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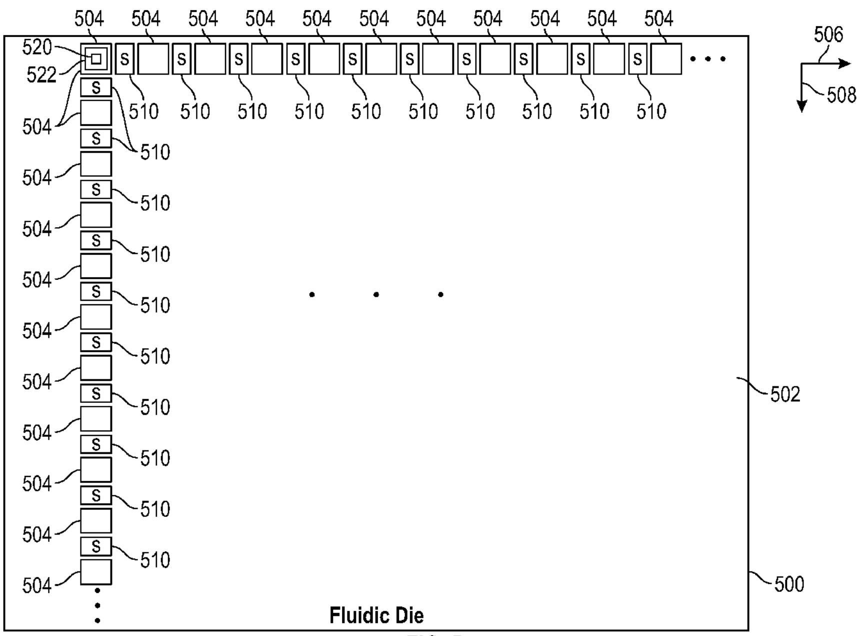

FIG. 5

(57) **Abstract:** In some examples, a fluidic die includes an arrangement of fluidic elements to dispense a fluid, each fluidic element of the fluidic elements including a fluidic actuator and a fluid chamber. An array of fluid feed holes is arranged in a plurality of dimensions to communicate the fluid with the fluidic elements, where each of multiple fluid feed holes along a first dimension of the plurality of dimensions is distinct from multiple fluid feed holes along a second dimension of the plurality of dimensions. Sense elements sense a property of the fluidic elements, where the sense elements are interspersed in regions between the fluidic elements along different axes of the fluidic die.

WO 2022/086562 A1

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INTERSPERSED SENSE ELEMENTS AND FLUIDIC ELEMENTS IN A FLUIDIC DIE

Background

[0001] A fluid dispensing system can dispense fluid towards a target. In some examples, a fluid dispensing system can include a printing system, such as a two-dimensional (2D) printing system or a three-dimensional (3D) printing system. A printing system can include printhead devices that include fluidic actuators to cause dispensing of printing fluids.

Brief Description of the Drawings

[0002] Some implementations of the present disclosure are described with respect to the following figures.

[0003] Fig. 1 is a block diagram of a fluidic die including an interspersed arrangement of fluidic cells and sense/circuit elements, according to some examples.

[0004] Fig. 2 is a schematic sectional view of a portion of a fluidic die including sense/control circuit element layers and layers of a fluidic cell, according to some examples.

[0005] Fig. 3 is a block diagram of a portion of a fluidic die including an interspersed arrangement of fluidic cells and sense/circuit elements, according to some examples.

[0006] Fig. 4 is a flow diagram of a process of forming a fluidic die, according to some examples.

[0007] Fig. 5 is a block diagram of a fluidic die according to further examples.

[0008] Throughout the drawings, identical reference numbers designate similar, but not necessarily identical, elements. The figures are not necessarily to scale, and the size of some parts may be exaggerated to more clearly illustrate the example shown. Moreover, the drawings provide examples and/or implementations consistent with the description; however, the description is not limited to the examples and/or implementations provided in the drawings.

Detailed Description

[0009] In the present disclosure, use of the term "a," "an", or "the" is intended to include the plural forms as well, unless the context clearly indicates otherwise. Also, the term "includes," "including," "comprises," "comprising," "have," or "having" when used in this disclosure specifies the presence of the stated elements, but do not preclude the presence or addition of other elements.

[0010] A fluid dispensing device can include fluidic actuators that when activated cause dispensing (e.g., ejection or other flow) of a fluid. For example, the dispensing of the fluid can include ejection of fluid droplets by activated fluidic actuators from respective nozzles of the fluid dispensing device. In other examples, an activated fluidic actuator (such as a pump) can cause fluid to flow through a fluid conduit or fluid chamber. Activating a fluidic actuator to dispense fluid can thus refer to activating the fluidic actuator to eject fluid from a nozzle or activating the fluidic actuator to cause a flow of fluid through a flow structure, such as a flow conduit, a fluid chamber, and so forth.

[0011] In some examples, the fluidic actuators include thermal-based fluidic actuators including heating elements, such as resistive heaters. When a heating element is activated, the heating element produces heat that can cause vaporization of a fluid to cause nucleation of a vapor bubble (e.g., a steam bubble) proximate the thermal-based fluidic actuator that in turn causes dispensing of a quantity of fluid, such as ejection from an orifice of a nozzle or flow through a fluid conduit or fluid chamber. In other examples, a fluidic actuator may be a deflecting-type fluidic actuator such as a piezoelectric membrane based fluidic actuator that when activated applies a mechanical force to dispense a quantity of fluid.

[0012] In examples where a fluid dispensing device includes nozzles, each nozzle can include an orifice through which fluid is dispensed from a fluid chamber, in response to activation of a fluidic actuator. Each fluid chamber provides the fluid to be dispensed by the respective nozzle. In other examples, a fluid dispensing device can include a microfluidic pump that has a fluid chamber.

[0013] Generally, a fluidic actuator can be an ejecting-type fluidic actuator to cause ejection of a fluid, such as through an orifice of a nozzle, or a non-ejecting-type fluidic actuator to cause displacement of a fluid.

[0014] In some examples, a fluid dispensing device can be in the form of a fluidic die. A “die” refers to an assembly where various layers are formed onto a substrate to fabricate circuitry, fluid chambers, and fluid conduits. Multiple fluidic dies can be mounted or attached to a support structure.

