



(51) International Patent Classification:

H01L 21/60 (2006.01) H01L 23/34 (2006.01)
H01L 23/48 (2006.01)

(21) International Application Number:

PCT/US201 1/066046

(22) International Filing Date:

20 December 2011 (20.12.2011)

(25) Filing Language:

English

(26) Publication Language:

English

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, 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, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, 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, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,

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(54) Title: HIGH PERFORMANCE TRANSIENT UNIFORM COOLING SOLUTION FOR THERMAL COMPRESSION BONDING PROCESS

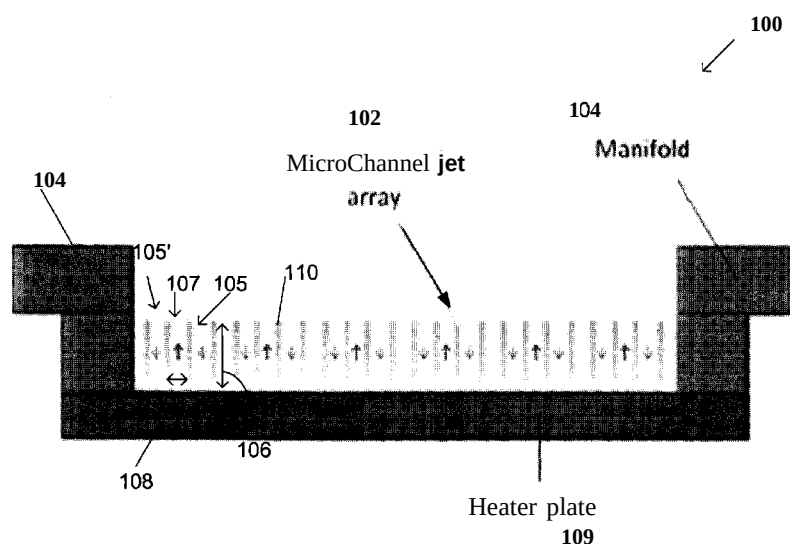


FIG. 1a

(57) Abstract: Various embodiments of thermal compression bonding transient cooling solutions are described. Those embodiments include a an array of vertically separated micro channels coupled to a heater surface, wherein every outlet micro channel comprises two adjacent inlet micro channel, and wherein an inlet and outlet manifold are coupled to the array of micro channels, and wherein the heater surface and the micro channels are coupled within the same block.





LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, **Published:**

SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, — *with international search report (Art. 21(3))*
GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

HIGH PERFORMANCE TRANSIENT UNIFORM COOLING SOLUTION FOR THERMAL COMPRESSION BONDING PROCESS

BACK GROUND OF THE INVENTION

5 Thermal compression bonding is being used in the microelectronic industry for finer control of first level interconnect (FLI) formation. In thermal compression bonding, a microelectronic die is first heated up until the solder is melted and a solder joint is formed. The die is then cooled down until the solder is solidified. The process time is determined by both the heating time and the cooling time. It is critical to cool the solder joint in the FLI region quickly
10 and uniformly to reduce the process time, and to guarantee the quality of the solder joint.

BRIEF DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims particularly pointing out and distinctly claiming certain embodiments of the present invention, the advantages of this invention can be more readily ascertained from the following description of the invention when read in
15 conjunction with the accompanying drawings in which:

FIGS. 1a- 1n represent structures according to various embodiments.

FIGS. 2a-2b represents structures according to the Prior Art.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

In the following detailed description, reference is made to the accompanying drawings that
20 show, by way of illustration, specific embodiments in which the methods may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the embodiments. It is to be understood that the various embodiments, although different, are not necessarily mutually exclusive. For example, a particular feature, structure, or characteristic described herein, in connection with one embodiment, may be implemented within other
25 embodiments without departing from the spirit and scope of the embodiments. In addition, it is to be understood that the location or arrangement of individual elements within each disclosed embodiment may be modified without departing from the spirit and scope of the embodiments. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the embodiments is defined only by the appended claims, appropriately interpreted, along with
30 the full range of equivalents to which the claims are entitled. In the drawings, like numerals refer to the same or similar functionality throughout the several views.

Embodiments of transient cooling block or assembly structures and methods of utilizing such structures are described. Those assemblies and methods may include structures and methods of actively cooling a die during such processes as chip attach, die bonding, and similar die processes wherein a die may be cooled. The embodiments herein enable direct air
5 impingement cooling which in turn enables high cooling rate of die and high heat transfer coefficient, for example, by utilizing micro jets/micro-channel structures during Thermal Compression Bonding (TCB) processes, in some embodiments.

FIGS. 2a-2b depict a plain jet cooling design 200 from the Prior Art. In the Prior Art cooling head 200 (FIG. 2a, top view), multiple jets 212 can be used, wherein the flow exits from
10 the side of the cooling head (FIG. 2b). However, the heat transfer coefficient is typically very low in such prior art systems because of the jet 212 interactions.

These jet interactions tend to block the hot air from centrally located jets from exiting to the ambient environment. Consequently, prior art TCB tools utilizing the head design 200 tend to take a long time to cool. This cooling rate requires the bonding process time to be long
15 because the package can only be removed after the solder joint solidifies. Prior art designs such as design 200 may thus introduce a bottleneck for TCB processes that tend towards a higher cooling rate to reduce the time taken to bond each unit.

Figure 1a shows the vertical cross section of an embodiment of a cooling solution, such as a direct air cooling solution 100. The cooling solution 100, which may comprise a portion of a
20 TCB tool heater head design 100 in an embodiment, may comprise inlet/outlet manifolds 104 that may be coupled to a fluid source, a heater plate 109, and a micro channel jet array 102. Fluid that may flow through the array of micro channel jets 102 may impinge on the hot surface of the heater plate 109. In an embodiment, the manifolds 104 may provide passages for air inlet and outlet.

In an embodiment, a fluid, such as one of liquid and a compresses gas (i.e. air, helium, CO₂, etc.) that may be incoming from two incoming micro channel jets 105, 105', may impinge
25 on the hot surface of the heater plate 109, and then may pick up the heat from the heater plate 109. The heat may then be circulated away away/transferred into an adjacent outgoing micro jet channel 107, wherein the heat may later exit into the ambient environment, via the manifolds
30 104, in some cases. The fluid that is in contact with the heater plate 109, may travel only a few hundred microns before exiting into the ambient, since the dimensions of individual incoming micro channel jets 105, 105' and the outgoing micro channel jets 107 of the micro channel jet array 102 are on the order of microns in size, thus keeping the thermal boundary layer very thin.

The heater surface is covered by small jets with the same high heat transfer coefficient. Therefore, the heater, the die and the solder joint in the first level interconnect region can be cooled uniformly and quickly. The transient process time can thus be significantly reduced.

In an embodiment, individual micro channel jets 105, 105', 107 may comprise a height 106 of about 200 microns or less, and a width 108 of about 10 microns or less although the height 106 and the width 108 may vary according to the particular application. In another embodiment, the width 108 may comprise about 20 microns or less. The height 106 and the width 108 may vary in a large range of size from a few microns to millimeters. In an embodiment, air may enter from the ambient environment from an intake slot and then enters individual inlet jetting holes 105 (FIG. 1j). In some embodiments, because each row of inlet jets may have an adjacent row of outlet jets 107, the air/fluid may then exit from the side of the cooling structure. Flow interactions are therefore minimized. The jetting holes size can range from several microns to several millimeters. The gap height between the bottom of the cooling block to the hot surface is less than the size of the jet diameter, in an embodiment. In an embodiment, the number of micron sized micro channel jets in the array 102 (referring back to FIG. 1a) may be numerous, and may comprise hundreds to thousands of channel jets and may be arranged in a vertical orientation across the heater plate 109. Individual micro jets may comprise a wall 110 that may serve to separate the micro jets of the array 120 from each other. In an embodiment, a distance between individual vertically separated micro channels of the array 102 may comprise about 20 to about 200 microns.

