cap 160 fits together with the structures disposed upon the substrate 110 once the bonding material solidifies. More particularly, it may be observed that the cap 160 engages the moat region 132 until the bonding material 150 and the bonding block 140 are fully engaged and therefore sealed. A space or cavity 175 is created in an area proximate to the MEMS device 115 when the cap 160 is bonded to the substrate 110.

In the illustrated example, the underside of the cap 160 includes a bottom triangularly-shaped rim portion with a tip that ii is substantially flat.

If desired, particular gas(ses) can be hermetically sealed within the MEMS cavity along with the MEMS device 115. More particularly, a non-flammable gas such as

nitrogen or carbon dioxide may be employed. An electronegative gas can be permanently sealed within the MEMS cavity 175 to improve its withstand voltage of the MEMS device 115.

In particular, a strongly electronegative gas such as sulfur hexafluoride (SF6) in a range of concentrations and pressure(s) is a particularly useful gas for the MEMS cavity. Pressures as low as 0.1 atmosphere up to and including many atmospheres are well within the operating range. In addition, concentrations as low as 1 PPM may show marked improvement in terms of the maximum voltage that it can be withstand over devices which do not include such an electronegative gas.

FIGS. 7 and 8 show an alternative example of the MEMS package 100. The cap 160 of this package 100 has a flat underside outer section 161. As shown, the barrier walls 130, 135 can serve as additional mechanical stops to the engagement of the cap 160 within the moat 132. As a result, when the cap 160 is placed upon the barrier walls 130, 135, it can be mechanically stopped from further downward movement while still permitting the bonding material 150 to provide an effective seal along the bottom surface of the cap 160 and the length of the bonding block 140.

At this point, those skilled in the art will recognize that the teachings of the present document are not limited to the illustrated examples. Accordingly, the improvements cover all of what is claimed in the claims attached hereto. For instance, the depth and width of the gap or moat is variable, depending upon the particular application. Furthermore, while the gap is shown having a symmetrical shape, it could nevertheless have a variable width as one traverses its perimeter. Those skilled in the art will quickly appreciate that the particular shapes and relative sizes of the components are matters of design choice, and wide variations are possible. In particular, it has been shown that the cap can engage the moat region upon placement. Such arrangement is not necessarily always required. Also, while sulfur hexafluoride is particularly of interest, it is to be understood that other electronegative gases or other halogen containing gases may be used in combination with other gases such as FREONS, Carbon Tetrachloride (CCl_4), HALONS (chloro-fluorohydrocarbons), dicarbon hexafluoride or combination thereof. Other gases are possible as well. The package is not limited to hold a single MEMS device. It can actually be a plurality of MEMS devices on a same substrate and covered by a simple cap. It is also possible to have a plurality of cavities on a same substrate, all covered by a plurality of caps or

even a single cap with a correspondingly-shaped bottom. The spatial references such as "upper", "bottom" and "underside" are purely for simplifying the text of the present document and is not limitative since the MEMS package can be assembled and used in alternative orientations. The bonding block can be omitted in some designs and if desired, be replaced by holes or other receptacles in the substrate for collecting the excess of bonding material. The design may otherwise allow the excess of bonding material to stay within the barrier walls. It is also possible to integrate the barrier walls, or only one of them and also possibly the bonding block, if any, on the substrate. More than two barrier walls can be used if desired. The bonding material can be initially provided on the substrate or the bonding block. It can be two separate products, for instance one provided on the cap and the other on the substrate, reacting with one another and solidifying after a given time. Other alternatives are possible as well, including melting a portion of the cap itself, through heating or a chemical reaction, before bonding the cap without another bonding material.

CLAIMS:

1. A microelectromechanical system (MEMS) package comprising:
   a substrate provided with a MEMS device thereon;
   a first barrier wall disposed upon the substrate and surrounding the MEMS device;
   a second barrier wall disposed upon the substrate and surrounding the first barrier wall, the first and the second barrier wall being spaced apart from each other; and
   a cap disposed over the substrate, the cap having an underside sealingly attached to the substrate between the first and the second barrier wall.

2. The MEMS package of claim 1 wherein the cap is attached to the substrate through a bonding material.

3. The MEMS package of claim 2 wherein the bonding material is an eutectic.

4. The MEMS package of claim 2 or 3 wherein further comprising a bonding block disposed between the substrate and the bonding material.