[0015] In some examples, a fluidic die can be a printhead die, which can be mounted to a print cartridge, a carriage assembly, and so forth. A printhead die includes nozzles through which a printing fluid (e.g., an ink, a liquid agent used in a 3D printing system, etc.) can be dispensed towards a target (e.g., a print medium such as a paper sheet, a transparency foil, a fabric, etc., or a print bed including 3D parts being formed by a 3D printing system to build a 3D object).

[0016] A fluidic die includes fluidic elements and circuitry that control fluid dispensing operations of the fluidic elements. The circuitry includes logic that is responsive to address signals and control signals to produce output signals that control switching elements used for activating respective fluidic actuators in the fluid elements.

[0017] A fluidic element includes flow structures that provide for fluid flow in the fluidic element. Examples of flow structures include any or some combination of the following: a fluid chamber that stores a fluid to be dispensed by the fluid element, an orifice through which fluid can pass from the fluid chamber to a region outside the fluid chamber, a fluid feed hole that is used to communicate fluid between a fluid flow conduit and the fluid chamber in the fluid element, a fluid channel to transport fluid, and a fluidic actuator that when activated causes dispensing of a fluid by the fluid element (a fluidic actuator can include a thermal-based fluidic actuator or a deflecting-type fluidic actuator, for example).

[0018] In some examples, a fluidic die includes fluidic elements contained in fluidic architecture regions that do not include circuitry with active devices. In other words, in such examples, the fluidic die is partitioned into the fluidic architecture regions and circuit regions that are outside of the fluidic architecture regions. The circuit regions include circuit elements including active devices. Examples of circuit elements include sense elements used to sense a property of the fluidic elements. Note that sensing a property can refer to sensing a single property or sensing multiple properties. In some examples, a sense element can be used to measure a property (e.g., an impedance, a pressure, a temperature, etc.) of a fluid contained in a fluid containing structure (e.g., a fluid chamber, a fluid channel, etc.) of a fluidic element. In further examples, a sense element can be used to measure a property of a structure of a fluidic element, such as a strain, an electrical voltage, an electrical current, and so forth.

[0019] As used here, an "active device" can refer to a device that can be switched between different states, such as an on state at which electrical current flows through the device, and off state at which electrical current does not flow through the device (or the amount of electrical current flow is negligible or below a specified threshold). An example of an active device is a transistor, such as a field effect transistor (FET). A transistor has a gate that is connected to a signal ("gate signal") to control the state of the transistor. When the gate signal is at an active level (e.g., a low voltage or a high voltage depending on the type of transistor used), the transistor turns on to conduct electrical current between two other nodes of the transistor (e.g., a drain node and a source node of an FET). On the other hand, if the gate signal is at an inactive level (e.g., a high voltage or a low voltage depending on the type of transistor used), then no electrical current flows through the transistor (or the amount of electrical current through the transistor is negligible or below a specified threshold). In some cases, the gate signal to the transistor can be set at an intermediate level between the active level or the inactive level, which causes the transistor to conduct an intermediate amount of electrical current.

[0020] Another example of an active device is a diode. If the voltage across two nodes of the diode exceeds a threshold voltage, then the diode turns on to conduct electrical current through the diode. However, if the voltage across that the two nodes of the diode is less than the threshold voltage, and the diode remains off.

[0021] In further examples, an active device (or multiple active devices) in a sense element can be used to implement sensing operations. For example, active devices can be used to implement an amplifier (that amplifies a signal of the sense element, such as a signal received from an electrode in contact with a fluid or a structure of a fluidic element), an electrical current source (which produces an electrical current for the sense element), a voltage reference circuit (which establishes a reference voltage to be compared to a sensed voltage for a sensing operation), and so forth.

[0022] Partitioning a fluidic die between fluidic architecture regions and circuit regions may simplify the interface between the circuit elements and the fluidic elements, or may be performed because of the arrangement of fluid feed slots in the fluidic die. A fluid feed slot refers to a fluid conduit that may run along an entire actuator column of the fluidic die. The fluid feed slot is used to carry fluid to and from the fluidic elements of the fluidic die.

[0023] Certain types of fluidic dies may employ a sparse arrangement of fluidic elements (the fluidic elements are arranged in patterns of lower density than fluidic elements in other fluidic dies). If a fluidic die has a sparse arrangement of fluidic elements, then the fluidic architecture regions would consume a larger area of the fluidic die than fluidic architecture regions of a fluidic die with a denser arrangement of fluidic elements. Given the same size of a fluidic die and assuming a same quantity of fluidic elements is used (compared to another fluidic die with a denser arrangement of fluidic elements), the larger fluidic architecture regions of the sparse arrangement would result in smaller circuit regions in the fluidic die, which leads to greater compaction of circuit elements. In some cases, there may not be sufficient space for circuit elements in a fluidic die with a sparse arrangement of fluidic elements.

[0024] In accordance with some implementations of the present disclosure, as shown in Fig. 1, a fluidic die 102 includes fluidic elements in the form of fluidic cells 104. A "fluidic cell" refers to a collection of flow structures, and the fluidic cell can be repeated across the fluidic die 102, such as to form an array. The fluidic cells 104 are interspersed with sense elements (blocks labeled with "S") along multiple different axes across a substrate 110 (of the fluidic die 102) on which the fluidic cells 104 and the sense elements are commonly formed. As noted above, sense elements can include active devices to implement an amplifier, an electrical current source, a voltage reference circuit, and so forth.

[0025] Additionally, as shown in Fig. 1, the fluidic cells 104 are also interspersed with control circuit elements (blocks labeled with "C") along the multiple different axes across the substrate 110 on which the fluidic cells 104 and the control circuit elements are commonly formed. A control circuit element can include an active device (or multiple active devices). In some examples, active devices of a control circuit element can be interconnected to provide a logical operation, such as a logical AND, a logical OR, a logical inversion, and so forth. Active devices of a circuit element C can also be used to perform other types of operations, such as to provide a latch, a register, or another storage element, to provide a variable resistance, and so forth. As an example, a control circuit element can be part of control circuitry of the fluidic die 102, where the control circuitry is used to control an operation of the fluidic cells 104 (and more specifically, the fluidic actuators in the fluidic cells 104), in response to input signals, such as address signals, control signals, data, and so forth. The input signals may be received from a controller of fluid dispensing system, such as a print controller of a printing system.

[0026] In further examples, active devices of a sense element ("S") or a control circuit element ("C") can be used to implement analog circuitry.