The multiple-jet impingement system of the cooling solution 100 removes the downside of boundary layer build up, thus enhancing the overall heat transfer of the system. In some embodiments, each inlet channel may have its own adjacent outlet channel, however for other embodiments, every two incoming micro jets 105, 105' may have their own outlet micro jet 107 reducing the interaction between the micro channel jets and also providing for a nearly uniform heat transfer coefficient across the entire heater surface 109.

Maintaining such a small thermal boundary in the cooling assembly 100 maximizes the heat transfer coefficient to limits never seen before in prior art conventional air cooling assemblies. The performance of such a direct fluid cooling solution 100 quickly approaches the spreading resistance fundamental limit. In an embodiment, the cooling solution 100 can achieve a high heat transfer coefficient by using compressed air, for example, and may achieve cooling rates as high as 200 degrees Celsius per second. In an embodiment, the high Nusselt number of the cooling solution 100 may be in the laminar flow regime. In prior art TCB processes (which uses prior art cooling solutions), the corresponding heat transfer coefficient using air as a cooling

fluid tends to be about 500W/m²K. In some cases, the cooling solution 100 of the embodiments herein achieve a much shorter cooling time for solder, such as may be used in a microelectronic solder joint, by illustration and not limitation. In some cases, a minimum heat transfer coefficient achieved by the cooling solution 100 is about 3000W/m²K.

5 FIGS. 1b and 1c depict a top view and cross sectional view of a portion of a cooling block 112 comprising micro channel jets, wherein inlet 105 and outlet jets 107 are depicted (please add further detail here if desired). FIG. 1d depicts an embodiment of a portion of the cooling block 112 wherein two inlet micro channel jets 105, 105' may receive fluid, such as air, which may impinge on the heater surface 109 and thus pick up the heat from the heater surface 109. In an
10 embodiment, the air may comprise compressed air from a building facility supply. The fluid, which travels only a tens to hundred of microns, is then circulated away into the adjacent outlet micro channel jet 107 (thus avoiding interaction with surrounding jets) which then exits through the manifold 104 (not shown).

 In an embodiment, the array of micro-channels 102 may be fabricated inside the cooling
15 block 112 (FIG. 1e). Instead of mounting a cooling block on top of a heating block, as in prior art cooling solutions, the cooling block 112 is fabricated in the same material piece 113 in which the heater loops 109 are embedded. In an embodiment, there is a gap 111 disposed between the heater plate 109/cooling block 112 portion 113 and a nozzle 114 disposed beneath the heater/cooling block 113 and beneath the gap 111. In an embodiment, the gap 111, which may
20 comprise an air gap 111 in some cases, may comprise a height of about 100 microns or less.

 FIG. 1f shows a top view of the cooling assembly comprising the heater block/cooling block piece 113 from a top view, wherein the heater loops 109 are disposed within the same piece/block 113, and wherein the inlet 105, 105' and outlet 107 micro channel jets are disposed within the cooling/heater piece 113 as well.

25 In another embodiment, a thermal electric cooling (TEC) element 116 is disposed between the cooling block 112 (including the inlet and outlet jets 105, 105', 107), and the heater 109, wherein the cooling solution further comprises a nozzle 114 disposed underneath the heater 109 (FIG. 1g). A backside of a die 115 (that is in thermal contact with the cooling solution 100) is disposed on a substrate 118, such as a package substrate 118 that is disposed on a pedestal 120,
30 such as a TCB pedestal, for example. In an embodiment, the TEC 116 response time may be in the millisecond range, which enhances the cooling of the die 115 by the cooling solution 100. In an embodiment, the TEC 116 initially cools the die 115 from the bottom of the TEC 116

instantly, and then the TEC 116 removes the heat from the die 115 from the TEC 116 top surface.

FIG 1h depicts a portion of the cooling solution 100, comprising the array of micro channel jets 102 disposed in the cooling block 112, wherein the cooling block 112 and heater 109 are fabricated in the same piece of material 113. In an embodiment, the heater plate 109 further comprises a micro fin 121 design on a top surface of the heater 109. The micro fins 121 can be rectangular, triangular, pins or any other suitable shapes that can maximize the micro fin 121 effectiveness, according to the particular application. In an embodiment, the micro fin 121 tips may be aligned with a center region between adjacent inlet and outlet micro channel jets, such as between the inlet and outlet micro channel jets 105, 107. The micro fins 121 enhance the heat transfer by increasing the heat transfer surface area on the heater side.

In an embodiment, there may be a gap 111 between the cooling block 112 portion and the heater portion 109 of the fabricated piece 113, which may comprise an air gap 111 in some cases. There is a connection/direct coupling between the cooling block 112 and the heater portion 109 on the edges of the fabricated piece 113.

In an embodiment, the time taken for first level interconnect (FLI) structures of the die 116 to cool herein is reduced by about sixty percent when using a TCB tool incorporating the cooling solution 100 of the embodiments, as compared with prior art TCB/cooling solution tools, such as those employing plain jet cooling designs. Additionally, given the same or similar fluid pressures, the cooling solution 100 of the various embodiments exhibit about a 500 percent higher heat transfer coefficient and about a 100% higher flow rate than prior art cooling solutions. Thus, the cooling solution 100 therefore can operate at much lower fluid pressure and therefore reduce tool vibrations caused by cooling, and therefore can increase throughput from the TCB tool for such applications as 3D packages, large die, multi-chip packages incorporating central processing unit (CPU), with other devices..

FIG. 1i depicts a method according to an embodiment. At step 130, a die backside surface may be cooled by coupling the die backside to a cooling solution, wherein the cooling solution comprises: an array of micro channel jets coupled to a heater surface, wherein an outlet micro channel jet is coupled with two adjacent inlet micro channel jets. At step 140, air may be circulated through the array of micro channel jets, wherein the air impinges onto the heater surface that is in thermal contact/is thermally coupled with the die and exits through a manifold coupled to the micro channel jets, wherein the heater surface and the array of micro channel jets are fabricated in the same block material.

In another embodiment, FIG. 1k shows a bottom view of the an embodiment of a cooling solution, such as a direct air cooling solution 150. The cooling solution 150, which may comprise a portion of a TCB tool heater head design 150 in an embodiment, may comprise single rows of inlet micro channel jets 105 and outlet micro channel jets 107 with a staggered arrangement. In some cases, a vertical pitch 152 is twice as large as a horizontal pitch 154, that is, $P_y = 2P_x$. In one embodiment, the inlet and outlet openings may be made as small as possible. In some cases, a 200um jet opening size may be used.

In an embodiment, a bottom portion 160 of the cooling solution 150 may be chamfered (FIG. 11), wherein the chamfered portion may follow flow lines from the inlet/outlet jets 105, 107 and wherein the chamfered portion may serve to reduce pressure drop of the cooling solution 150. In some cases, the spacing between jet inlets and the heater surface can be less than or equal to a diameter of the jet inlet openings. In this case, a gap height 156 may be equal to jetting hole diameter 158 of 200 microns, for example. In an embodiment, the spacing between inlet jets 105 and outlet jets 162 maybe greater than the diameter 158 of the inlet jet. By adding chamfers, the recirculation zone of the cooling solution 150 is significantly reduced. Therefore heat transfer is enhanced.

In another embodiment of a cooling solution 170, double rows of inlet jets 105 may be used (FIG. 1m, bottom view). In another embodiment of a cooling solution 180, the horizontal spacing may be increased between inlet 105 and outlet jets 107, and the unicell arrangements become rectangular (FIG. 1n). Both designs in FIGS 1m-1n may have chamfered bottom portions of the cooling block. Both designs increase horizontal spacing with the same number of jetting holes for ease of manufacturing. Both designs may have rectangular, square, circular or other shapes of jetting holes.

Prior art thermal compression bonding (TCB) tools using active cooling solutions have slower cooling rates. Embodiments herein can achieve heat transfer coefficient much greater and comprise at least three times faster transient cooling rates as compared with prior art cooling solutions, and thus greatly reduce solder joint solidification times.

