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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
23 September 2021 (23.09.2021)

WIPO | PCT

(10) International Publication Number
WO 2021/188093 A1

(51) International Patent Classification:
B29C 64/209 (2017.01) *B41J 2/16* (2006.01)
B33Y 30/00 (2015.01) *B01L 3/00* (2006.01)
B41J 2/14 (2006.01)

(21) International Application Number: PCT/US2020/023105

(22) International Filing Date: 17 March 2020 (17.03.2020)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant: **HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.** [US/US]; 10300 Energy Drive, Spring, TX 77389 (US).

(72) Inventors: **CHEN, Chien-Hua**; 1070 NE Circle Blvd., Corvallis, OR 97330 (US). **FAASE, Kenneth**; 1070 NE Circle Blvd., Corvallis, OR 97330 (US).

(74) Agent: **HOOPES, Benjamin** et al.; HP Inc., 3390 E. Harmony Road, Mail Stop 35, Fort Collins, CO 80528 (US).

(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, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, 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, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, 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, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:
— *as to the identity of the inventor (Rule 4.17(i))*
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:
— *with international search report (Art. 21(3))*

(54) Title: MOLDED FLUIDIC DIE WITH FLUID SLOT CROSSBEAM

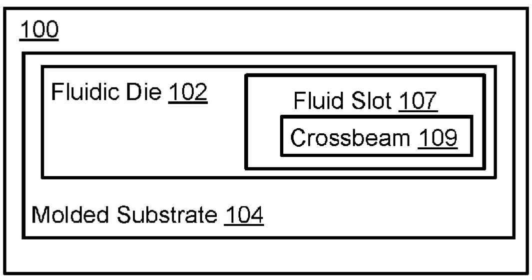

Fig. 1

(57) Abstract: Examples in accordance with the present disclosure are directed to an apparatus that includes a molded substrate and a fluidic die. The fluidic die is integrated with the molded substrate. A fluid slot is defined through the fluidic die. The apparatus further includes a crossbeam that extends across the fluid slot.

WO 2021/188093 A1

MOLDED FLUIDIC DIE WITH FLUID SLOT CROSSBEAM

Background

[0001] Fluidic dies may be used in a number of contexts. As an example, fluidic dies may be used by printing apparatuses to dispense ink or another jettable fluid onto a print medium. In the context of printing apparatuses, such fluidic dies may alternatively be referred to as “printhead dies.” By way of example, the fluidic dies may be included in ejection devices, which may include electronic and fluidic delivery components to enable dispensing the jettable fluid to form markings on the print medium. In three-dimensional (3D) examples, the fluidic dies may enable ejection of fluids, such as binder fluids, to be used in an additive manufacturing process, such as 3D printing. While fluidic dies may be relevant to printing, fluidic dies may additionally be used in other contexts, such as in the field of biomedical devices for testing fluids and fluid components.

Brief Description of the Drawings

[0002] FIG. 1 illustrates an example device that includes a molded fluidic die, in accordance with examples of the present disclosure.

[0003] FIG. 2 illustrates an example fluidic die integrated with a molded substrate, in accordance with examples of the present disclosure.

[0004] FIG. 3 illustrates an example fluidic die integrated with a molded substrate, in accordance with examples of the present disclosure.

[0005] FIG. 4 illustrates an example fluidic die integrated with a molded substrate, in accordance with examples of the present disclosure.

[0006] FIG. 5 illustrates an example fluidic die integrated with a molded substrate, in accordance with examples of the present disclosure.

[0007] FIGs. 6A-6B illustrate an example fluidic die having a plurality of crossbeams, in accordance with examples of the present disclosure.

[0008] FIGs. 7A-7B illustrate another example fluidic die having a plurality of crossbeams, in accordance with examples of the present disclosure.

[0009] FIGs. 8A-8B illustrate an example fluidic die having a layer of material forming a crossbeam with a plurality of apertures formed therein, in accordance with examples of the present disclosure.

[0010] FIGs. 9A-9B illustrate an example fluidic die having a plurality of crossbeams extending from a layer of material, in accordance with examples of the present disclosure.

[0011] FIG. 10 illustrates an example method of forming a molded fluidic die, in accordance with examples of the present disclosure.

[0012] FIGs. 11A-11B illustrate examples of a molding process, in accordance with examples of the present disclosure.

Detailed Description

[0013] In the following detailed description, reference is made to the accompanying drawings which form a part hereof, and in which is shown by way of illustration specific examples in which the disclosure may be practiced. It is to be understood that other examples may be utilized, and structural or logical changes may be made without departing from the scope of the present disclosure. The following detailed description, therefore, is not to be taken in a limiting sense, and the scope of the present disclosure is defined by the appended claims. It is to be understood that features of the various examples described herein may be combined, in part or whole, with each other, unless specifically noted otherwise.

[0014] Fluidic dies may be implemented in a variety of different types of fluidic dispersion or fluidic ejection apparatuses or devices. As used herein, the term fluidic die includes or refers to a semiconductor structure, which may be formed of silicon, on and/or in which electronic structures, such as integrated circuit components, and fluidic structures, such as fluidic passages, channels or slots, are formed. The fluidic die may have fluid passages, channels or slots arranged at a relatively high density.

[0015] Example fluidic dies may be integrated with a molded substrate. A molding compound may be used to form the molded substrate about or abutting the fluidic die. Example molding compounds include, but are not limited to, epoxy molding compounds (EMC). Through the application of heat and/or pressure, the molding compound may be used to form the molded substrate using a molding process. However, such heat and/or pressure may cause damage to the fluidic die. Specifically, as the fluidic die may include comparatively large fluid slots therethrough to enable fluid transfer through the fluidic die, such fluid slots may weaken the fluidic die. There may be a desire, therefore, for an approach of forming the molded substrate without damaging the fluidic die. The present disclosure includes the use of a crossbeam structure that extends across the fluid slot to help strengthen or reinforce the fluidic die and avoid damage to the fluidic die during the molding process.

[0016] FIG. 1 illustrates an example device which includes a molded fluidic die, in accordance with examples of the present disclosure. The device 100 includes a fluidic die 102 integrated with a molded substrate 104. The fluidic die 102 has a fluid slot 107 defined therein. The device 100 further includes a crossbeam 109 that extends across the fluid slot 107.

[0017] In one implementation, the device 100 includes an ejection device capable of ejecting fluids. An ejection device, such as device 100, includes electronic and fluidic delivery components to enable dispensing fluid. Example ejection devices may include ink-based ejection devices, digital titration devices, two-dimensional (2D) and/or three-dimensional (3D) printing devices, pharmaceutical dispensation devices, lab-on-chip devices, fluidic diagnostic circuits, and/or other such devices in which amounts of fluids may be dispensed or ejected. As specific examples, an ink-based ejection device may include a thermal inkjet (TIJ) ejection device, a bubblejet ejection device, or a piezo-based ejection device. The ejection device may be implemented as a fluidic dispensing apparatus used to eject fluid onto a medium, such as paper, onto a layer of powered-based build material, or onto a reactive device or another substrate, such as may be used for a biologic or chemical assay.

[0018] A crossbeam 109, as used herein, includes structural material that extends across or spans a fluid slot 107 from one side wall of the fluid slot 107 to another side wall of the fluid slot 107. The crossbeam 109 may be referred to as spanning a cross-sectional width of the fluid slot 107, and may be defined as extending substantially perpendicular to a longitudinal axis or length of the fluid slot 107, although in some cases the crossbeam 109 may extend at different angles with respect to the longitudinal axis of the fluid slot 107. The crossbeam 109 allows for fluid to feed or flow through the fluid slot 107 from a slot inlet port of the fluidic die 102 to a slot outlet port of the fluidic die 102. The crossbeam 109 may extend between the slot inlet port and the slot outlet port of the fluidic die 102. As further illustrated and described herein, the device 100 may further include a plurality of ejection chambers arranged at and/or communicated with the slot outlet port of the fluidic die 102. The crossbeam 109 may help to prevent or mitigate cracks from forming in the fluidic die 102 during the molding process of integrating the fluidic die 102 with the molded substrate 104. Specifically, the crossbeam 109 helps support the fluidic die 102 and maintain a uniform fluid slot in the molded fluidic die 102. A uniform fluid slot, as used herein, includes a fluid slot having a uniform cross-sectional width laterally along the fluid slot.

[0019] Molding the fluidic die 102 with the molding compound integrates the fluidic die 102 with the molded substrate 104. The molding process may allow for the molded substrate 104 to be flush with the first side and/or the second side of the fluidic die 102, in various examples, such that the first and/or second side of the fluidic die 102 are exposed. However, examples are not so limited. The molded substrate 104 being flush with the first and/or second sides of the fluidic die 102 may allow for easier attachment of the fluidic die 102 to other components of a fluidic dispersion apparatus which includes the device 100. As used herein, a molding process includes or refers to a process of shaping a molding compound using a rigid frame, sometimes referred to as a mold, and which includes the use of pressure and/or heat.