[0027] Collectively, the control circuit elements ("C") and the sense elements ("S") are referred to as "circuit elements." In other words, a "circuit element" as used here can refer to either a control circuit element or a sense element (or both a control circuit element and a sense element).

[0028] Although Fig. 1 shows both control circuit elements ("C") and sense elements ("S") interspersed along the different axes 106 and 108 with the fluidic cells 104, in other examples, just sense elements ("S") are interspersed along the different axes 106 and 108 with respect to the fluidic cells 104.

[0029] Fluidic cells are interspersed with circuit elements if along a given axis, successive fluidic cells are separated by circuit element(s), and successive circuit elements are separated by fluidic cell(s).

[0030] The different axes include a first axis 106 and a second axis 108 that is substantially orthogonal to the first axis 106. The first axis 106 and the second axis 108 are substantially orthogonal if the first axis 106 has an angle with respect to the second axis 108 that is in any of the following ranges: between 45° and 135°, between 60° in 120°, between 75° and 115°, and so forth.

[0031] In the example of Fig. 1, the fluidic cells 104 are arranged in a two-dimensional array, along the first axis 106 and the second axis 108. In other examples, the array of fluidic cells 104 can have a different pattern; for example, instead of a row or column that is generally parallel to the axis 106 or 108, respectively, a line of fluidic cells 104 may be slanted with respect to the axis 106 or 108. Moreover, instead of the fluidic cells 104 having a regular pattern, the fluidic cells 104 may have an irregular pattern or even a random pattern across the substrate 110 of the fluidic die 102.

[0032] In some examples, a first quantity of circuit elements (control circuit elements and/or sense elements) interspersed in regions between the fluidic cells 104 along the axis 106 is greater than a specified number (e.g., 10, 20, etc.), and a second quantity of circuit elements (control circuit elements and/or sense elements) interspersed in regions between the fluidic cells 104 along the axis 108 is greater than a specified number (e.g., 10, 20, etc.).

[0033] Each fluidic cell 104 includes a respective fluid feed hole 112 and a fluid chamber 114 into which a fluid can be fed through the fluid feed hole 112, in the example of Fig. 1. The fluidic cell 104 can also include a fluidic actuator 115, which when activated causes the fluid in the fluid chamber to be dispensed through an orifice (not shown in Fig. 1) of the fluidic cell 104. In further examples, a fluidic cell 104 can include multiple fluid feed holes and/or multiple orifices.

[0034] Although specific flow structures have been identified as being part of the fluidic cell 104, it is noted that in other examples, additional or alternative types of flow structures can be included in each fluidic cell 104.

[0035] In the example of Fig. 1, an array of fluid feed holes 112 is arranged in multiple dimensions (e.g., along the axes 106 and 108). The array of fluid feed holes 112 include distinct fluid feed holes that extend along a first dimension of the multiple dimensions, and distinct fluid feed holes that extend along a different second dimension of the multiple dimensions. "Distinct" fluid feed holes refer to fluid feed holes that are individually separate from one another, as opposed to a fluid feed slot that can extend a relatively long length to feed multiple fluidic cells, such as a column of fluidic cells. The fluid feed holes 112 are used to communicate fluid with respective fluid chambers of the fluidic cells 104.

[0036] The fluidic die 102 has multiple outer edges 102-1, 102-2, 102-3, and 102-4, which collectively form a general rectangle (when viewed from the top or bottom) in the example of Fig. 1. An "outer edge" of a fluidic die refers to a segment of an outermost boundary of the fluidic die 102. In other examples, the fluidic die 102 can have different shapes.

[0037] In some examples, either the first dimension or the second dimension of the multiple dimensions along which the array of fluid feed holes 112 is arranged can be parallel to an outer edge (one of 102-1, 102-2, 102-3, and 102-4) of the fluidic die

102. In further examples, both the first dimension and the second dimension are parallel to respective outer edges of the fluidic die 102.

[0038] In addition, each of multiple fluid feed holes along the first dimension (e.g., along the axis 106) is distinct from multiple fluid feed holes along the second dimension (e.g., along the axis 108). For example, in the first row 150 of the array of fluidic cells 104 shown in Fig. 1, each of fluid feed holes 112 in the fluidic cells 104 in the second column 158 and the third column 160 is distinct from multiple fluid feed holes 112 in the fluidic cells 104 in the second row 152 and last row 154 of the first column 156 of the array. Even though there is a common fluidic cell 104 at the intersection of the first row 150 and the first column 156, the first row 150 has multiple fluidic cells (in columns other than the first column 156) that are distinct from multiple fluidic cells in the first column 156 (in rows other than the first row 150).

[0039] In some examples, the fluidic die 102 can be mounted on a support structure (e.g., a print cartridge, a carriage, etc.), which is relatively moveable with respect to a target to which fluid of the fluidic die 102 is to be dispensed. For example, the target can be a print substrate onto which printing fluid is to be dispensed in a 2D printing system, or a 3D build part onto which liquid agents are to be dispensed during a 3D build operation of a 3D printing system. The fluidic die 102 is relatively moveable with respect to the target if either or both of the fluidic die 102 and the target is (are) moveable. In some examples, the fluidic die 102 is relatively moveable with respect to the target along a direction that is parallel to either axis 106 or 108.

[0040] Regions that are without flow structures are provided between successive fluidic cells 104 along both the first axis 106 and the second axis 108. Such regions are not used by the fluidic cells 104 for fluid flow. The circuit elements (control circuit elements and/or sense elements) are placed in the regions between the fluidic cells 104. As a result, the circuit elements are interspersed with the fluidic cells 104 along both the axes 106 and 108. The elements of the fluidic cells 104 being interspersed with the circuit elements result in an alternating arrangement of fluidic elements and circuit elements along the different axes 106 and 108.

[0041] By alternating the fluidic elements with the circuit elements (control circuit elements and/or sense elements) in multiple different axes, more space on the substrate 110 of the fluidic die 102 is provided to accommodate the circuit elements while still allowing for a sparse arrangement of the fluidic cells 104, in some examples.