Although the foregoing description has specified certain steps and materials that may be used in the assemblies of the embodiments herein, those skilled in the art will appreciate that many modifications and substitutions may be made. Accordingly, it is intended that all such modifications, alterations, substitutions and additions be considered to fall within the spirit and scope of the invention as defined by the appended claims. In addition, the Figures provided herein may illustrate only portions of an exemplary microelectronic devices that pertain to the

practice of the various embodiments. Thus the embodiments are not limited to the structures/assemblies described herein.

IN THE CLAIMS

What is claimed is:

- 5 1. A method of uniform transient cooling in a thermal compression bonding process comprising;

cooling the solder joint of a die during thermal compression bonding by a die backside surface by coupling a cooling solution to the die backside surface, wherein the cooling solution comprises:

10 an vertical array of micro channel jets coupled to a heater surface, wherein an outlet micro channel jet is coupled with two adjacent inlet micro channel jets; and

circulating air through the array of micro channel jets , wherein the air impinges onto the heater surface that is coupled to the die and exits through a manifold coupled to the micro channel jets, wherein the heater surface and the array of micro channel jets are fabricated in the

15 same block material.
2. The method of claim 1, further comprising wherein an exit and an inlet manifold is coupled to the array of micro channel jets.
3. The method of claim 2 further comprising wherein a supply of compressed air is coupled to the inlet manifold.
- 20 4. The method of claim 1 further comprising wherein two inlet jets feed air to one outlet jet to transfer heat away from the heater surface to the cooling fluid.
5. The method of claim 1 wherein the cooling solution comprises a portion of a TCB tool, and wherein a heat transfer coefficient of the cooling solution is above about 3000 W/m²K cooling rate of the die.
- 25 6. The method of claim 1 further comprising wherein a TEC is disposed between the heater surface and a cooling block of the cooling solution.
7. The method of claim 1 further comprising wherein the micro channel jets comprise vertical individual inlet and outlet nozzles attached to the heater surface.

8. A method of comprising;

cooling a solder joint of a die by coupling a cooling solution to the die backside surface, wherein the cooling solution comprises:

5 a vertical array of micro channel jets coupled to a heater surface, wherein an outlet micro channel jet is coupled with an adjacent inlet micro channel jet; and

circulating a fluid through the vertical array of micro channel jets, wherein the fluid impinges onto the heater surface that is thermally coupled to the die and exits through a manifold coupled to the vertical array of micro channel jets, wherein the heater surface and the array of micro channel jets are fabricated in the same block material.

10 9. The method of claim 8 further comprising wherein the vertical array of micro channel jets comprise a plurality of vertical individual inlet and outlet nozzles attached to the heat spreader.

10. The method of claim 8 further comprising wherein the heater surface comprises micro fins.

15 11. The method of claim 8 further comprising wherein a TEC pad is disposed between the heater surface and a cooling block of the assembly.

12. The method of claim 10 further comprising wherein a tip of the micro fin is aligned in a center position between adjacent inlet and outlet micro channel jets.

20 13. The method of claim 8 further comprising wherein the micro channels are disposed inside the heater block, and wherein a cooling block of the assembly is fabricated in the same material piece in which the heater loops are embedded.

14. The method of claim 8 further comprising wherein inlet and outlet micro channels are disposed in a staggered configuration, and wherein a bottom portion of the cooling block is chamfered.

25 15. The method of claim 8 further comprising wherein the cooling solution further comprises a nozzle coupled to the heater, and a die coupled to the nozzle, wherein the die is on a substrate disposed on a pedestal.

16. The method of claim 8 further comprising wherein the cooling solution comprises a portion of a TCB bonding system that provides uniform transient cooling in a TCB process.

17. The method of claim 8 further comprising wherein the micro channels comprise a height of less than about 200 microns.

18. The method of claim 8 further comprising wherein an air gap between the nozzle and the heater is less than about 100 microns.

5 19. The method of claim 8 further comprising wherein the fluid comprises at least one of liquid air, liquid helium, liquid carbon dioxide and compressed air, compressed helium, and compresses carbon dioxide.

20. An assembly comprising:

10 an array of vertical micro channels coupled to a heater surface, wherein an outlet micro channel of the array is adjacent inlet micro channel of the array; and

an inlet and outlet manifold coupled to the array of vertical micro channels, wherein the heater surface and the array of vertical micro channels are coupled in the same block.

21. The assembly of claim 20 wherein the heater surface comprises micro fins.

15 22. The assembly of claim 20 wherein a TEC pad is disposed between the heater surface and a cooling block of the assembly.

23. The assembly of claim 21 wherein a tip of the micro fin is aligned in a center position between adjacent inlet and outlet micro channel jets.

20 24. The assembly of claim 20 wherein the vertical array of micro channels are disposed inside the heater block, and wherein a cooling block of the assembly is fabricated in the same material piece in which the heater loops are embedded.

25. The assembly of claim 24 further comprising wherein inlet and outlet micro channels are disposed in a staggered configuration, and wherein a bottom portion of the cooling block is chamfered.

26. The assembly of claim 20 wherein the assembly further comprises a nozzle
25 coupled to the heater, and a die coupled to the nozzle, wherein the die is on a substrate disposed on a pedestal.

27. The assembly of claim 26 wherein the assembly comprises a portion of a TCB bonding system.

28. The assembly of claim 20 wherein the individual micro channels comprise a height of less than about 200 microns.

29. The assembly of claim 26 wherein an air gap between the nozzle and the heater is less than about 100 microns.

5 30. The assembly of claim 20 wherein every outlet micro channel comprises two adjacent inlet micro channels.