[0020] The molded substrate 104 may be formed of an EMC or a non-EMC mold compound (NEMC). An EMC includes or refers to any material including an epoxide functional group. In one example, the EMC is a self-cross-linking epoxy. In an example, the EMC may be cured through catalytic homopolymerization. In another example, the EMC may be a polyepoxide that uses a co-reactant to cure the polyepoxide. Curing of the EMC in these examples forms a thermosetting polymer with high mechanical properties, and high temperature and chemical resistance. Example non-EMC molding compounds include non-epoxy based thermal set materials, polymide, thermal plastics, glasses, silicon alloys, semiconductor materials, ceramics, metal oxides, and metals, among others. Some examples of NEMC plastics may include liquid crystal polymers (LCPs), polyimide (PI), acrylonitrile butadiene styrene and styrene acrylonitrile (ABS & SAN), polycarbonate (PC), polyamide (PA), polymethyl methacrylate (PMMA), polyacetal/polyoxymethylene (POM), polybutylene terephthalate (PBT), polyethylene terephthalate (PET), polyphenylene oxide (PPO/PPE Blends), fluoropolymers (PTFE), polyphenylene sulfide (PPS), and polyketones (PEEK & PEKK), among others.

[0021] The molded substrate 104 may provide physical support for interconnect traces, support wire bonding, and/or enable tape-automated bonding (TAB). The molded fluidic die 102 may allow for a reduction in die size and associated cost. For example, the molding process simplifies the ejection device assembly process as chiclets or other fluid distribution manifolds or fluidic interposers may no longer be used within the device 100. To further reduce the cost, electrical interconnects may be extended from the rows of nozzles to printed circuit boards (PCB) or lead frames. The PCBs or lead frames connect rows of nozzles to the edge of the fluidic die 102 so the device 100 may be connected to an electrical contact of a fluidic apparatus directly instead of using TAB circuits or surface-mounted technology (SMT) connectors.

[0022] Example devices are not limited to a single fluidic die, a single fluid slot per fluidic die, and/or a single crossbeam per fluid slot, as illustrated by FIG. 1, and may include a plurality of dies, a plurality of fluid slots and/or a plurality of crossbeams. As a specific example, an ejection device may have a plurality of molded inkjet fluidic dies. Each of the plurality of fluidic dies may include a fluid slot defined therein, and a crossbeam extending across the respective fluid slot, as described above in connection with the fluid slot 107 and the crossbeam 109. In such examples, the plurality of fluidic dies, such as the fluidic die 102 and a plurality of additional fluidic dies, are integrated with the molded substrate 104. In specific examples, a device having the plurality of fluidic dies may be a media-wide array or a print bar. The plurality of fluidic dies each include a first side having a slot inlet port and a second side opposite the first side, and the fluid slots feed fluid from the slot inlet port to the slot output port. As with the fluidic die 102, the molded substrate 104 may be flush with the second side and/or the first side of the plurality of fluidic dies, and the plurality of fluid slots of the fluidic dies may be uniform from a first end to a second end of the fluid slots.

[0023] In different implementations, the fluidic die 102 may include a rectangular shape and a non-rectangular shape, by way of non-limiting example. The non-rectangular shaped die may include an S-shape, a staggered die edge shape, a staired die edge shape, a sloped die edge shape, a chamfered die edge shape, a pentangle die edge shape, or combinations thereof. In some examples, the non-rectangular shaped die may be shaped using a stealth dicing process. In various examples, non-rectangular shaped dies may be arranged in a stitching configuration wherein ejection of fluid from a number of nozzles within overlapping portions of the plurality of dies is adjusted.

[0024] Other example variations to the device 100 illustrated by FIG. 1, include but are not limited to the fluid slot 107 including the crossbeam 109 and a plurality of additional crossbeams. In other examples and/or in addition, the fluidic die 102 may include a plurality of fluid slots and each of the plurality of fluid slots includes a crossbeam or a plurality of crossbeams. In examples including a plurality of crossbeams, each of the plurality of crossbeams may be the same shape or different shape and/or same sized or different sized, such as different widths and heights. Additionally, the crossbeam 109 may be formed of the same or different material as the fluidic die 102.

[0025] As illustrated and described below, the crossbeam 109 may have a variety of orientations within the fluid slot 107. The crossbeam 109 may be arranged between the first side and second side of the fluidic die 102. In some specific examples, the crossbeam 109 may extend to a plane extending from the first side and/or the second side of the fluidic die 102. For example, the crossbeam 109 may extend to a first plane that is parallel with and coincident to a surface of the first side of the fluidic die 102 and/or may extend to a second plane that is parallel with and coincident to a surface of the second side of the fluidic die 102. In further examples and/or in addition, the crossbeam 109 may extend short of a plane extending from the first side and/or the second side of the fluidic die 102. For example, the crossbeam 109 may extend short of (i.e., less than all the way to) a first plane that is parallel with and coincident to a surface of the first side of the fluidic die 102 and/or may extend short of (i.e., less than all the way to) a second plane that is parallel with and coincident to a surface of the second side of the fluidic die 102.

[0026] FIG. 2 illustrates an example fluidic die integrated with a molded substrate, in accordance with examples of the present disclosure. The fluidic die 102 may form part of an ejection device 200, as an example of the device 100 of FIG. 1. Hereinafter, reference to preceding elements, such as those of FIG. 1, will be made to note similar function and/or structure, but this is not to be taken in a limiting sense. For example, the components of a particular implementation may vary slightly as compared with other implementations.

[0027] The ejection device 200 includes the fluidic die 102 integrated with the molded substrate 104, as previously described in connection with FIG. 1. The fluid slot 107 of the fluidic die 102 has a plurality of crossbeams that extend across the fluid slot 107. For ease of reference, two crossbeams 109-1, 109-2 are labelled, although the example illustrates four crossbeams and examples may include more crossbeams or less crossbeams. The fluid slot 107 may have end walls 220-1, 220-2 at ends or end regions of the fluid slot 107.

[0028] The ejection device 200 includes a chamber layer at the second side 205 of the fluidic die 102 which includes ejection chambers, as illustrated by the particular ejection chamber 225. Each of the ejection chambers have a firing resistor, such as the illustrated firing resistor 213, located within a respective one of the chambers. The chamber layer is covered by a nozzle layer having nozzles (orifices), as illustrated by the particular nozzle 223, which correspond with each chamber. The nozzles form a nozzle column, on either side of the fluid slot 107 of the fluidic die 102. The fluid slot 107 and nozzle columns on either side of the fluid slot 107 extend between end regions of the fluidic die 102. During operation, fluid 224 may flow to the ejection chambers through the fluid slot 107 from the first side 203 of the fluidic die 102 to the second side 205 of the fluidic die 102. In examples, fluid 224 supplied by the respective fluid slot 107 is ejected through the nozzles as firing resistors in the chambers heat up and create expanding vapor bubbles that force fluid drops through the nozzles.

[0029] In the example of FIG. 2, the crossbeams 109-1, 109-2 are flush with or extend to a plane of the second side 205 of the fluidic die 102 and extend short of a plane of the first side 203 of the fluidic die 102. In such an example, the ejection chambers may be included (e.g., formed or defined) on top of the crossbeams 109-1, 109-2, as illustrated by the ejection chamber 225. Including (e.g., forming or defining) the ejection chambers on top of the crossbeams 109-1, 109-2 may allow for slot outlet ports, such as feed holes, to be closer to the ejection chambers, thereby increasing ejection device performance. Additionally, the crossbeams 109-1, 109-2 being flush with or extending to a plane of the second side 205 of the fluidic die 102 may provide a larger architecture region to accommodate additional nozzles, allow for nozzle placement flexibility and/or enable cross-slot electrical routing.

[0030] FIGs. 3-5, similar to FIG. 2, illustrate examples of fluidic dies 102 that may form part of respective ejection devices 300, 400, and 500, as examples of the device 100 of FIG. 1. Each of the illustrated ejection devices 300, 400, and 500 includes a fluidic die 102 integrated with a molded substrate 104, and the fluidic dies 102 have a plurality of crossbeams 109-1, 109-2 that extend across a fluid slot 107 of the respective fluidic die 102. For ease of reference, the various components are not repeated.

[0031] FIG. 3 illustrates another example fluidic die integrated with a molded substrate, in accordance with examples of the present disclosure. In the particular example of FIG. 3, the crossbeams 109-1, 109-2 are flush with or extend to a plane of the first side 203 of the fluidic die 102 and extend short of a plane of the second side 205 of the fluidic die 102. The crossbeams 109-1, 109-2 being flush with or extending to a plane of the first side 203 of the fluidic die 102 may allow for greater design flexibility and ease of combining the fluidic die 102 with other fluidic dispersion components.