5. The MEMS package of claim 4 wherein the bonding block has a width being less than a distance between the first barrier wall and the second barrier wall.

6. The MEMS package of any one of claims 1 to 5 wherein a cavity defined between the cap and the substrate is hermetically sealed from outside the MEMS package.

7. The MEMS package of claim 6, further comprising an electronegative gas provided between the cap and the substrate.

8. The MEMS package of claim 7, wherein the electronegative gas includes a gas chosen from the group consisting of nitrogen, carbon dioxide, halogenated hydrocarbons, sulfur hexafluoride, FREONS, Carbon Tetrachloride, HALONS, dicarbon hexafluoride and combinations thereof.

9. The MEMS package of claim 7, wherein the sealed cavity contains from 1 to 100 % by volume sulfur hexafluoride.

10. The MEMS package of claim 7, 8 or 9, wherein the sealed cavity is pressurized to a pressure of 0.1 to 10.0 Atmospheres.

11. The MEMS package of any one of claims 1 to 10 wherein the MEMS device includes a switch.

12. A microelectromechanical system (MEMS) package having a MEMS device provided on a substrate, the package comprising:

means for hermetically covering the MEMS device; and

means for preventing bonding material leakage during assembly of the means for hermetically covering the MEMS device.

13. The MEMS package according to claim 12 further comprising:

a quantity of an electronegative gas contained within a hermetically covered region adjacent to the MEMS device.

14. The MEMS package according to claim 13 wherein the gas is chosen from the group consisting of nitrogen, carbon dioxide, halogenated hydrocarbons, sulfur hexafluoride, FREONS, Carbon Tetrachloride, HALONS, dicarbon hexafluoride and combinations thereof.

15. A method of attaching a cap over a microelectromechanical system (MEMS) device provided on a substrate, the method comprising:

providing a bonding material on an underside of the cap;

bringing the underside of the cap and the substrate together so as to cover the MEMS device; and

preventing the bonding material from flowing to unintended areas before the bonding material solidifies.

16. The method of claim 15 wherein the bonding material is an eutectic.

17. The method of claim 15 or 16 wherein a cavity defined between the cap and the substrate is hermetically sealed from outside.

18. The method of claim 17, further comprising the step of providing an electronegative gas between the cap and the substrate.

19. The method of claim 18, wherein the electronegative gas includes a gas chosen from the group consisting of nitrogen, carbon dioxide, halogenated hydrocarbons, sulfur hexafluoride, FREONS, Carbon Tetrachloride, HALONS, dicarbon hexafluoride and combinations thereof.

20. The method of claim 18, wherein the sealed cavity contains from 1 to 100 % by volume sulfur hexafluoride.

21. The method of any one of claims 17 to 20, wherein the sealed cavity is pressurized to a pressure of 0.1 to 10.0 Atmospheres.