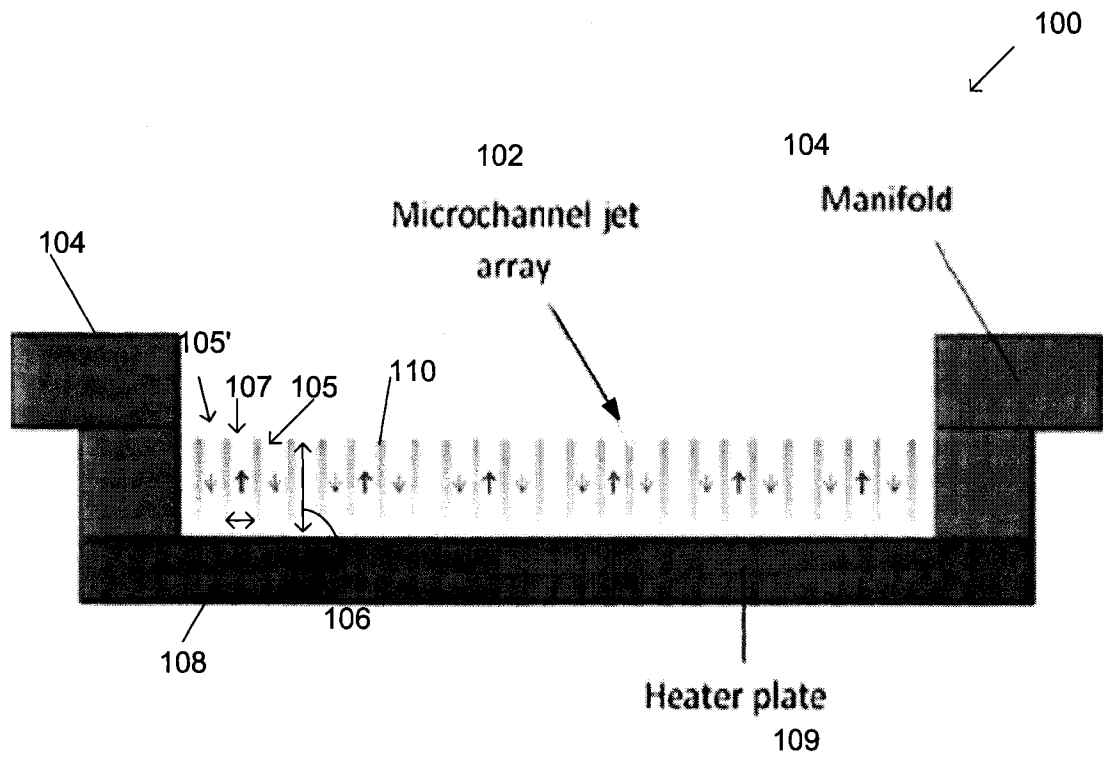


FIG.1a

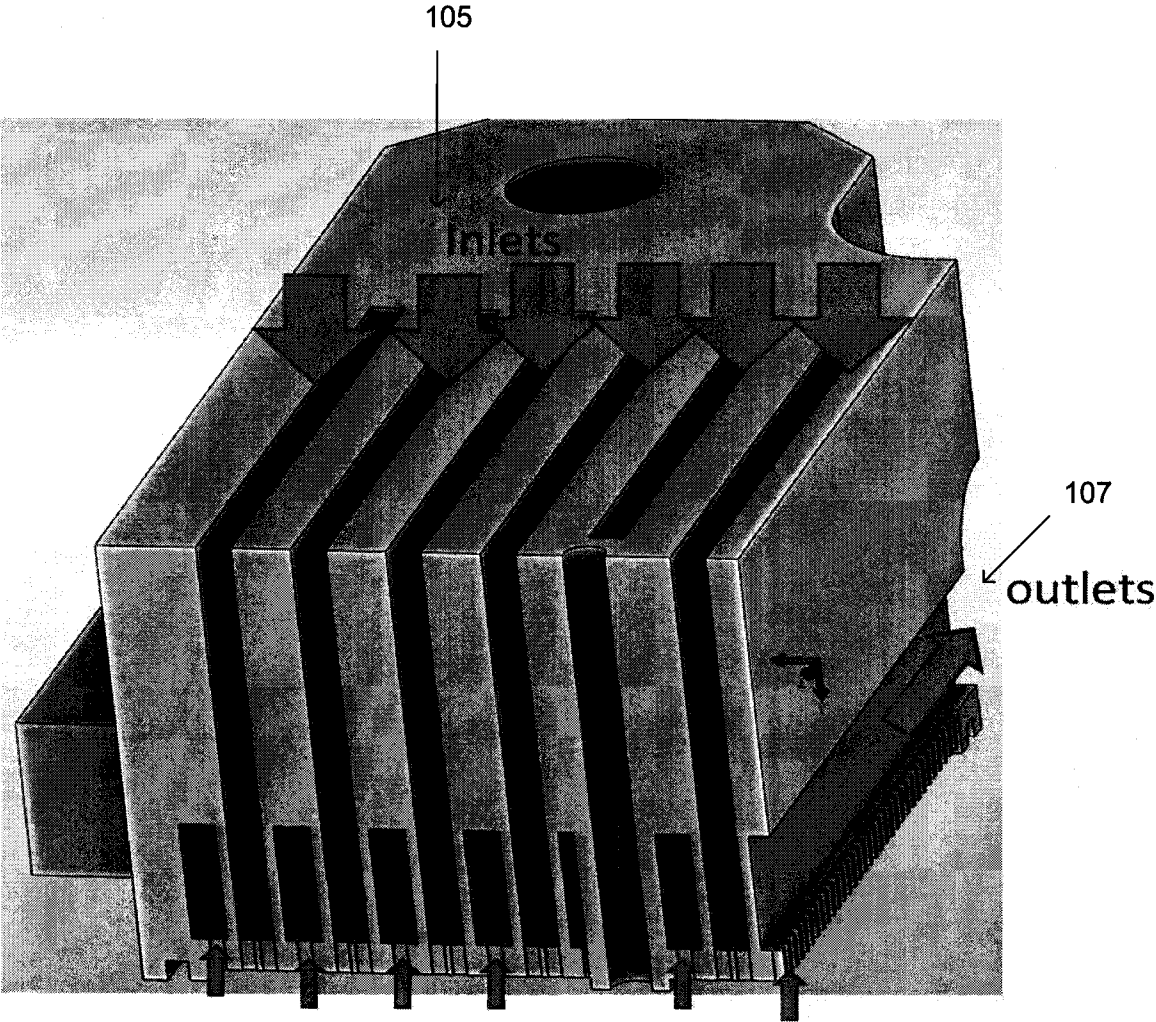
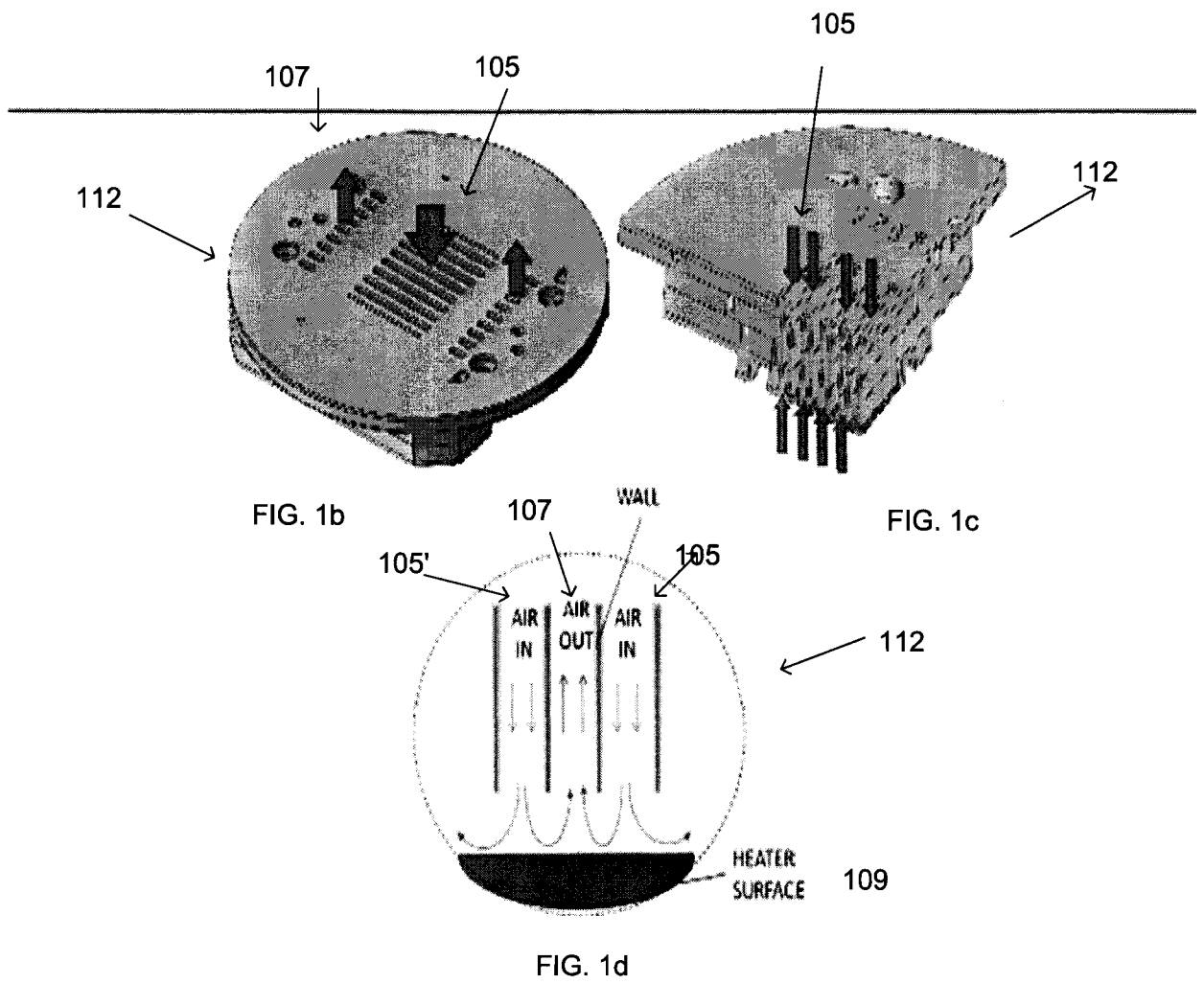