[0032] FIG. 4 illustrates another example fluidic die integrated with a molded substrate, in accordance with examples of the present disclosure. In the particular example of FIG. 4, the crossbeams 109-1, 109-2 are flush with or extend to a plane of the first side 203 of the fluidic die 102 and are flush with or extend to a plane of the second side 205 of the fluidic die 102. The crossbeams 109-1, 109-2 being flush with or extending to a plane of the first and second sides 203, 205 of the fluidic die 102 may allow for greater design flexibility and ease of combining the fluidic die 102 with other fluidic dispersion components, as well as accommodating the ejection chambers on top of the crossbeams 109-1, 109-2, such as illustrated by the ejection chamber 225.

[0033] FIG. 5 illustrates another example fluidic die integrated with a molded substrate, in accordance with examples of the present disclosure. In the particular example of FIG. 5, the crossbeams 109-1, 109-2 extend from (or to) and are in contact with a first wafer 552 that is provided on or at the first side 203 of the fluidic die 102, and extend from (or to) and are in contact with a second wafer 551 that is provided on or at the second side 205 of the fluidic die 102. In examples, the crossbeams 109-1, 109-2 extend perpendicular to the first and second wafers 552, 551. The first and second wafers 552, 551 may form part of the overall crossbeam structure with the crossbeams 109-1, 109-2, which may improve the die strength, and/or may provide for greater design flexibility and ease of combining the fluidic die 102 with other fluidic dispersion components. And, as noted above, the ejection chambers may be included on top of the plurality of crossbeams 109-1, 109-2, such as illustrated by the ejection chamber 225.

[0034] Although the examples of FIGs. 2-5 illustrate the molded substrate 104 as being flush with the second side 205 and the first side 203 of the fluidic die 102, examples are not so limited and may include the molded substrate 104 being flush with the second side 205 of the fluidic die 102, being flush with the first side 203 of the fluidic die 102, or being flush with neither of the first side 205 and the second side 205 of the fluidic die 102. Additionally, example crossbeams are not limited to the shapes illustrated by FIGs. 2-5, and may be a variety of 3D shapes. For example, as further disclosed herein, shapes of example crossbeams may include a rib, such as a prism-shaped rib or chevron-shaped rib, a layer of material with a plurality of apertures formed therein, or a rib extending from a layer of material that extends across the fluidic die 102.

[0035] FIGs. 6A-6B, 7A-7B, 8A-8B, 9A-9B illustrate different example fluidic dies 102 that include a plurality of fluid slots 107-1, 107-2, with each fluid slot 107-1, 107-2 having a crossbeam or a plurality of crossbeams which extend across a respective one of the fluid slots 107-1, 107-2. In some cases, the crossbeam(s) may extend perpendicular to the length or longitudinal axis of the respective fluid slot. Although not illustrated for clarity purposes, the fluidic dies 102 are integrated with a molded substrate.

[0036] FIGs. 6A-6B illustrate an example fluidic die having a plurality of crossbeams, in accordance with examples of the present disclosure. The crossbeams may be prism-shaped ribs, which are 3D in shape. For example, each rib has width 673, length 675, and height 676 dimensions. As illustrated in the example of FIG. 6A, the fluidic die 102 includes two fluid slots 107-1, 107-2, each including a plurality of prism-shaped ribs, as illustrated by the particular ribs 645-1, 645-2, 645-3. The prism-shaped ribs may extend perpendicularly across the fluid slots 107-1, 107-2. FIG. 6B illustrates a perspective of the particular fluid slot 107-2 along the line 671. Although the prism-shaped ribs are illustrated as rectangular prisms, examples are not so limited and may include a hexagonal prism, a triangular prism, and a pentagonal prism, among other geometric prisms.

[0037] FIGs. 7A-7B illustrate another example fluidic die having a plurality of crossbeams, in accordance with examples of the present disclosure. The crossbeams may be chevron-shaped ribs, which are 3D in shape. For example, each rib has width 773, length 775, and height 776 dimensions. As illustrated in the example of FIG. 7A, the fluidic die 102 includes two fluid slots 107-1, 107-2, each including a plurality of ribs, as illustrated by the particular ribs 747-1, 747-

2, 747-3, which extend across the fluid slots 107-1, 107-2. A chevron-shaped rib includes or refers to a rib that forms a V-shape across the fluid slot 107-1, 107-2. Using the particular chevron-shaped rib 747-1 as an example, the chevron-shaped rib 747-1 has a first arm 741 that extends from a first side wall 737 of the fluid slot 107-2 at a first angle and a second arm 742 that extends from a second side wall 739 of the fluid slot 107-2 at a second angle. The first and second arms 741, 742 may connect or meet and form a point 743 at a location between the first and second side walls 737, 739 of the fluid slot 107-2. Each of the arms 741, 742 may be 3D prisms, such as rectangular shaped prisms, although examples are not so limited. FIG. 7B illustrates a perspective of the particular fluid slot 107-2 along the line 771.

[0038] FIGs. 8A-8B illustrate an example fluidic die having a layer of material forming a crossbeam with a plurality of apertures formed therein, in accordance with examples of the present disclosure. The crossbeam has width 873, length 875, and height 876 dimensions. As illustrated in the example of FIG. 8A, the fluidic die 102 includes two fluid slots 107-1, 107-2, each including a crossbeam 849-1, 849-2 that includes a layer of material having a plurality of apertures formed therein, as illustrated by the particular crossbeam 849-1 that includes a layer of material and particular apertures 848-1, 848-2 in the fluid slot 107-2. The plurality of apertures may extend through the respective layer of material which spans and extends across the respective fluid slot 107-1 107-2, and allow for fluid to flow through the fluid slots 107-1, 107-2. The apertures may include a variety of 3D shapes. For example, the plurality of 3D shaped apertures may include an elliptical prism, a cylindrical or circular prism, a hexagonal prism, a triangular prism, and a pentagonal prism, among other geometric prisms. In the particular example, the apertures are hexagonal 3D prisms, such that the layer of material forms a honeycomb shaped structure. The diameters of the plurality of apertures may be the same or varied. FIG. 8B illustrates a perspective of the particular fluid slot 107-2 along the line 871.

[0039] FIGs. 9A-9B illustrate an example fluidic die having a plurality of crossbeams extending from a layer of material, in accordance with examples of the present disclosure. The crossbeams may be prism-shaped ribs, which are

3D in shape. For example, each rib has width 973, length 975, and height 976 dimensions. As illustrated in the example of FIG. 9A, the fluidic die 102 includes two fluid slots 107-1, 107-2, each including a plurality of ribs which extend across the fluid slots 107-1, 107-2, as illustrated by the particular ribs 951-1, 951-2, 951-3. FIG. 9B illustrates a perspective of the particular fluid slot 107-2 along the line 971. As illustrated in the example of FIG. 9B, the plurality of ribs, as illustrated by particular ribs 951-1, 951-2, extend from a layer of material 960 which spans a length and width of the fluidic die 102. The layer of material 960 and the ribs may be formed of the same material or different material.

[0040] Example crossbeams are not limited to the above-described shapes. For example, although FIGs. 9A-9B illustrate a plurality of 3D prism-shaped ribs, examples are not so limited and the plurality of ribs that extend from the layer of material 960 may be different shapes including chevron-shaped ribs.

[0041] In some of the examples illustrated by FIGs. 6A-9B, crossbeam(s) may extend perpendicularly across the fluid slots 107-1, 107-2, such as across the width of the plurality of fluid slots 107-1, 107-2. The widths of the crossbeams may be equal to the width of the respective fluid slots 107-1, 107-2, although not all examples are so limited. The length and/or height of crossbeams may be the same within a fluid slot 107-1, 107-2 and/or a fluidic die 102, or may vary within a fluid slot 107-1, 107-2 and/or fluidic die 102. The crossbeams may be a variety of different widths, lengths, heights, pitches, and/or have different gaps between the crossbeams or the apertures of a crossbeam.

[0042] In the particular examples illustrated by FIGs. 6A-9B, the crossbeams extend between and to the first side 203 to the second side 205 of the fluidic die 102. As such, the heights of the crossbeams may be equal to the distance between the first side 203 and the second side 205 of the fluidic die 102. However, examples are not so limited, and the crossbeams may not extend to the first side 203 and/or the second side 205, and/or may be "sandwiched" by silicon wafers (see, e.g., the implementation illustrated in FIG. 5). In specific examples, the crossbeam(s) may have a height of between and including twenty percent of the thickness of the fluidic die 102 and one hundred percent of the thickness of the fluidic die 102.