[0042] The fluidic cells 104 and the circuit elements (control circuit elements and/or sense elements) are formed on a common substrate, i.e., the substrate 110 of the fluidic die 102. The substrate 110 can be a silicon substrate, or a substrate formed of another semiconductor material or a different material. Forming the fluidic cells 104 and the circuit elements on a common substrate refers to forming layers of the fluidic cells 104 and the circuit elements as part of an integrated circuit processing flow for a single integrated circuit device, which in Fig. 1 is the fluidic die 102. Circuit elements and fluidic cells 104 formed on different substrates, such as being part of different integrated circuit devices formed using different integrated circuit process flows, would not be considered to be formed on a common substrate.

[0043] Fig. 2 is a schematic sectional view of a portion of a fluidic die 200 attached to an interposer 240 or another type of structure, according to further examples. The fluidic die 200 includes layers 206, 208, 218, and 224. A "layer" (any of 206, 208, 218, and 224) can include a single layer or multiple layers, possibly formed of different materials. The layers 224 and 218 make up a substrate for the fluidic die 200. The layers 224 and 218 can include epoxy-based photoresist (e.g., SU-8), silicon, another semiconductor material, or a different material.

[0044] Fig. 2 shows layers of a fluidic cell 204 and a circuit element (202 represents sense/control circuit element layers, such as layers of an active device or multiple active devices for a sense element and/or a control circuit element). The sense/control circuit element layers 202 can include any or some combination of metal layers, polysilicon layers, doped regions, and so forth. Doped regions can be formed into the layer 218. Metal layers and polysilicon layers of active devices can be formed over the doped regions. A thin film interconnect layer or layers 230 (including a metal or another electrically conductive material) can be formed over the layer 218, where the thin film interconnect layer 230 can form an electrical contact or via to electrically connect to an active device.

[0045] The fluidic cell 204 can be arranged in similar manner as the fluidic cell 104 of Fig. 1 (i.e., multiple fluidic cells 204 can be arranged in an array along multiple axes, such as the axes 106 and 108 shown in Fig. 1). The circuit elements formed using sense/control circuit element layers 202 can also be interspersed with the fluidic cells 204 along multiple different axes.

[0046] The fluidic cell 204 includes an orifice layer 206 in which an orifice 207 (or multiple orifices) is (are) formed. A chamber layer 208 is provided under the orifice layer 206, and the chamber layer 208 defines a fluid chamber 210. The layers 206 and 208 can include any of various different types of materials, such as epoxy, silicon, and so forth.

[0047] A fluidic actuator 212 is formed over the layer 218 in the fluid chamber 210. If the fluidic actuator is a resistive heater, the fluidic actuator 212 can be formed using a thin film of an electrically resistive material (such as tungsten-silicon nitride, polysilicon or any other material that exhibits electrical resistivity). Activation of the fluidic actuator 212 causes fluid in the fluid chamber 210 to be expelled through the orifice 207.

[0048] In some examples, the sense/control circuit element layers 202 are formed on the substrate (including layers 224 and 218) of the fluidic die 200 before various layers of the fluidic cell 204. A layer is on the substrate if the layer is directly on the substrate, or if the layer is supported by the substrate through other layer(s). The chamber layer 208 is formed over the layer 218 as well as over thin film layers (the thin film layer for the fluidic actuator 212 and the thin film interconnect layer 230). Thus, in Fig. 2, the sense/control circuit element layers 202 are formed over the substrate (including layers 224 and 218) prior to the layers 208 and 206 for the fluidic cell 204. After the sense/control circuit element layers 202 are formed over the substrate, the thin film layers (the thin film layer for the fluidic actuator 212 and the thin film interconnect layer 230) are formed, followed by the fluidic cell layers 208 and 206 over the sense/control circuit element layers 202.

[0049] In some examples, a sense element can include an active device that is connected to a sensor. In some examples, the sensor can include an electrode (formed of a thin film layer similar to the thin film interconnect layer 230) that is the fluid chamber 210 such that the electrode is in contact with the fluid in the fluid chamber 210. In such examples, the sense element can measure a property (e.g., an impedance, etc.) of the fluid in the fluid chamber 210. In such examples, the sense element can measure the property of the fluid in the fluid chamber 210 directly. In other examples, the sense element can be connected to a sensor (e.g., a temperature sensing resistor, a temperature sensing diode, a strain sensor, etc.), which senses a property of a part of the fluidic die. In such examples, the sense element can measure a property of a fluidic element indirectly (e.g., a temperature of the fluidic die around the fluidic element may provide an indication of a temperature of a fluid in the fluidic element).

[0050] In the example of Fig. 2, two fluid feed holes 214 and 216 are formed in a feed hole layer 218 (by etching the feed hole layer 218 to form the fluid feed holes, for example). The fluid feed hole 214 is an inlet fluid feed hole that allows fluid to flow into the fluid chamber 210. The fluid feed hole 216 is an outlet fluid feed hole from which fluid in the fluid chamber 210 flows. The inlet fluid feed hole 214 is in communication with a high pressure chamber 220, and the outlet fluid feed hole 216 is in communication with a low pressure chamber 222. The high pressure chamber 220 and the low pressure chamber 222 are formed in a layer 224 (by etching the layer 224 to form the chambers 220 and 222, for example). The high pressure chamber 220 is divided from the low pressure chamber 222 by a wall 221 of the layer 224.

[0051] The pressure in the high pressure chamber 220 and the pressure in the low pressure chamber 222 can be controlled by respective pressure regulators (not shown). The high pressure chamber 220 has a pressure that is higher than the pressure of the low pressure chamber 222.

[0052] The arrangement of the fluidic cell 204 allows for fluid recirculation along fluid path 226. Fluid can flow from the high pressure chamber 220 into the inlet fluid feed hole 214, which is then passed to the fluid chamber 210. The fluid exits from the fluid chamber 210 through the outlet fluid feed hole 216 to the low pressure chamber 222.

[0053] Recirculation can be performed to carry any contaminants or non-homogeneity of the fluid in the fluid chamber 210 out of the fluid chamber 210 to be replaced by fresh and uncontaminated fluid. In other examples, recirculation of fluid through the fluid chamber 210 can be performed for other purposes.

[0054] Although a specific arrangement is shown in Fig. 2 to enable fluid recirculation in the fluidic cell 204, recirculation can be enabled using other arrangements in other examples.

[0055] The sense/control circuit element layers 202 are formed in a region 250 that is devoid of flow structures of the fluid cell 204. The region 250 is between successive fluidic cells 204 in each of multiple axes, such as axes 106 and 108 shown in Fig. 1.