FIG. 1j



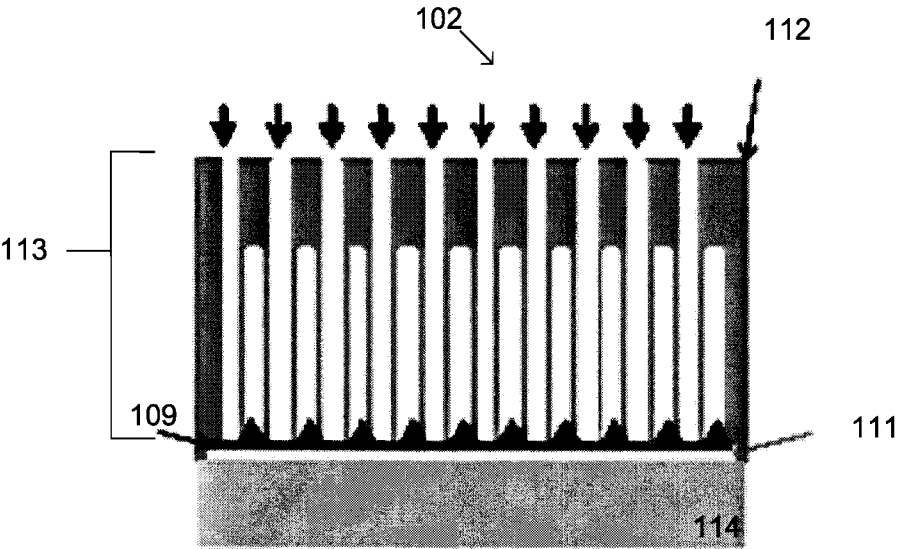


FIG. 1e

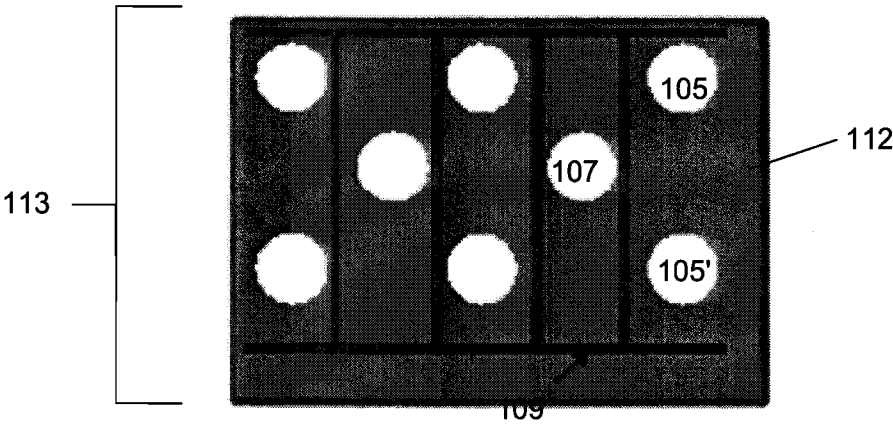


FIG. 1f
Top view

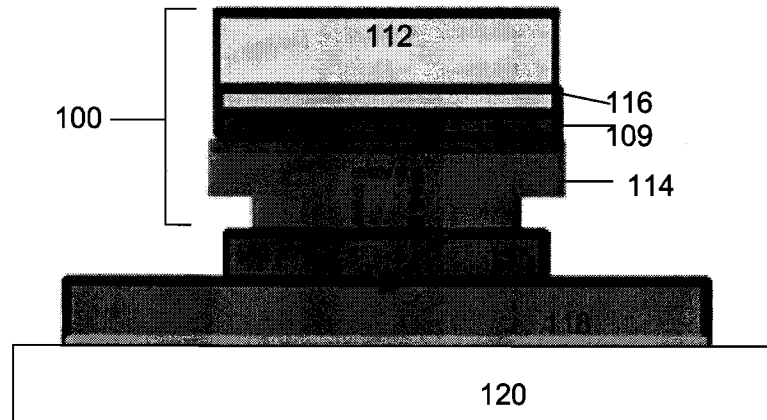


FIG. 1g

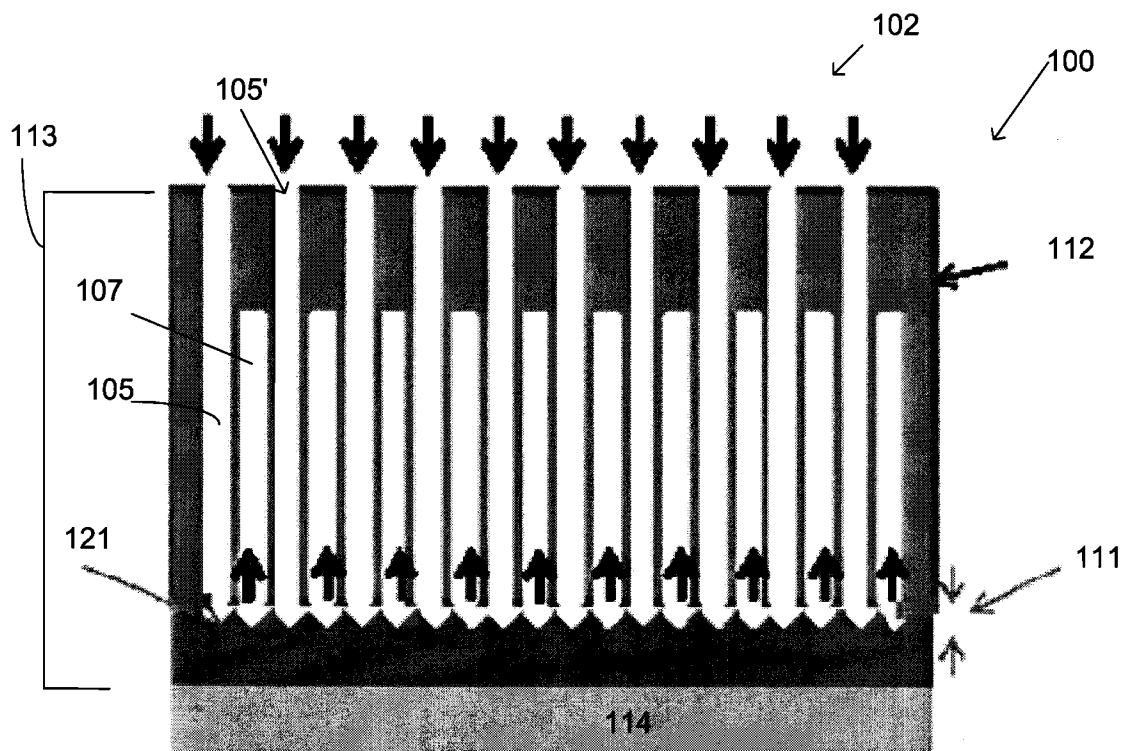


FIG. 1h

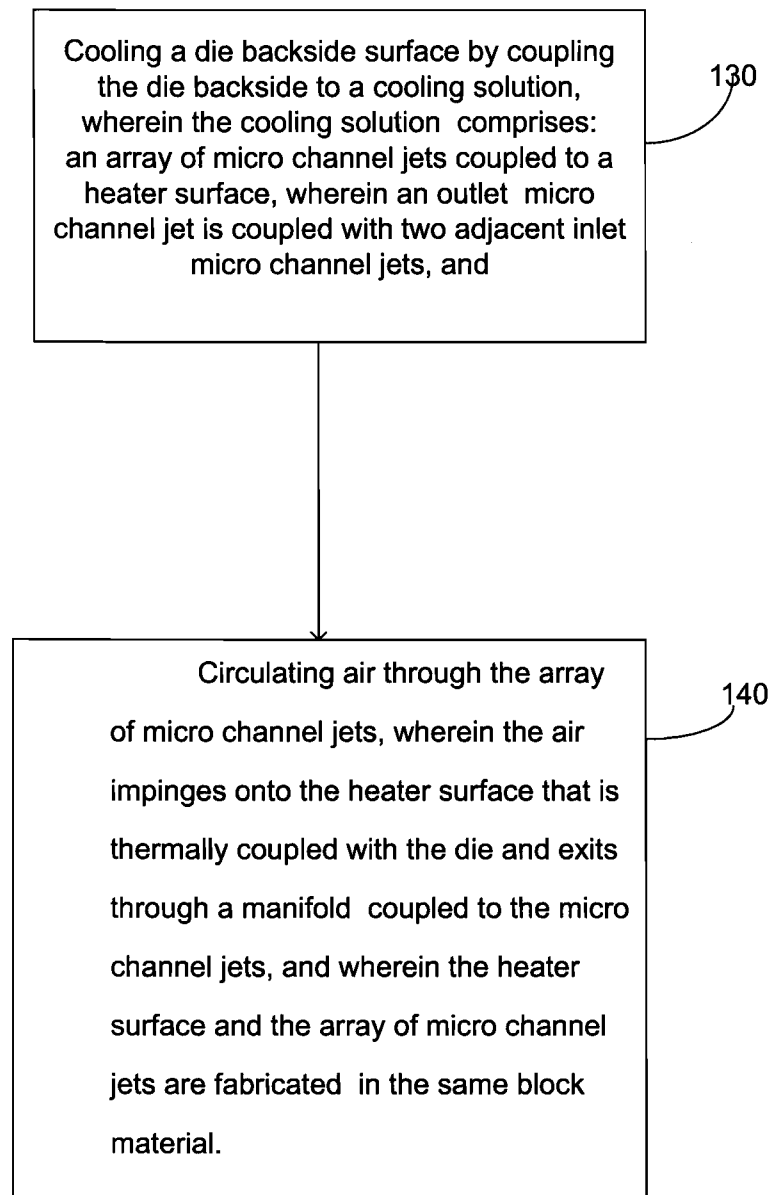