[0043] FIG. 10 illustrates an example method of forming a molded fluidic die, in accordance with examples of the present disclosure. At 1080, the method includes placing a fluidic die on a die carrier. The fluidic die includes a fluid slot defined through the fluidic die and a crossbeam that extends across the fluid slot. The fluidic die with the crossbeam extending across the fluid slot is formed prior to the molding process to provide structural strength to the fluidic die. As noted above, the fluidic die includes a first side having a slot inlet port and a second side having a slot outlet port, with the second side being opposite the first side. The fluid slot may be defined through the fluidic die from the slot inlet port to the slot outlet port. Placing the fluidic die on the die carrier may include placing the fluidic die with the first side or the second side of the fluidic die facing and in contact with the die carrier.

[0044] At 1082, the method further includes molding the fluidic die into a molded substrate with a molding compound. As noted above, the crossbeam provides structural strength to the fluidic die while molding with the molding compound. Molding the fluidic die with the molding compound may include forming the molded substrate of the molding compound, such by overmolding the fluidic die with the molding compound as described below. The molded substrate may provide physical support to the fluidic die. In some examples, the resulting molded substrate is flush with the first side of the fluidic die and/or the second side of the fluidic die. The crossbeam of the fluid slot may mitigate cracking of the fluidic die and/or maintain uniformity of the fluid slot molded fluidic die from a first end to a second end of the fluid slot, as noted above.

[0045] In examples, the molding processing includes an overmolding process. As used herein, overmolding is a type of molding process that includes creating a single integrated part using two materials and/or components, such as the fluidic die and the molding compound. In examples, the overmolding processing may include compression and/or transfer overmolding. For compression overmolding, a mold, or a plurality of molds, may be used to heat the molding compound at appropriate locations and/or force the molding compound against the fluidic die using pressure forced onto all areas within the mold. For transfer overmolding, the molding compound is heated, such as in a pot, and the heated molding compound is pressure forced from the pot into a mold cavity through an orifice, such as gates or sprues. The pressure forces the molding compound to fill the mold cavity prior to the molding compound curing. Depending on the particular example, a die carrier, tape and/or the mold may be used to prevent or mitigate molding compound from entering the nozzles and/or the fluid slots. After the molding compound has cured and/or cooled, the tape and die carrier may be removed from the overmolded fluidic die and the overmolded fluidic die may be affixed to other components, such as a mounting structure of a print bar body. In some examples, a PCB and/or other components, such as electrical interconnects, are overmolded with the fluidic die. Other molding techniques may also be used to form the molded fluidic die.

[0046] FIGs. 11A-11B illustrate examples of a molding process, in accordance with examples of the present disclosure. A variety of different mold processes may be used to integrate a plurality of fluidic dies 1102 with a molded substrate formed of a molding compound 1104. Each of the fluidic dies 1102 include a plurality of fluid slots 1107, and each fluid slot has a crossbeam extending across, as illustrated by the particular crossbeams 1109.

[0047] FIG. 11A illustrates an example of transfer overmolding a plurality of fluidic dies 1102 with a co-planar molding compound substrate. The fluidic dies 1102 may be sealed from both the front and back sides 1103, 1105 during the transfer mold process, although examples are not so limited. As illustrated in the example of FIG. 11A, at 1111, the fluidic dies 1102 are placed on a die carrier 1108 with the front sides 1105 of the fluidic dies 1102 facing and in contact with the die carrier 1108. In examples, the fluidic dies 1102 may be secured to the die carrier 1108 via release tape (not illustrated). At 1112, an upper mold chase or cavity 1110 having a release liner seals off the back sides 1103 of the fluidic dies 1102 and the molding compound 1104 is forced into the mold cavity between the die carrier 1108 and upper mold chase or cavity 1110. After curing, at 1113, a result is the fluidic dies 1102 being overmolded and integrated within the molded substrate formed of the cured molding compound 1104, with the molding compound 1104 being flush with the back sides 1103 of the dies 1102, in the particular example. The example molding process allows for sealing the fluid slots 1107 without the use of wax or caps during the process. As a flat mold cavity 1110 is used, dies 1102 may be placed either face up or face down.

[0048] FIG. 11B illustrates an example of transfer overmolding a plurality of fluidic dies 1102 with a molding compound. As illustrated in the example of FIG. 11B, at 1115, the fluidic dies 1102 are placed on a die carrier 1108 with the back sides 1103 of the fluidic dies 1102 facing and in contact with the die carrier 1108. The fluidic dies 1102 may be secured to the die carrier 1108 via release tape (not illustrated). At 1116, an upper mold cavity 1122 having topologies is placed relative to the front sides 1105 of the fluidic dies 1102 and the molding compound 1104 is forced into the mold cavity between die carrier 1108 and upper mold cavity 1122. After curing, at 1117, a result is the fluidic dies 1102 being overmolded and integrated within the molded substrate formed of the cured molding compound 1104, with the molding compound 1104 being flush with the back sides 1103 of the dies 1102. In examples, the upper mold cavity 1122 may include topologies such that bond wires may be encapsulated with the molding compound 1104 as the fluidic dies 1102 are overmolded.

[0049] Examples are directed to ejection devices having a fluidic die with a fluid slot crossbeam and methods of forming the same. The crossbeam may mitigate or prevent cracking of the fluidic die during the mold process, and/or allow for a reduction in die size and fabrication costs while maintaining structural integrity of the die. For example, while a smaller die size may result in a tighter slot pitch and/or narrower slot width, which may weaken the die, the crossbeam provides structural integrity to the fluidic die, such as during the mold process.

[0050] Although specific examples have been illustrated and described herein, a variety of alternate and/or equivalent implementations may be substituted for the specific examples shown and described without departing from the scope of the present disclosure. This application is intended to cover any adaptations or variations of the specific examples discussed herein. Therefore, it is intended that this disclosure be limited by the claims and the equivalents thereof.

CLAIMS

1. A device, comprising:
a molded substrate;
a fluidic die integrated with the molded substrate;
a fluid slot defined through the fluidic die; and
a crossbeam that extends across the fluid slot.

2. The device of claim 1, wherein the crossbeam extends to a plane extending from a side of the fluidic die.

3. The device of claim 1, wherein the crossbeam comprises one of: a rib, a layer of material with a plurality of apertures formed therein, and a rib extending from a layer of material that expands across the fluidic die.

4. The device of claim 1, wherein the fluidic die includes a first side having a slot inlet port and a second side having a slot outlet port, wherein the crossbeam extends between the slot inlet port and the slot outlet port, and wherein the device further includes a plurality of ejection chambers arranged at the slot outlet port.

5. The device of claim 4, wherein the crossbeam includes a first wafer provided at the first side of the fluidic die, a second wafer provided at the first side of the fluidic die, and a rib that extends from and in contact with the first wafer to and in contact with the second wafer.

6. The device of claim 4, wherein the molded substrate is flush with the first side of the fluidic die.

7. The device of claim 4, wherein the molded substrate is flush with the second side of the fluidic die.

8. The device of claim 4, wherein the crossbeam extends to a plane that is parallel with and coincident to the first side.

9. A device, comprising:

a plurality of fluidic dies each including a first side and a second side opposite the first side, each of the plurality of fluidic dies including:

a fluid slot defined through the respective fluidic die; and

a crossbeam that extends across the fluid slot; and

a molded substrate formed of a molding compound, wherein the plurality of fluidic dies are integrated with the molded substrate and the molded substrate is flush with the second side of the plurality of fluidic dies.

10. The device of claim 9, wherein the fluid slot is to feed fluid from a slot inlet port to a slot outlet port of the respective fluidic die, the fluid slot is uniform from a first end of the fluid slot to a second end of the fluid slot, and the first side of the respective fluidic die includes the slot outlet port and the second side of the respective fluidic die includes the slot inlet port.

11. The device of claim 9, wherein the crossbeam of each of the plurality of fluidic dies extend between and to the first side and the second side of the respective fluidic die.

12. A method, comprising:

placing a fluidic die on a die carrier, the fluidic die including:

a first side having a slot inlet port and a second side having a slot outlet port;

a fluid slot defined through the fluidic die from the slot inlet port to the slot outlet port; and

a crossbeam that extends across the fluid slot; and with the fluidic die on the die carrier, molding the fluidic die into a molded substrate with a molding compound, wherein the crossbeam provides structural strength to the fluidic die while molding with the molding compound.

13. The method of claim 12, wherein molding the fluidic die includes overmolding the fluidic die with the molding compound, wherein the crossbeam of the fluid slot is to maintain uniformity of the fluid slot from a first end of the fluid slot to a second end of the fluid slot.

14. The method of claim 12, wherein molding the fluidic die includes forming the molded substrate of the molding compound, the molded substrate to provide physical support to the fluidic die.

15. The method of claim 14, wherein molding the fluidic die includes forming the molded substrate flush with the first side of the fluidic die.