[0056] The interposer 240 is a structure that is attached to the fluidic die 200. The interposer 240 can include fluid flow channels (not shown) to communicate fluid with the chambers 220 and 222. The interposer 240 can be a die that is separate from the fluidic die 200.

[0057] Fig. 3 is a block diagram of a portion of a fluidic die according to further examples, in which fluidic cells 304, sense elements (represented by blocks labeled with "S") and control circuit elements (represented by blocks labeled with a "C") are interspersed along different axes 306 and 308. The fluidic cells 304 in Fig. 3 have a stepped arrangement with respect to the axis 306. Thus, unlike the arrangement of Fig. 1 where the fluidic cells 104 are aligned in rows and columns that are generally parallel to the respective axes 106 and 108, the arrangement of the fluidic cells 304 in Fig. 3 is a stepped arrangement in which the fluidic cells 304 are stepped downwardly with respect to the axis 306 such that a line of fluidic cells 304 (extending generally along 320) is not parallel to the axis 306. The line (320) of fluidic cells is angled (slanted) with respect to the axis 306. In the stepped arrangement, each successive fluidic cell 304 along the line 320 is shifted downwardly (along the axis 308) from the immediately preceding fluidic cell 304 along the line 320, so that the line 320 of fluidic cells 304 progressively step downwardly along the axis 308 relative to the axis 306.

[0058] Along the orthogonal axis 308, the fluidic cells 304 are lined up generally parallel to the axis 308.

[0059] Each fluidic cell 304 includes fluid feed holes 310 and 312 (e.g., similar to the fluid feed holes 214 and 216 shown in Fig. 2). Also, each fluidic cell 304 includes orifices 314 and 316. For example, the orifice 314 is larger than the orifice 316.

[0060] Fig. 4 is a flow diagram of a process 400 of forming a fluidic die (e.g., a fluidic die according to Fig. 1, 2, or 3) according to some examples.

[0061] The process 400 includes forming (at 402) layers for sense elements on a substrate. Forming the layers for the sense elements includes forming layers for active devices in the sense elements. Additionally, in some examples, the process 400 includes forming electrodes for the sense elements, where the electrodes are arranged to be in fluid contact with the fluid in the fluidic elements.

[0062] The process 400 includes forming (at 404) layers for fluidic elements over the layers for the sense elements, where the fluidic elements are to dispense a fluid, an arrangement of the fluidic elements across the substrate has regions without flow structures between successive fluidic elements, and each fluidic element of the fluidic elements includes a fluidic actuator and a fluid chamber, and where the sense elements are to sense a property of the fluidic elements.

[0063] The process 400 includes interspersing (at 406) the sense elements in the regions between the fluidic elements along different axes of the fluidic die.

[0064] The process 400 includes forming (at 408) an array of fluid feed holes in a plurality of dimensions to communicate the fluid with the fluidic elements, where each of multiple fluid feed holes along a first dimension of the plurality of dimensions is distinct from multiple fluid feed holes along a second dimension of the plurality of dimensions.

[0065] Fig. 5 is a block diagram of a fluidic die 500 including a substrate 502 and an arrangement of fluidic elements 504 on the substrate 502 to dispense a fluid, each fluidic element of the fluidic elements 504 including a fluidic actuator 520 and a fluid chamber 522. The arrangement of fluidic elements 504 includes first fluidic elements along a first axis 506 across the substrate 502, and second fluidic elements along a different second axis 508 across the substrate 502.

[0066] The fluidic die 500 further includes sense elements 510 on the substrate 502 to sense a property of the fluid in the fluidic elements 504. The sense elements 510 are interspersed between the fluidic elements 504 along each of the first axis 506 and the second axis 508. The sense elements 510 include greater than 10 first sense elements along the first axis 506 in first regions between successive first fluidic elements 504, and greater than 10 sense circuit elements along the second axis 508 in second regions between successive second fluidic elements 504.

[0067] The fluidic elements 504 and the sense elements 510 include integrated circuit layers commonly formed on the substrate 502.

[0068] Interspersed arrangements of fluidic elements and sense/control circuit elements according to some examples of the present disclosure may provide various benefits. For example, greater space is provided on the substrate of a fluidic die to accommodate sense/control circuit elements in a sparse arrangement of fluidic elements. Also, sense/control circuit elements being placed closer to fluidic elements can reduce parasitic impedances in signals transmitted or received by the sense/control circuit elements. Interspersing sense/control circuit elements with fluidic elements allows for a greater density of the sense/control circuit elements without increasing the overall size of a fluidic die.

[0069] In the foregoing description, numerous details are set forth to provide an understanding of the subject disclosed herein. However, implementations may be practiced without some of these details. Other implementations may include modifications and variations from the details discussed above. It is intended that the appended claims cover such modifications and variations.

What is claimed is:

1. A fluidic die comprising:

an arrangement of fluidic elements to dispense a fluid, each fluidic element of the fluidic elements comprising a fluidic actuator and a fluid chamber;

an array of fluid feed holes in a plurality of dimensions to communicate the fluid with the fluidic elements, wherein each of multiple fluid feed holes along a first dimension of the plurality of dimensions is distinct from multiple fluid feed holes along a second dimension of the plurality of dimensions; and

sense elements to sense a property of the fluidic elements, the sense elements interspersed in regions between the fluidic elements along different axes of the fluidic die.

2. The fluidic die of claim 1, wherein each sense element of the sense elements comprises an amplifier.

3. The fluidic die of claim 1, wherein each sense element of the sense elements comprises an electrical current source.

4. The fluidic die of claim 1, wherein each sense element of the sense elements comprises a voltage reference circuit.

5. The fluidic die of claim 1, wherein each sense element of the sense elements comprises an active device to be connected to a sensor of the fluidic die.

6. The fluidic die of claim 1, wherein the arrangement of the fluidic elements comprises:

first fluidic elements extending along a first axis of the different axes, wherein first regions without flow structures are provided between fluidic elements of the first fluidic elements, and

second fluidic elements extending along a second axis of the different axes, wherein second regions without flow structures are provided between fluidic elements of the second fluidic elements, and

wherein the sense elements comprise:

first sense elements in the first regions, and

second sense elements in the second regions.

7. The fluidic die of claim 1, further comprising:

control circuit elements to control fluidic actuators in the fluidic elements, wherein the control circuit elements are interspersed in the regions between the fluidic elements along the different axes of the fluidic die.