22. The method of any one of claims 15 to 21 wherein the MEMS device includes a switch.

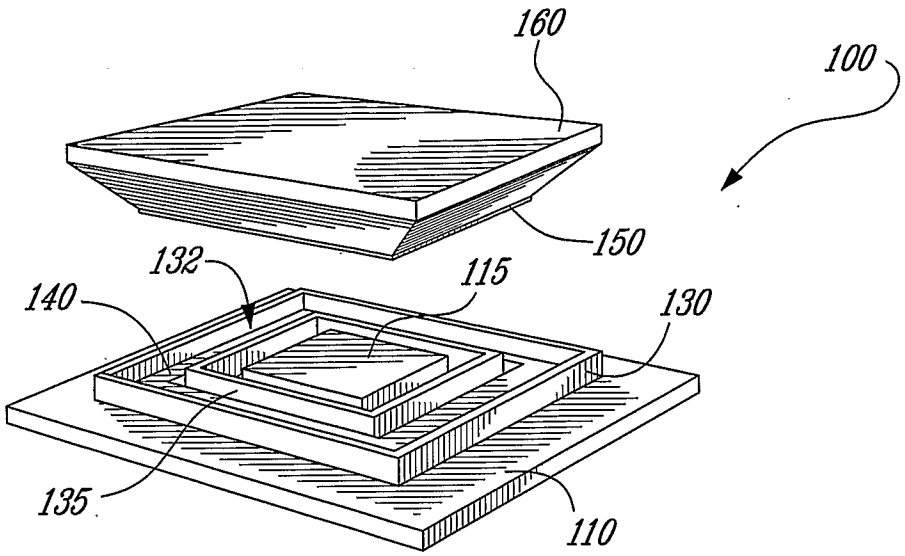

160
100
150
132
115
140
130
135
110

Fig. 1

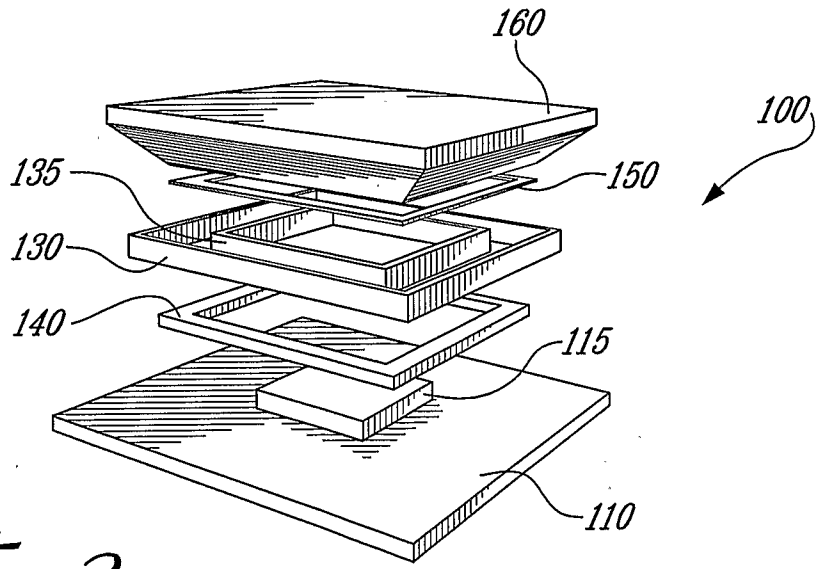

160
100
135
150
130
140
115
110

Fig. 2

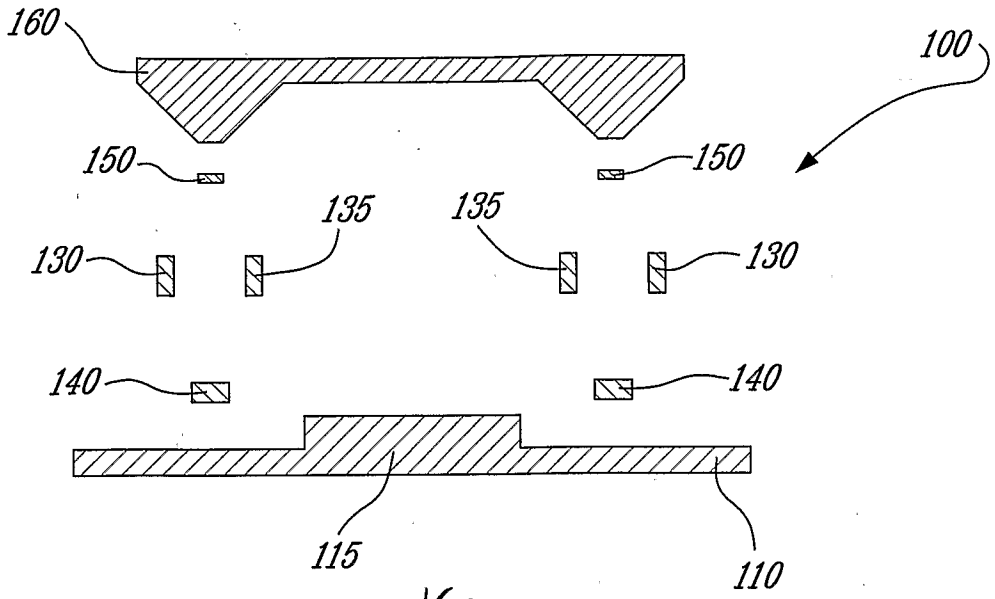

160
100
150
150
135
135
130
130
140
140
115
110

Fig. 3

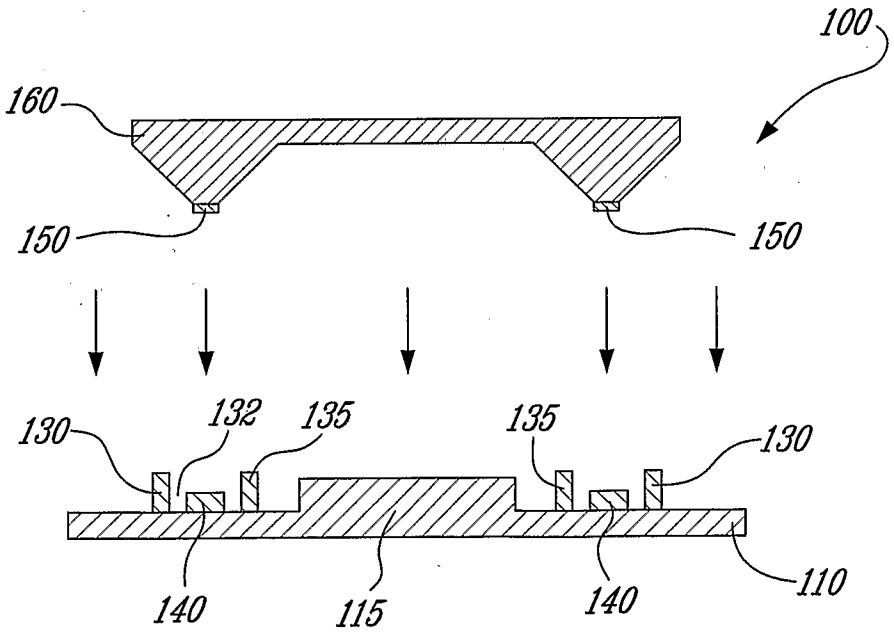

100
160
150
150
130
132
135
135
130
140
115
140
110

Fig. 4

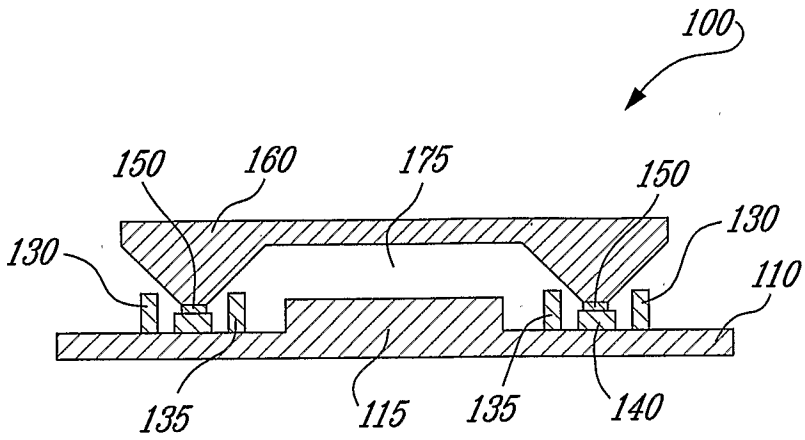


Fig. 5

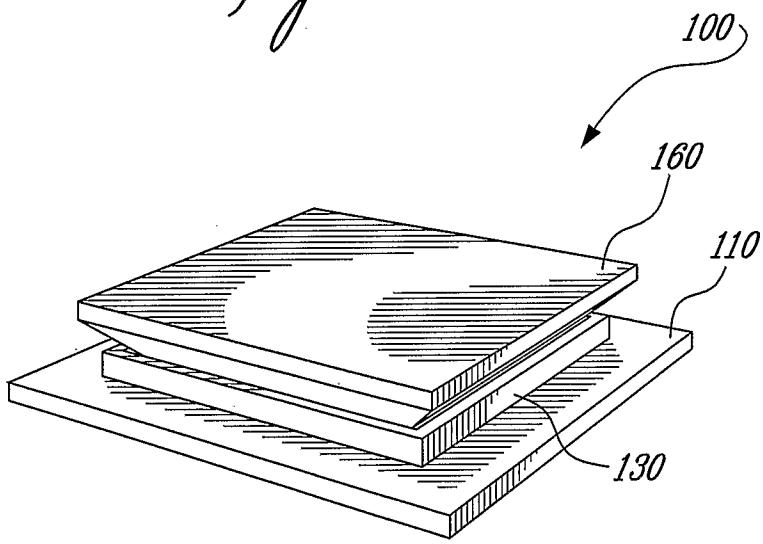


Fig. 6

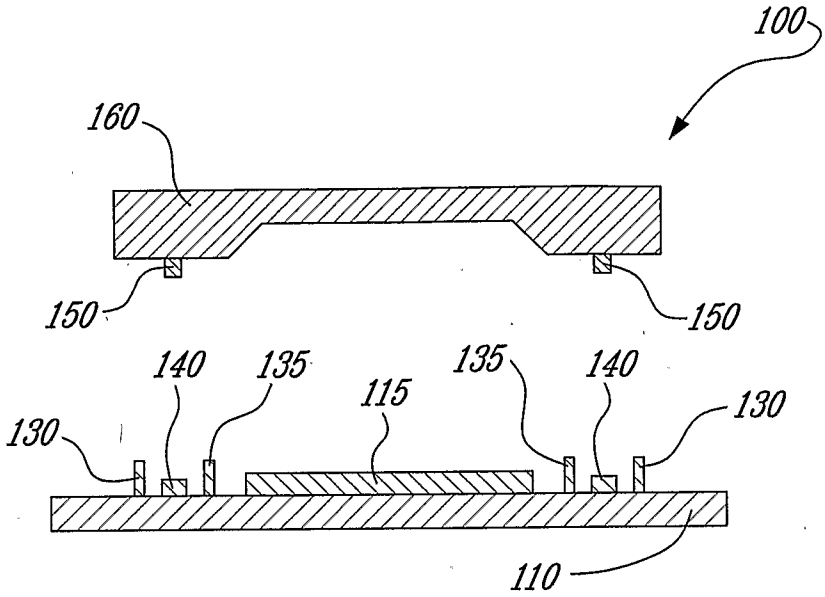

100
160
150
150
140
135
115
135
140
130
130
110

Fig. 7

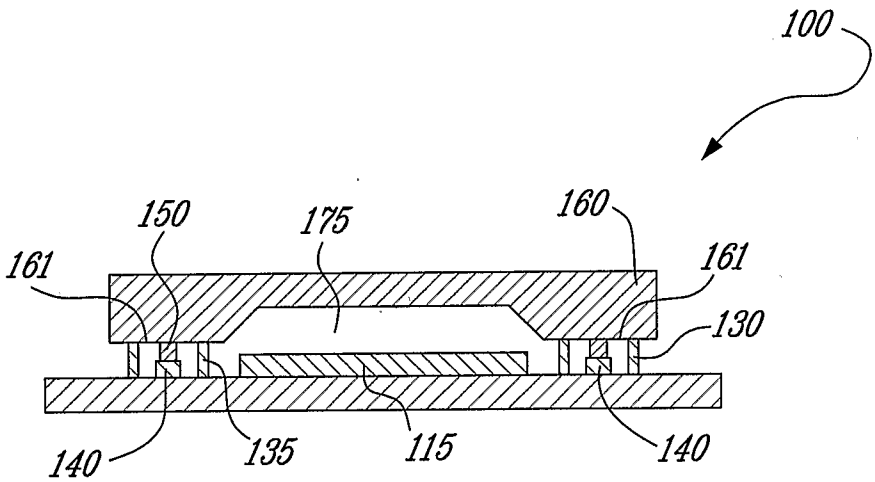

100
150
175
160
161
161
130