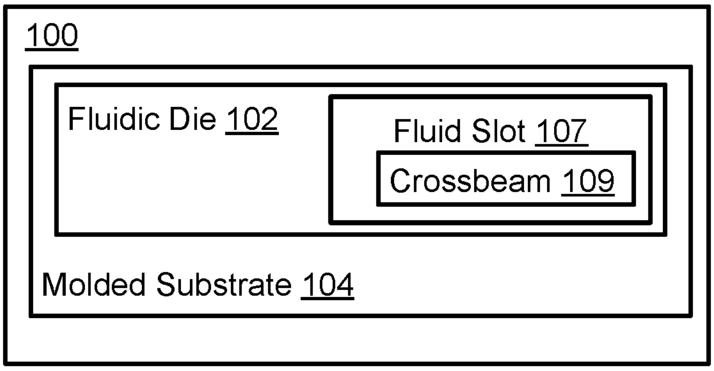
100
Fluidic Die 102
Fluid Slot 107
Crossbeam 109
Molded Substrate 104

Fig. 1

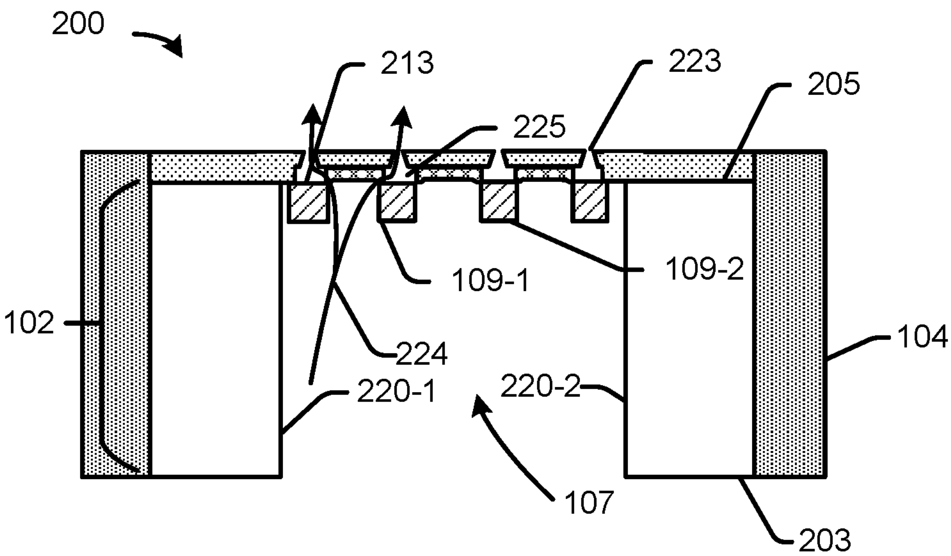
200
213
223
205
225
109-1
109-2
102
104
224
220-1
220-2
107
203

Fig. 2

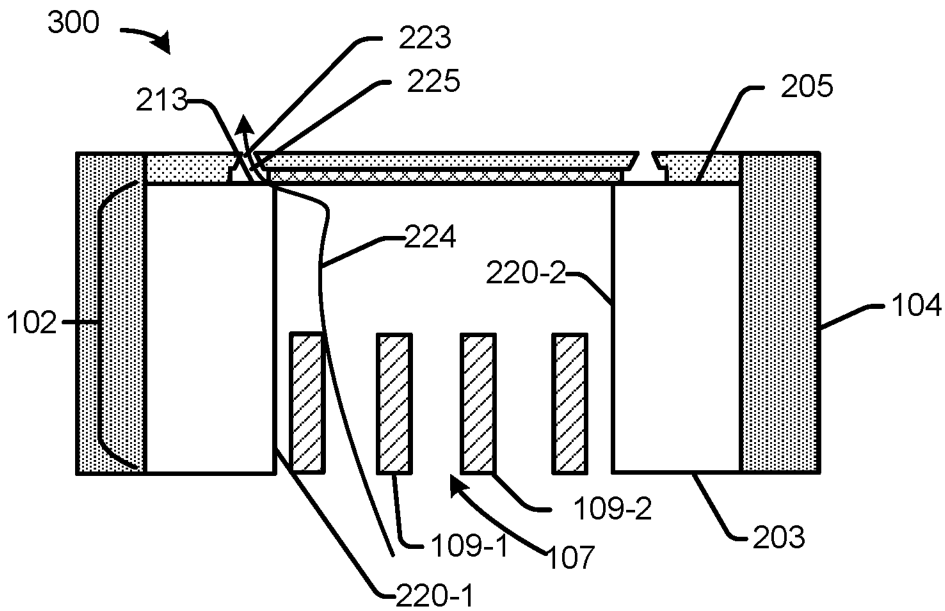
300
223
225
213
205
224
220-2
102
104
109-2
203
109-1
107
220-1

Fig. 3

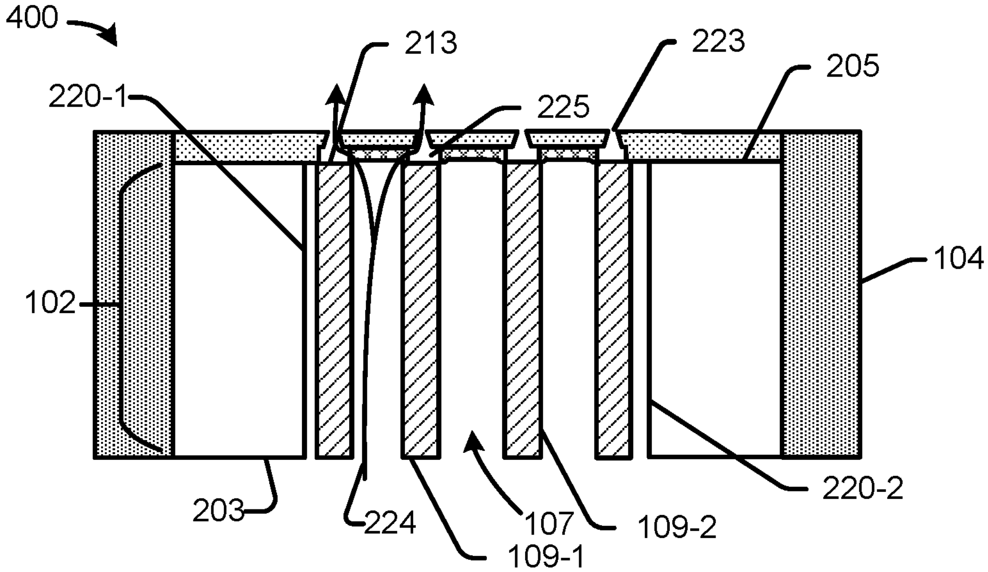
400
213
223
205
220-1
225
102
104
203
224
107
109-2
220-2
109-1

Fig. 4

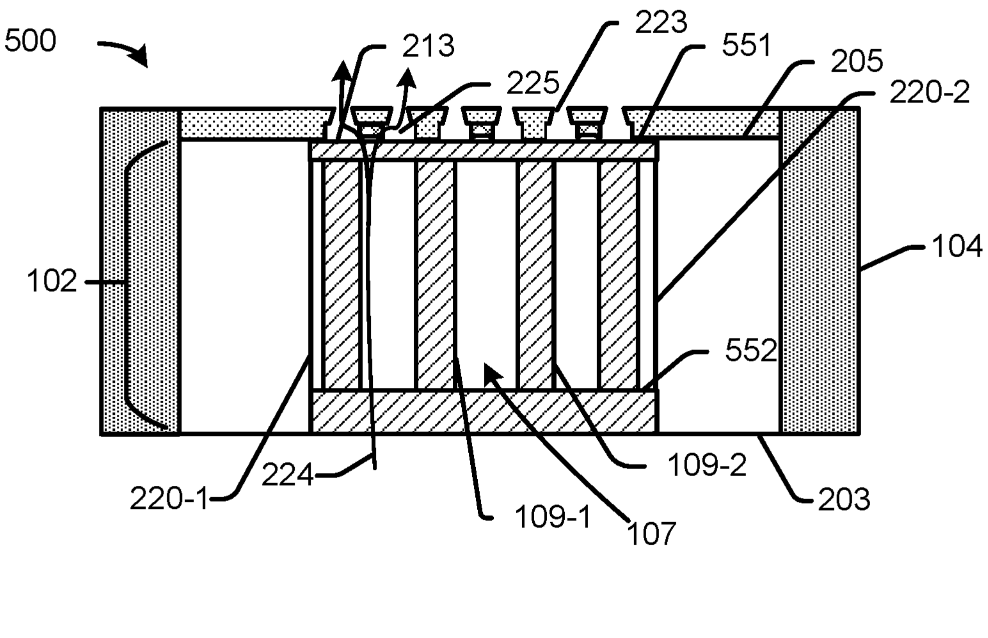
500
223
213
551
205
225
220-2
102
104
552
224
220-1
109-1
107
109-2
203