8. The fluidic die of claim 1, wherein the different axes are substantially orthogonal axes.

9. The fluidic die of claim 1, wherein a first quantity of sense elements interspersed in regions between the fluidic elements along a first axis of the different axes is greater than 10, and a second quantity of sense elements interspersed in regions between the fluidic elements along a second axis of the different axes is greater than 10.

10. A method of forming a fluidic die, comprising:

forming layers for sense elements on a substrate;

forming layers for fluidic elements over the layers for the sense elements, wherein the fluidic elements are to dispense a fluid, an arrangement of the fluidic elements across the substrate has regions without flow structures between successive fluidic elements, and each fluidic element of the fluidic elements comprises a fluidic actuator and a fluid chamber, and wherein the sense elements are to sense a property of the fluidic elements;

interspersing the sense elements in the regions between the fluidic elements along different axes of the fluidic die; and

forming an array of fluid feed holes in a plurality of dimensions to communicate the fluid with the fluidic elements, wherein each of multiple fluid feed holes along a first dimension of the plurality of dimensions is distinct from multiple fluid feed holes along a second dimension of the plurality of dimensions.

11. The method of claim 10, wherein forming the layers for the sense elements comprises forming layers for active devices in the sense elements.

12. The method of claim 11, further comprising forming electrodes for the sense elements, the electrodes arranged to be in fluid contact with the fluid in the fluidic elements.

13. The method of claim 10, wherein forming the layers for the sense elements comprises forming layers for a circuit element selected from among an amplifier, an electrical current source, and a reference voltage circuit.

14. A fluidic die comprising:

an arrangement of fluidic elements to dispense a fluid, each fluidic element of the fluidic elements comprising a fluidic actuator and a fluid chamber, wherein the arrangement of fluidic elements comprise first fluidic elements along a first axis across a substrate, and second fluidic elements along a different second axis across the substrate; and

sense elements to sense a property of the fluid in the fluidic elements, the sense elements interspersed between the fluidic elements along each of the first axis and the second axis, and wherein the sense elements comprise greater than 10 first sense elements along the first axis in first regions between successive first fluidic elements, and greater than 10 sense circuit elements along the second axis in second regions between successive second fluidic elements.

15. The fluidic die of claim 14, further comprising a substrate on which the fluidic elements and the sense elements are commonly formed.

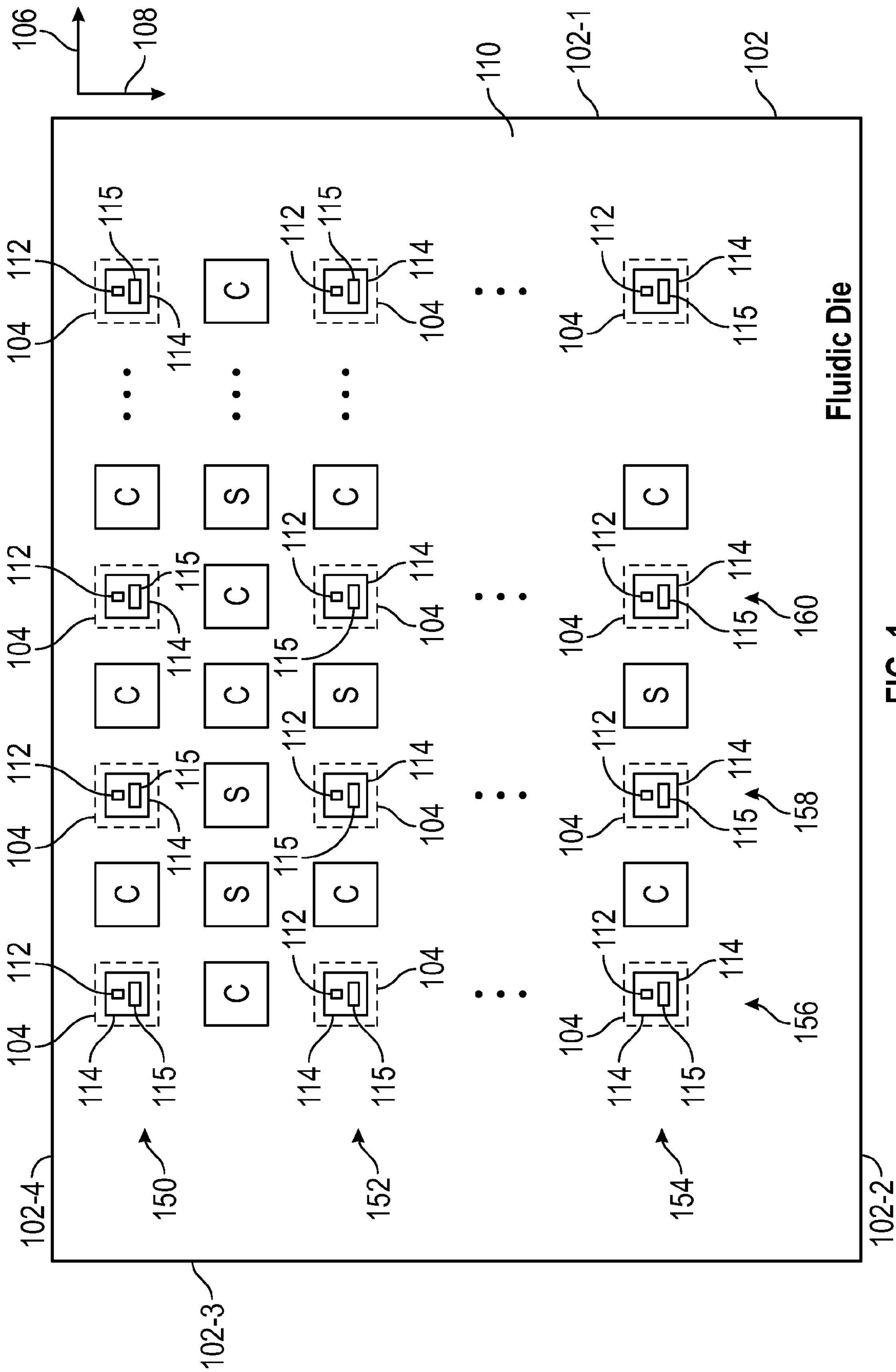
Fluidic Die
C
S
102
102-1
102-2
102-3
102-4
104
106
108
110
112
114
115
150
152
154
156
158
160