FIG. 1i

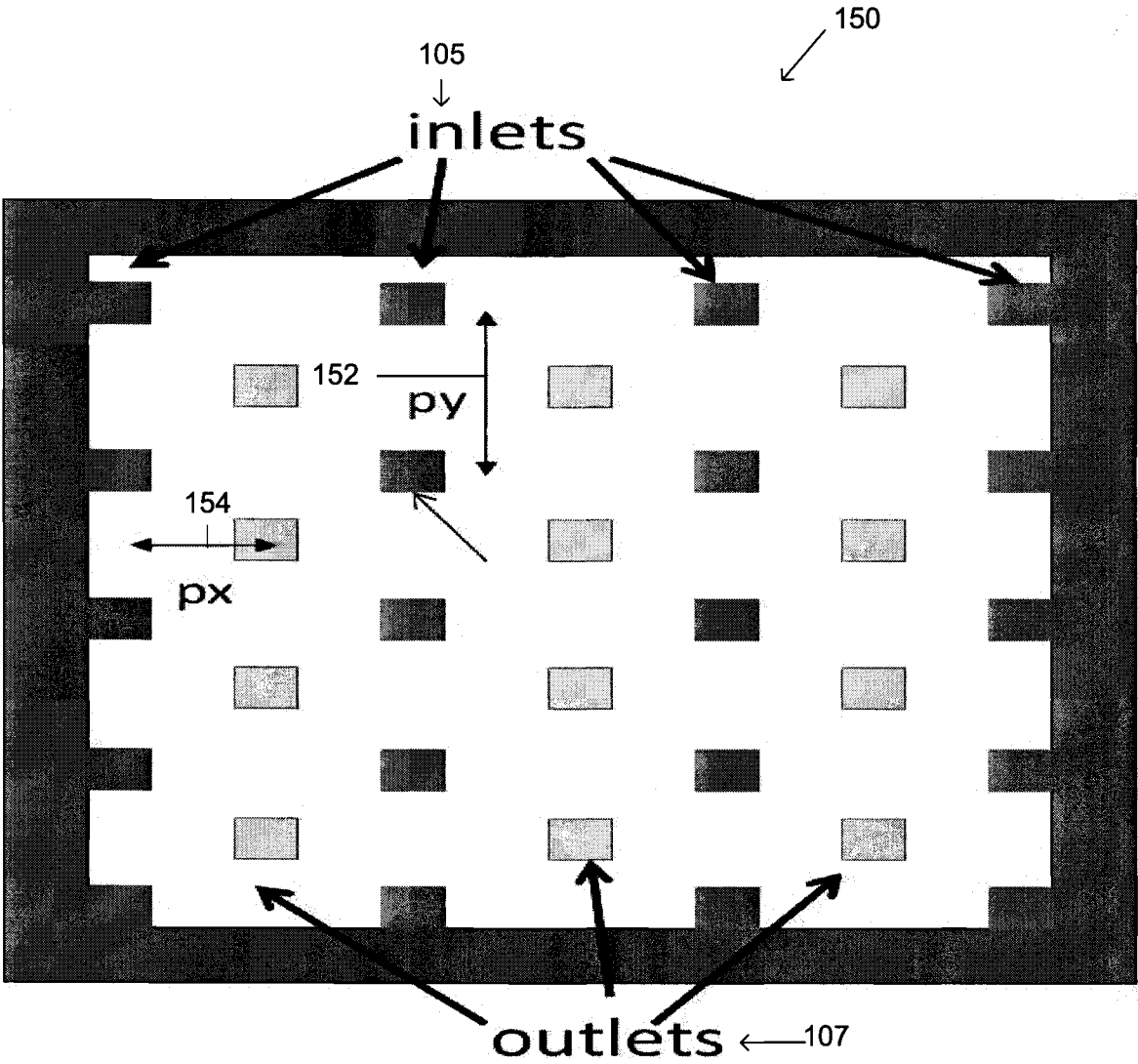


FIG. 1k

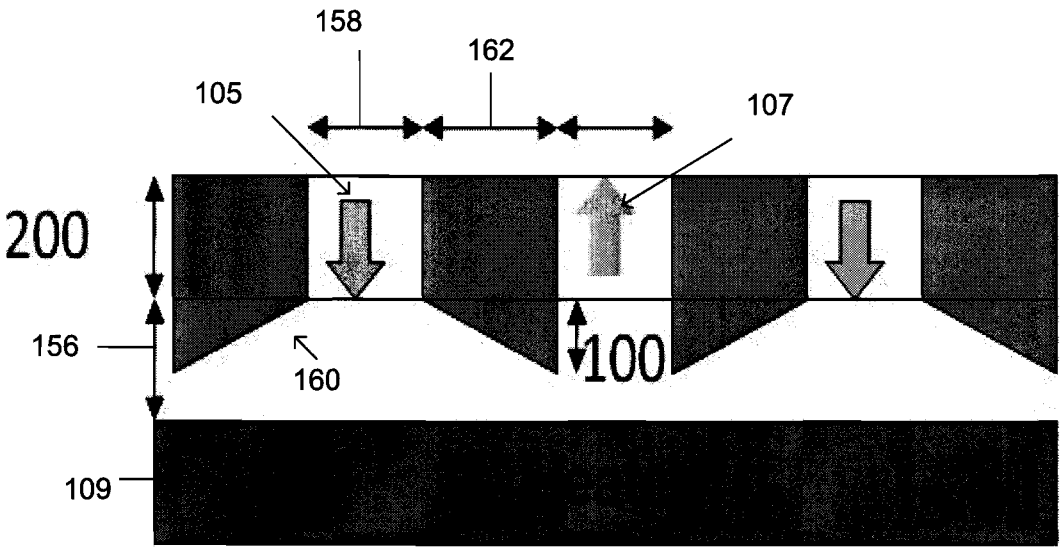


FIG. 1I

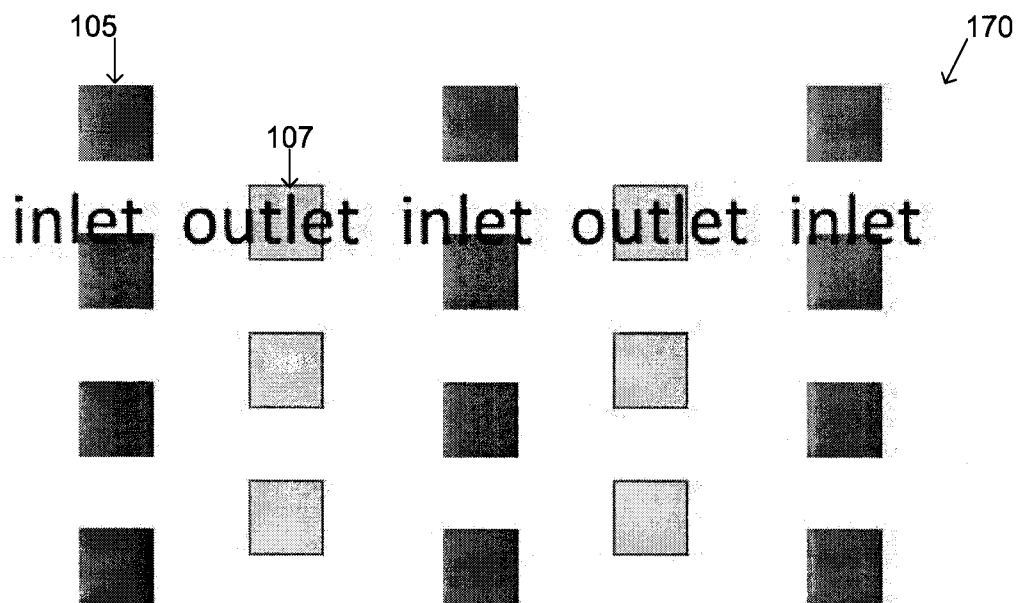


FIG. 1m

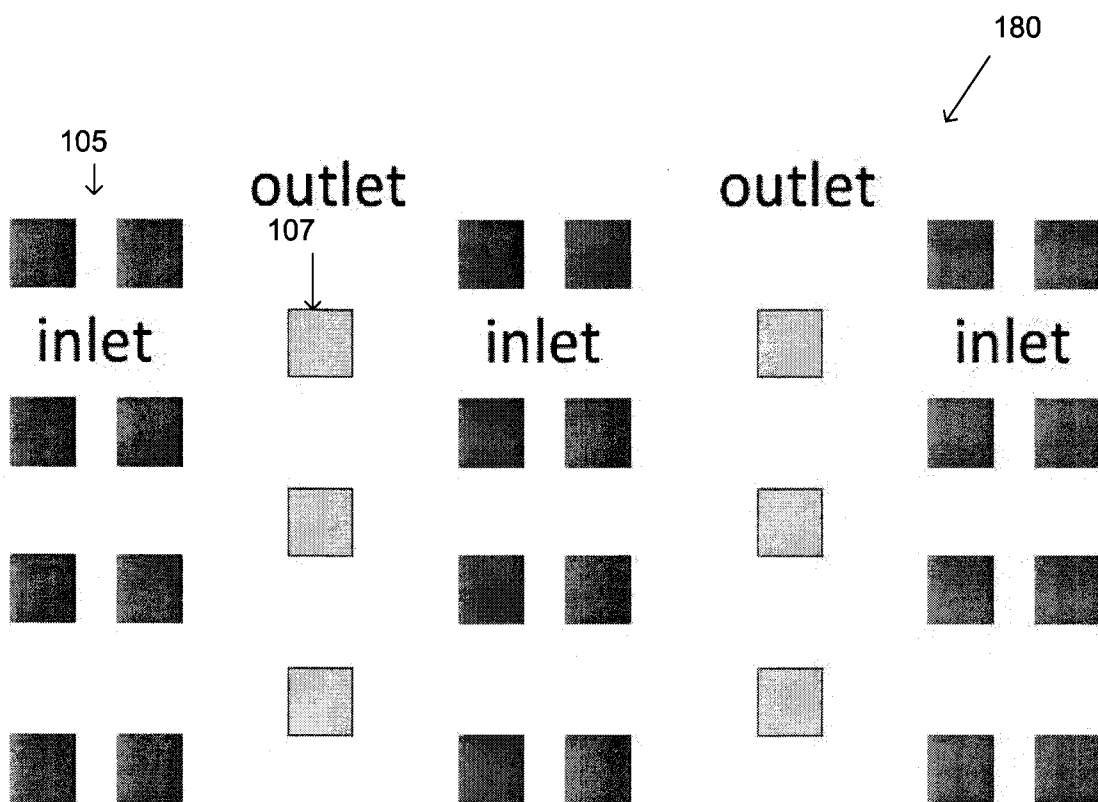


FIG. 1n

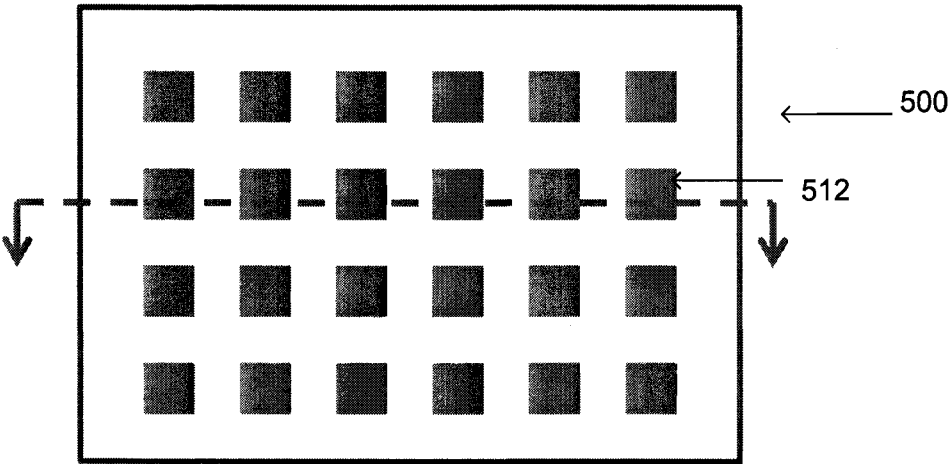