140
135
115
140

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2007/001660

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***B81B 7/02*** (2006.01) , ***B81C 5/00*** (2006.01)
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: B81B 7/02, B81C 5/00

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

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Databases: Delphion
Keywords: barrier, wall, walls, mems, cap, package

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US7045868 B2 (16-05-2006) Ding et al. *whole document*	12 15-17, 22
Y	US6893574 B2 (17-05-2005) Felton et al. *whole document*	15-17, 22
A	WO2004/095508 A2 (4-11-2004) Eliacin et al. *whole document*	1-22

[ ] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 December 2007 (12-12-2007)	2 January 2008 (02-01-2008)

Name and mailing address of the ISA/CA	Authorized officer
Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001-819-953-2476	Coralie Gill 819- 934-5143

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2007/001660

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
US7045868	16-05-2006	EP1652215 A2	03-05-2006
		JP2007516092T T	21-06-2007
		US2006105503 A1	18-05-2006
		WO2005017954 A2	24-02-2005
US6893574	17-05-2005	AU2002368046 A1	19-01-2004
		WO2004003965 A2	08-01-2004
WO2004095508	04-11-2004	AU2003304052 A1	19-11-2004
		CN1732590 A	08-02-2006
		EP1576690 A2	21-09-2005
		JP2006511353T T	06-04-2006
		US6859119 B2	22-02-2005