Fig. 5

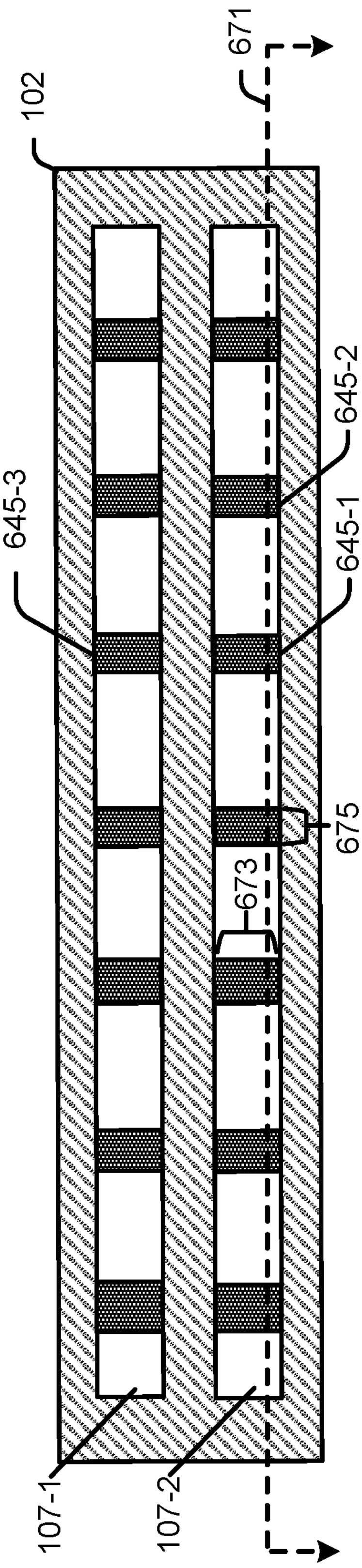
102
671
645-3
645-2
645-1
675
673
107-1
107-2

Fig. 6A

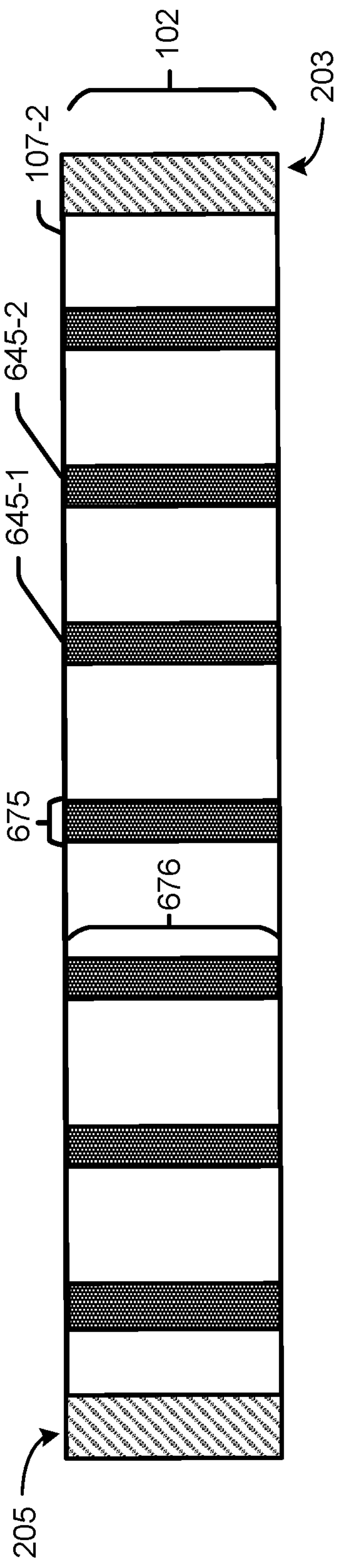
102
203
107-2
645-2
645-1
675
676
205

Fig. 6B

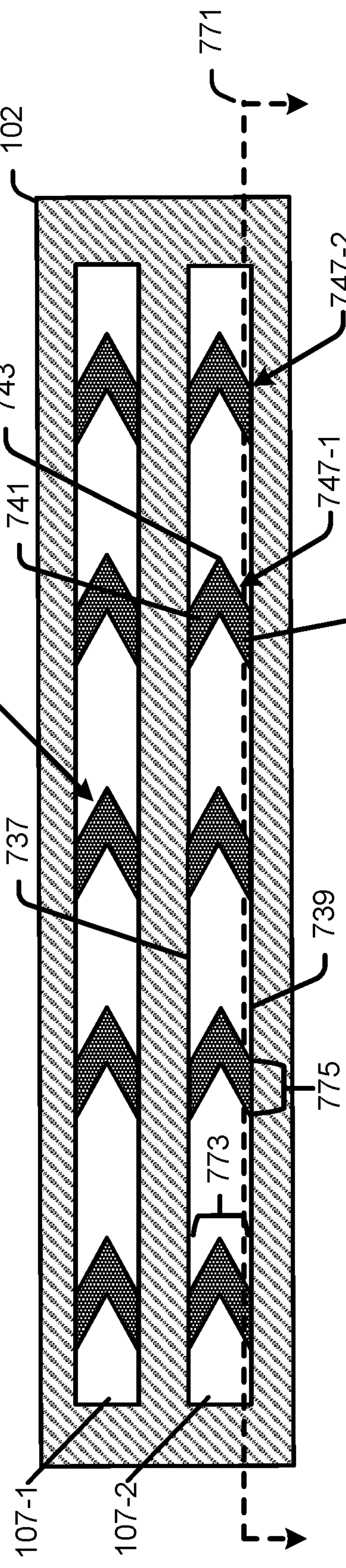
771
102
747-2
743
747-1
741
742
747-3
737
739
775
773
107-1
107-2

Fig. 7A

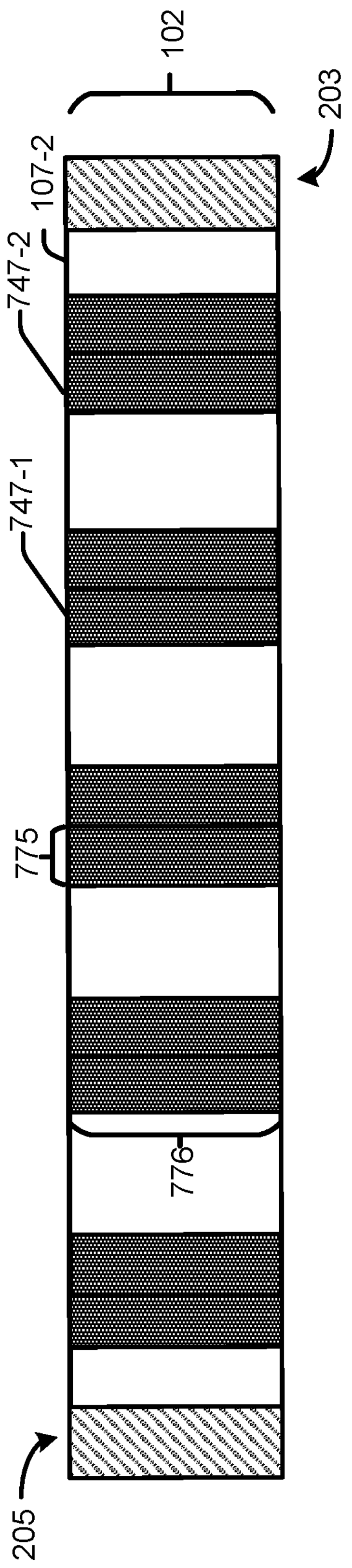
102
203
107-2
747-2
747-1
775
776
205

Fig. 7B

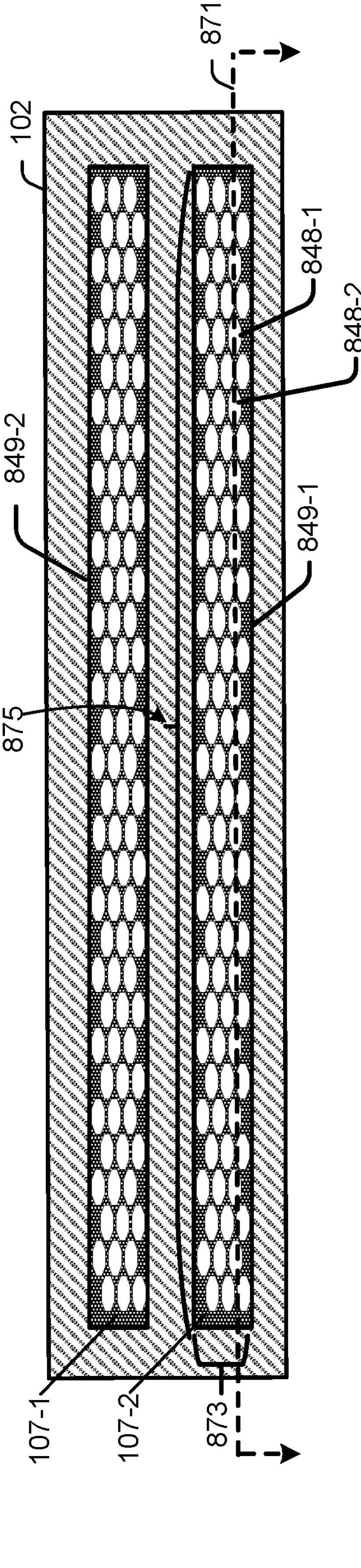
871
102
848-1
848-2
849-2
849-1
875
107-1
107-2
873