FIG. 1

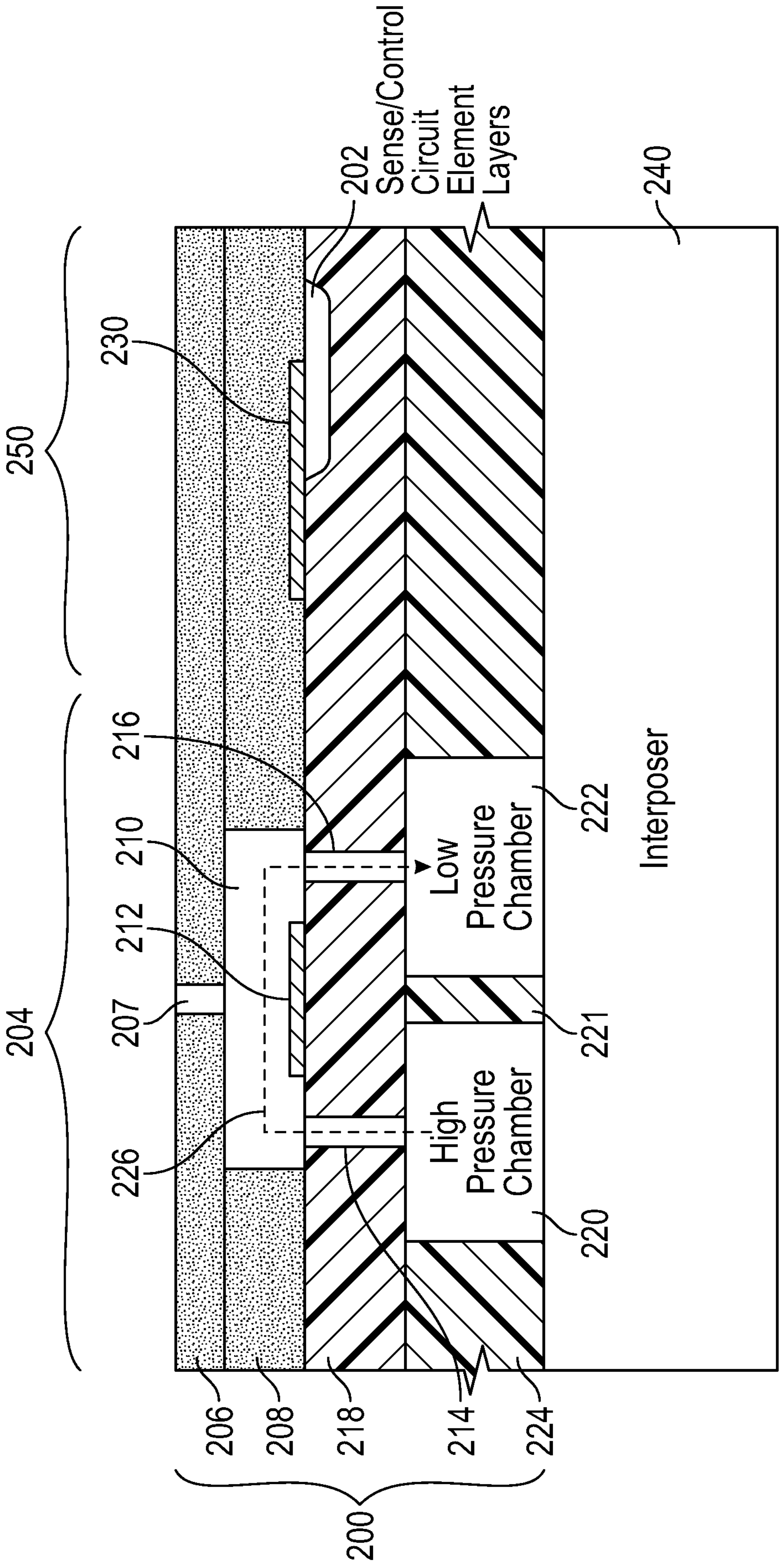
202
Sense/Control
Circuit
Element
Layers
240
230
250
216
210
212
207
204
226
Low
Pressure
Chamber
222
High
Pressure
Chamber
220
221
Interposer
206
208
218
214
224
200