FIG. 2a
Prior Art

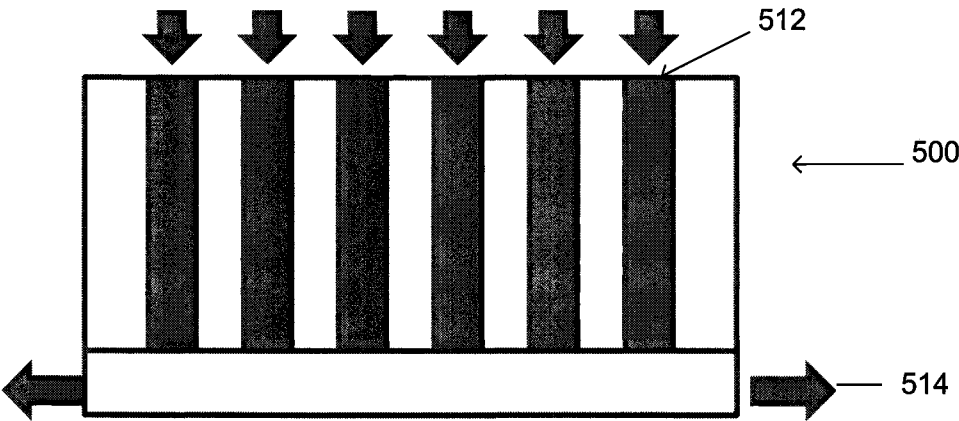


FIG. 2b
Prior Art

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US201 1/066046**A. CLASSIFICATION OF SUBJECT MATTER****H01L 21/60(2006.01)i, H01L 23/48(2006.01)1, H01L 23/34(2006.01)1**