Fig. 8A

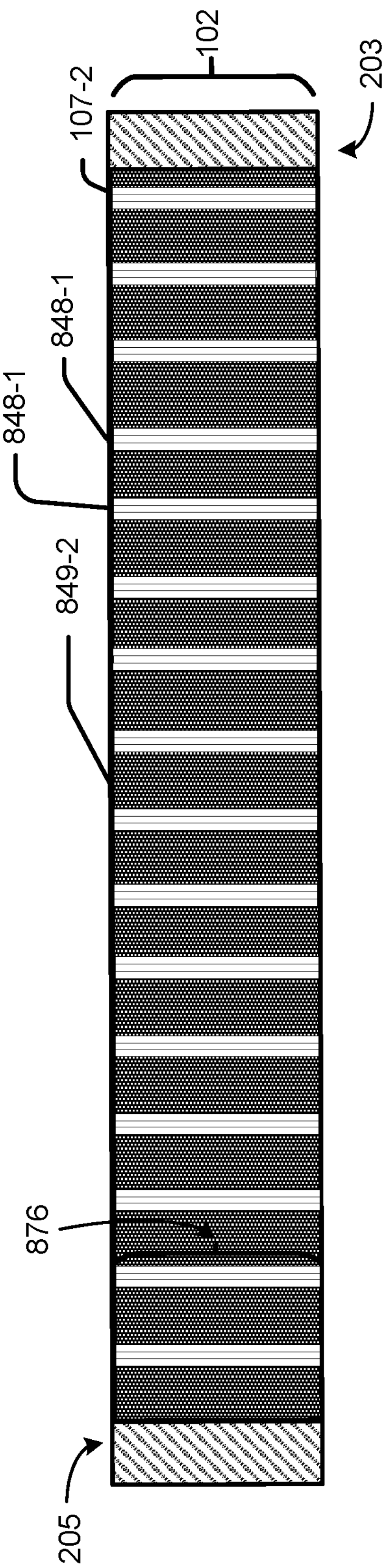
102
203
107-2
848-1
848-1
849-2
876
205

Fig. 8B

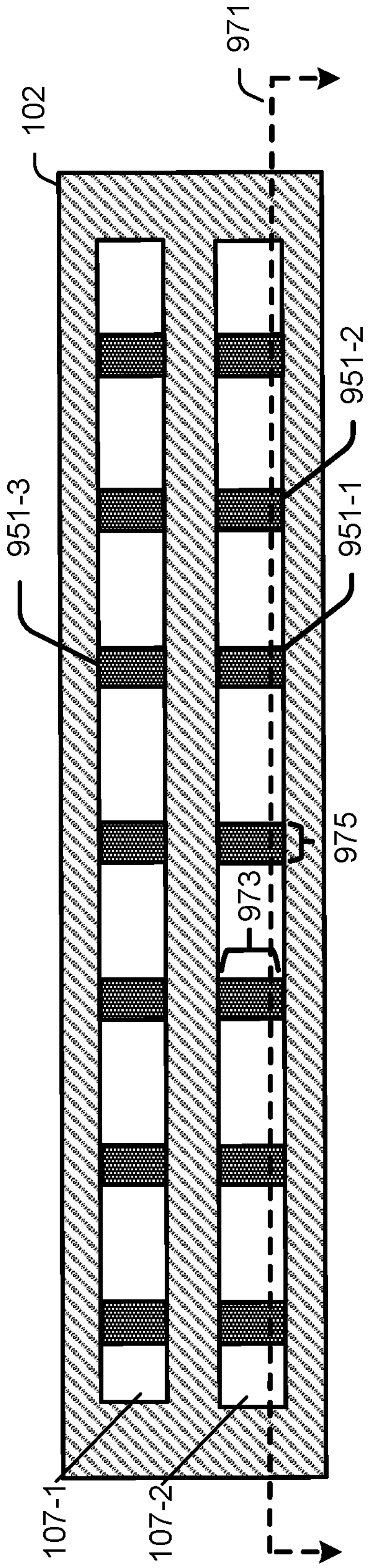
102
971
951-3
951-2
951-1
975
973
107-1
107-2

Fig. 9A

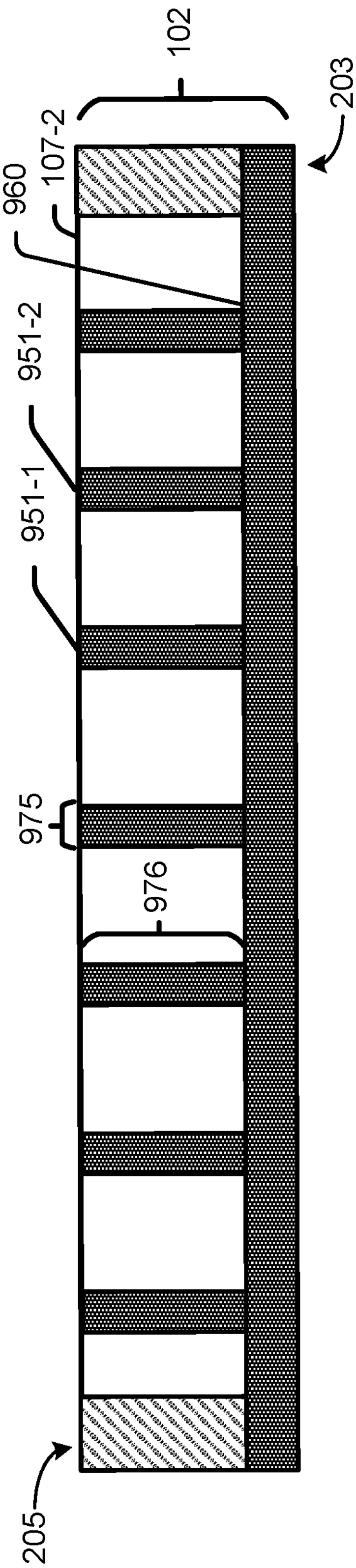
102
203
107-2
960
951-2
951-1
975
976
205

Fig. 9B

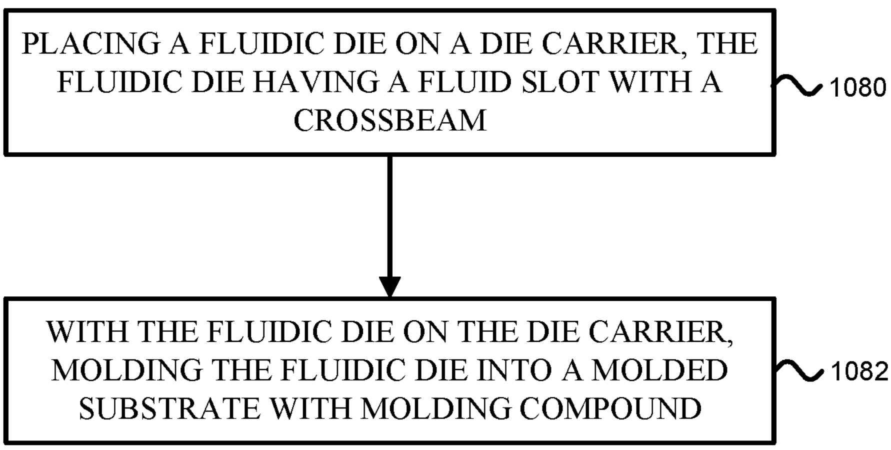
PLACING A FLUIDIC DIE ON A DIE CARRIER, THE FLUIDIC DIE HAVING A FLUID SLOT WITH A CROSSBEAM
1080
WITH THE FLUIDIC DIE ON THE DIE CARRIER, MOLDING THE FLUIDIC DIE INTO A MOLDED SUBSTRATE WITH MOLDING COMPOUND
1082