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)

H01L 21/60; F28F 7/00; H05B 6/10; H05B 3/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: thermal compression bonding,solder,cooling,channel,jet,uniform**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2003-303856 A (SHINKO ELECTRIC IND CO LTD) 24 October 2003 See figures 1-2 ; paragraphs [0010] -[0015]	1-9 , 11 , 13 , 15-17 , 19 , 24
X	US 2004-0206477 A1 (THOMAS W. KENNY et al.) 21 October 2004	20 , 22 , 28 , 30
Y	See abstract ; figures 2A-14 ; paragraphs [0047]-[0130]	1-9 , 11 , 13 , 15-17 , 19 , 24 , 26
Y	US 2005-0103774 A1 (SONG-HUA SHI) 19 May 2005 See figure 1a; paragraph [0001]	15 , 26
A	US 06031216 A (SINGH;INDERJIT et al.) 29 February 2000 See figure 6; column 9 lines 37-60	1-30

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

08 AUGUST 2012 (08.08.2012)

Date of mailing of the international search report

09 AUGUST 2012 (09.08.2012)

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INTERNATIONAL SEARCH REPORT

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International application No.

PCT/US2011/066046

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2003-303856 A	24. 10. 2003	JP 3809125 B2	16. 08. 2006
US 2004-0206477 A1	21. 10. 2004	AU 2003-2488 17 A1	23. 01. 2004
		AU 2003-2488 17 A8	23. 01. 2004
		AU 2003-270882 A1	04. 05. 2004
		AU 2003-270884 A1	08. 04. 2004
		AU 2003-270884 A8	08. 04. 2004
		AU 2003-277341 A1	07. 06. 2004
		AU 2003-284038 A1	07. 06. 2004
		AU 2003-284038 A8	07. 06. 2004
		AU 2003-28682 1 A1	07. 06. 2004
		AU 2003-28682 1 A8	07. 06. 2004
		AU 2003-286855 A1	07. 06. 2004
		AU 2003-286855 A8	07. 06. 2004
		AU 2003-287408 A1	07. 06. 2004
		AU 2003-287408 A8	07. 06. 2004
		AU 2003-29 1347 A1	07. 06. 2004
		AU 2003-29 1347 A8	07. 06. 2004
		AU 2003-30 1878 A1	07. 06. 2004
		AU 2003-30 1878 A8	07. 06. 2004
		CN 101248327 A	20. 08. 2008
		CN 101248327 CO	20. 08. 2008
		DE 10393423 T5	06. 10. 2005
		GB 2408781 A	08. 06. 2005
		GB 2418961 A	12. 04. 2006
		GB 2419925 A	10. 05. 2006
		JP 2006-04986 1 A	16. 02. 2006
		JP 2006-054434 A	23. 02. 2006
		JP 2006-086503 A	30. 03. 2006
		JP 2006-506603 A	23. 02. 2006
		JP 2006-51 1787 A	06. 04. 2006
		JP 2006-514734 A	11. 05. 2006
		JP 2006-514734 T	11. 05. 2006
		JP 2006-515054 A	18. 05. 2006
		JP 2006-516068 A	15. 06. 2006
		JP 2006-51683 1 A	06. 07. 2006
		JP 2006-517728 A	27. 07. 2006
		JP 2006-52 1690 A	21. 09. 2006
		JP 2006-522463 A	28. 09. 2006
		JP 2008-1 11653 A	15. 05. 2008
		JP 2008-530482 A	07. 08. 2008
		TW I289192B	01. 11. 2007
		TW I300466A	01. 09. 2008
		TW I300466B	01. 09. 2008
		TW I300469A	01. 09. 2008
		TW I300469B	01. 09. 2008
		TW I304879A	01. 01. 2009
		TW I304879B	01. 01. 2009
		TW I314610A	11. 09. 2009

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2011/066046

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		TW I314610B	11.09.2009
		TW I318289A	11.12.2009
		TW I318289B	11.12.2009
		TW I318290A	11.12.2009
		TW I318290B	11.12.2009
		TW 289192 A	01.11.2007
		TW 289192 B	01.11.2007
		us 2004-0101421 A1	27.05.2004
		us 2004-0104010 A1	03.06.2004
		us 2004-0104022 A1	03.06.2004
		us 2004-0112571 A1	17.06.2004
		us 2004-0148959 A1	05.08.2004
		us 2004-0182548 A1	23.09.2004
		us 2004-0182551 A1	23.09.2004
		us 2004-0182560 A1	23.09.2004
		us 2004-0188065 A1	30.09.2004
		us 2004-0188066 A1	30.09.2004
		us 2004-0233639 A1	25.11.2004
		us 2005-0042110 A1	24.02.2005
		us 2005-0084385 A1	21.04.2005
		us 2005-0183443 A1	25.08.2005
		us 2005-0183444 A1	25.08.2005
		us 2005-0183445 A1	25.08.2005
		us 2005-0183845 A1	25.08.2005
		us 2005-0210913 A1	29.09.2005
		us 2005-0211417 A1	29.09.2005
		us 2005-0211418 A1	29.09.2005
		us 2005-0211427 A1	29.09.2005
		us 2007-0034356 A1	15.02.2007
		us 2008-0210405 A1	04.09.2008
		us 6881039 B2	19.04.2005
		us 6986382 B2	17.01.2006
		us 6988534 B2	24.01.2006
		us 7000684 B2	21.02.2006
		us 7017654 B2	28.03.2006
		us 7044196 B2	16.05.2006
		us 7077634 B2	18.07.2006
		us 7086839 B2	08.08.2006
		us 7156159 B2	02.01.2007
		us 7201012 B2	10.04.2007
		us 7201214 B2	10.04.2007
		us 7278549 B2	09.10.2007
		us 7344363 B2	18.03.2008
		us 7402029 B2	22.07.2008
		us 7449122 B2	11.11.2008
		us 7806168 B2	05.10.2010
		us 7836597 B2	23.11.2010
		wo 2004-006484 A2	15.01.2004
		wo 2004-006484 A3	15.01.2004
		wo 2004-027262 A2	01.04.2004

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2011/066046

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		Wo 2004-027262 A3	01.04.,2004
		Wo 2004-036040 A1	29.04.,2004
		wo 2004-042297 A2	21.05.,2004
		wo 2004-042297 A3	21.05.,2004
		wo 2004-042302 A2	21.05.,2004
		wo 2004-042302 A3	21.05.,2004
		wo 2004-042303 A2	21.05.,2004
		wo 2004-042303 A3	21.05.,2004
		wo 2004-042304 A2	21.05.,2004
		wo 2004-042304 A3	21.05.,2004
		wo 2004-042305 A2	21.05.,2004
		wo 2004-042305 A3	21.05.,2004
		wo 2004-042306 A2	21.05.,2004
		wo 2004-042306 A3	21.05.,2004
		wo 2004-042313 A1	21.05.,2004
		wo 2004-070304 A2	19.08.,2004
		wo 2004-070304 A3	19.08.,2004
		wo 2004-071139 A2	19.08.,2004
		wo 2004-071139 A3	19.08.,2004
		wo 2004-076857 A2	10.09.,2004
		wo 2004-076857 A3	10.09.,2004
		wo 2004-083742 A2	30.09.,2004
		wo 2004-083742 A3	30.09.,2004
		wo 2004-083759 A2	30.09.,2004
		wo 2004-083759 A3	30.09.,2004
		wo 2004-083760 A2	30.09.,2004
		wo 2004-083760 A3	30.09.,2004
		wo 2006-074353 A2	13.07.,2006
		wo 2006-074353 A3	13.07.,2006
US 2005-0103774 A1	19.05.2005	US 2005-0230817 A1	20.10.,2005
		US 6940053 B2	06.09.,2005
		US 7176422 B2	13.02.,2007
US 06031216 A	29.02.2000	None	