Fig. 10

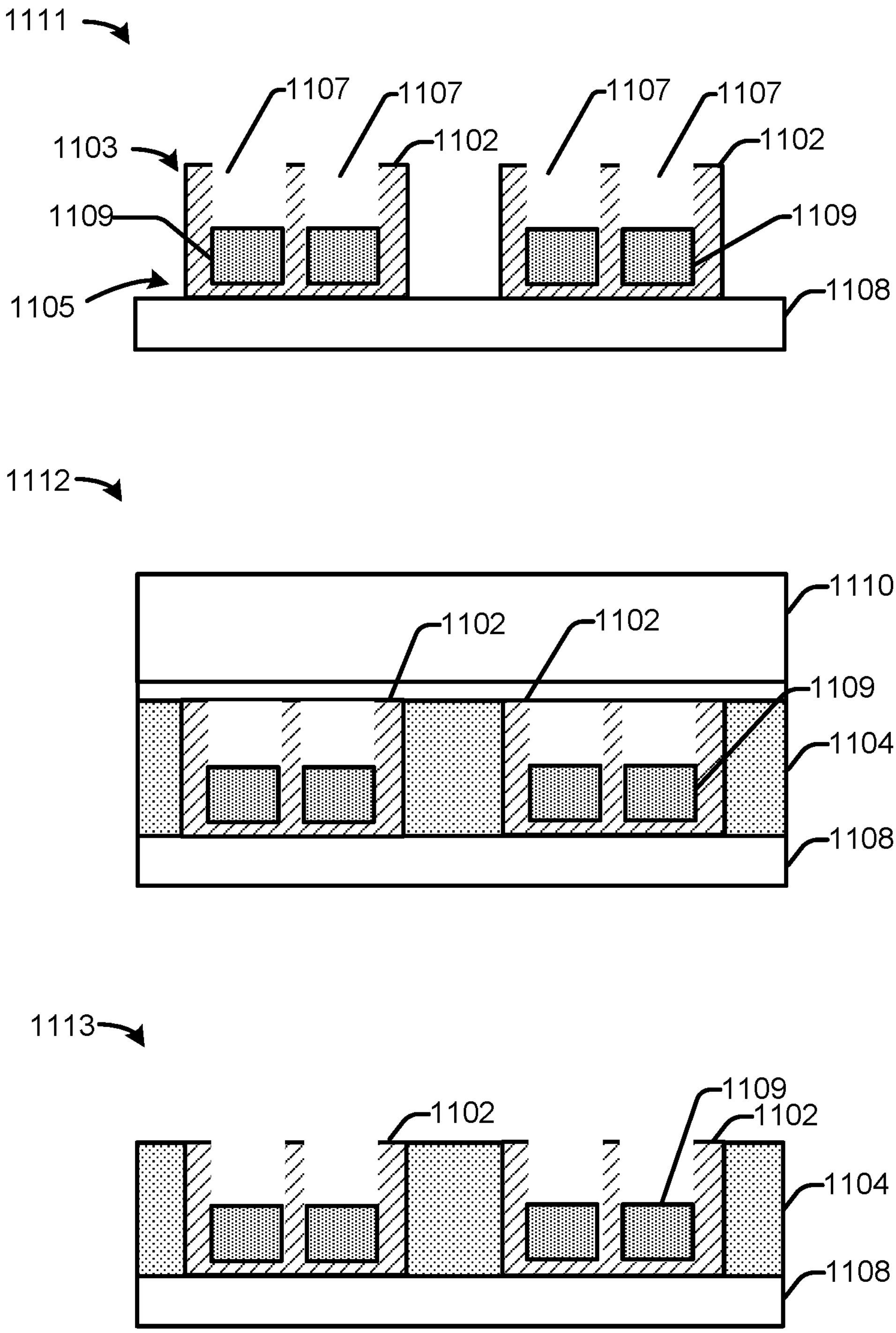
1111
1107
1107
1107
1107
1103
1102
1102
1109
1109
1105
1108
1112
1110
1102
1102
1109
1104
1108
1113
1109
1102
1102
1104
1108

Fig. 11A

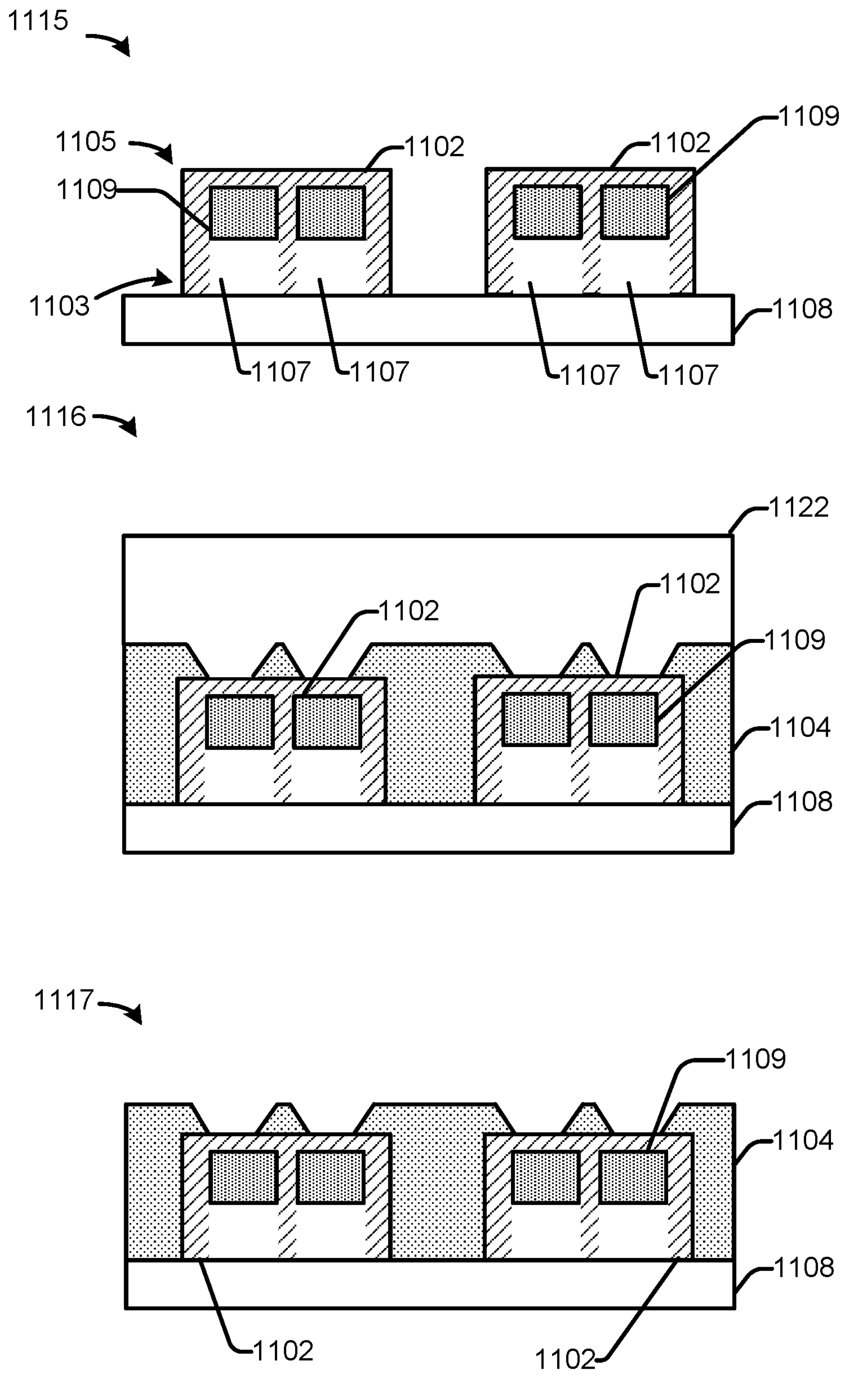
1115
1105
1102
1102
1109
1109
1103
1108
1107
1107
1107
1107
1116
1122
1102
1102
1109
1104
1108
1117
1109
1104
1108
1102
1102

Fig. 11B

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2020/023105

A. CLASSIFICATION OF SUBJECT MATTER

B29C 64/209 *(2017.01)*
B33Y 30/00 *(2015.01)*
B41J 2/14 *(2006.01)*
B41J 2/16 *(2006.01)*
B01L 3/00 (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)

B29C 64/209, B33Y 30/00, B05B 1/00 – B05B 1/36, B41J 2/14, B41J 2/16, B01L 3/00

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

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

EAPATIS, ESPACENET, PatSearch (RUPTO internal), Information Retrieval System of FIPS, USPTO, PATENTSCOPE, Google

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2009/136915 A1 (HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P. et al.) 12.11.2009, claim 1, paragraphs [0020], [0027], figure 3	1-11
Y		12-15
Y	WO 2019/022773 A1 (HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.) 31.01.2019, claims 1, 12, p. 12, lines 27-31, figure 3	12-15
A	WO 2017/078661 A1 (HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.) 11.05.2017, claims, abstract, figures	1-15
A	WO 2010/005434 A1 (HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P. et al.) 14.01.2010, abstract, figures	1-15

☐ Further documents are listed in the continuation of Box C.

☐ 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

"D" document cited by the applicant in the international application

"E" earlier document 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
17 November 2020 (17.11.2020)	03 December 2020 (03.12.2020)

Name and mailing address of the ISA/RU:
Federal Institute of Industrial Property,
Berezhkovskaya nab., 30-1, Moscow, G-59,
GSP-3, Russia, 125993
Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37

Authorized officer

V. Grigoruk

Telephone No. +7 (495) 531-64-81