FIG. 2

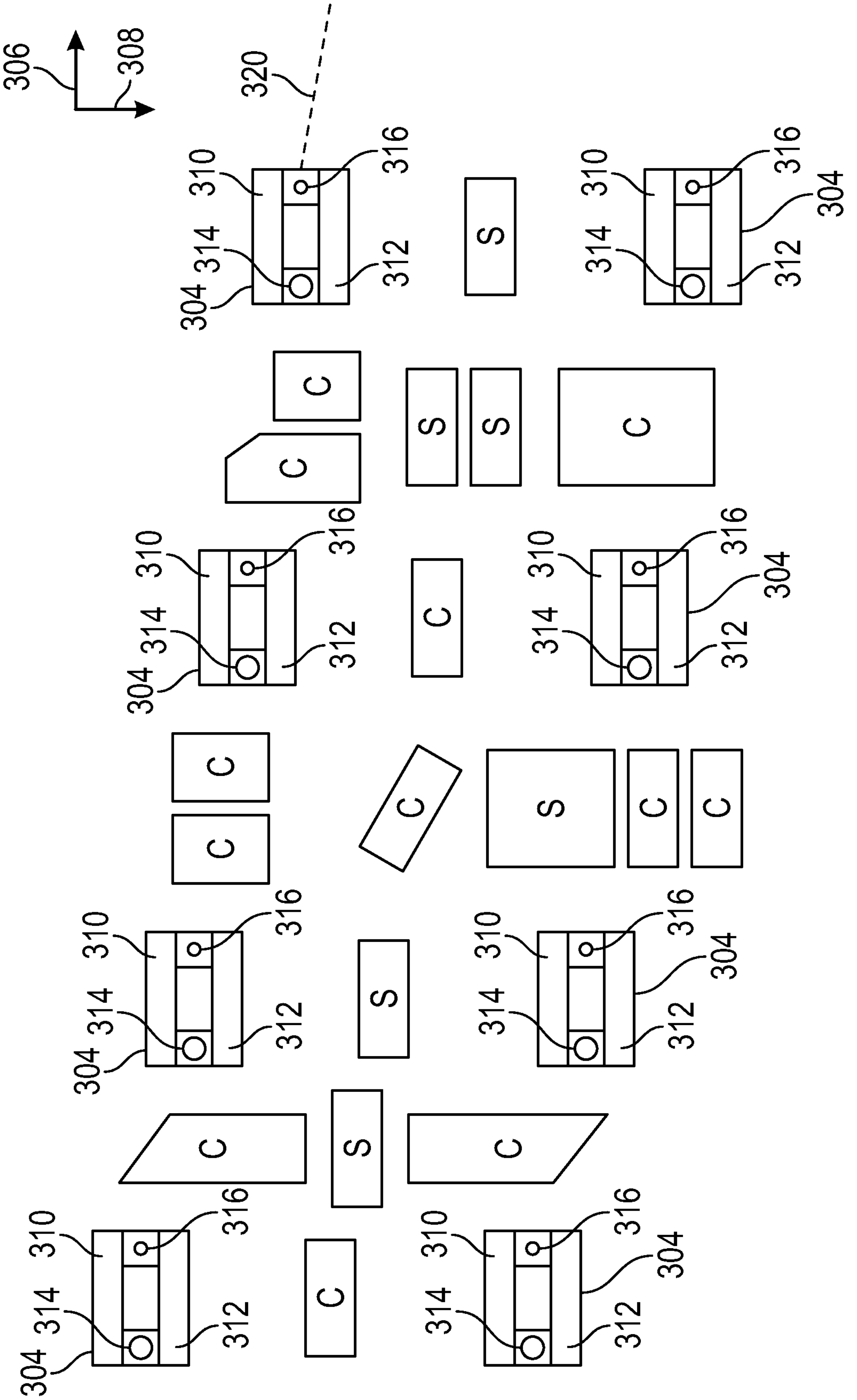

FIG. 3

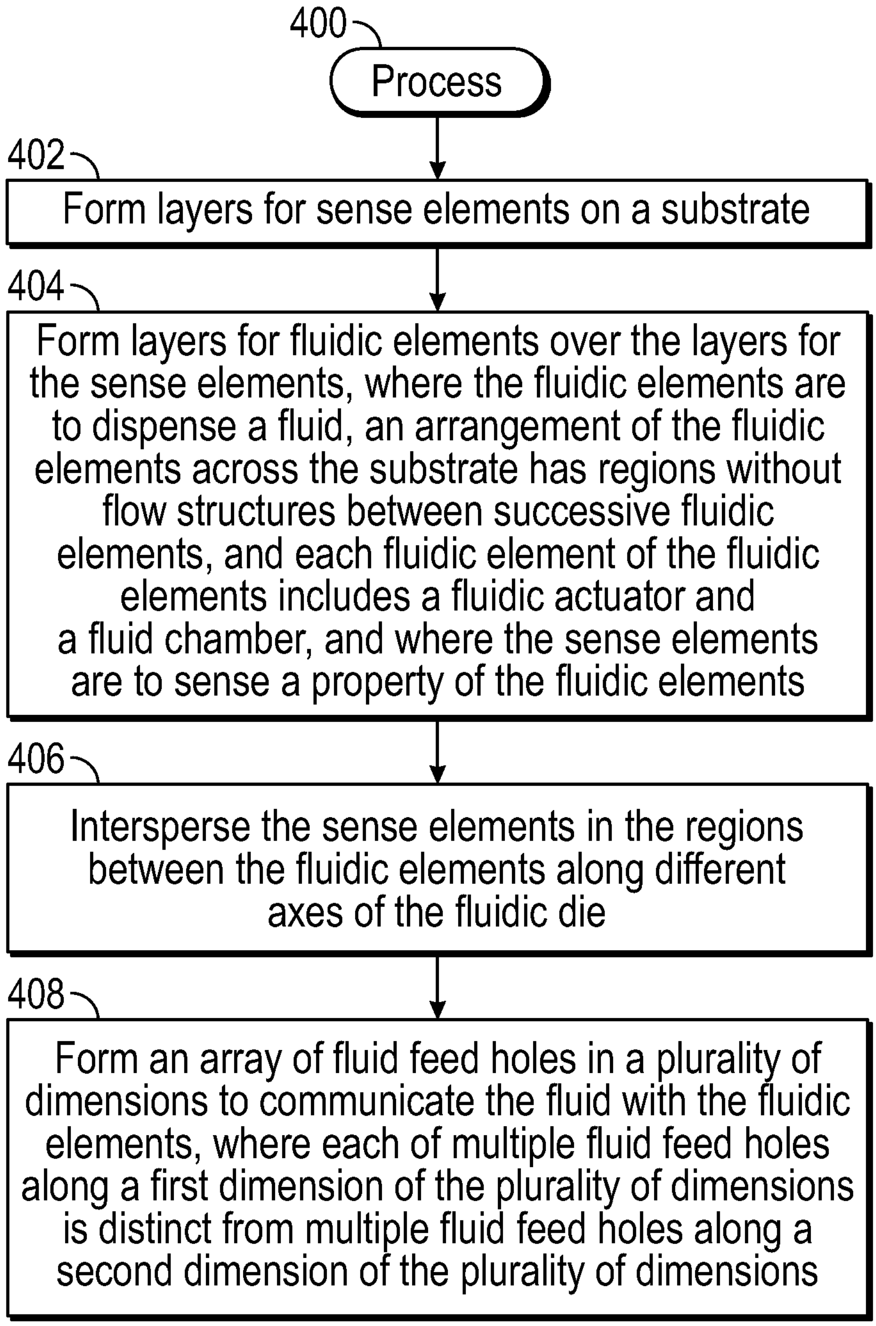
400
Process
402
Form layers for sense elements on a substrate
404
Form layers for fluidic elements over the layers for the sense elements, where the fluidic elements are to dispense a fluid, an arrangement of the fluidic elements across the substrate has regions without flow structures between successive fluidic elements, and each fluidic element of the fluidic elements includes a fluidic actuator and a fluid chamber, and where the sense elements are to sense a property of the fluidic elements
406
Intersperse the sense elements in the regions between the fluidic elements along different axes of the fluidic die
408
Form an array of fluid feed holes in a plurality of dimensions to communicate the fluid with the fluidic elements, where each of multiple fluid feed holes along a first dimension of the plurality of dimensions is distinct from multiple fluid feed holes along a second dimension of the plurality of dimensions

FIG. 4

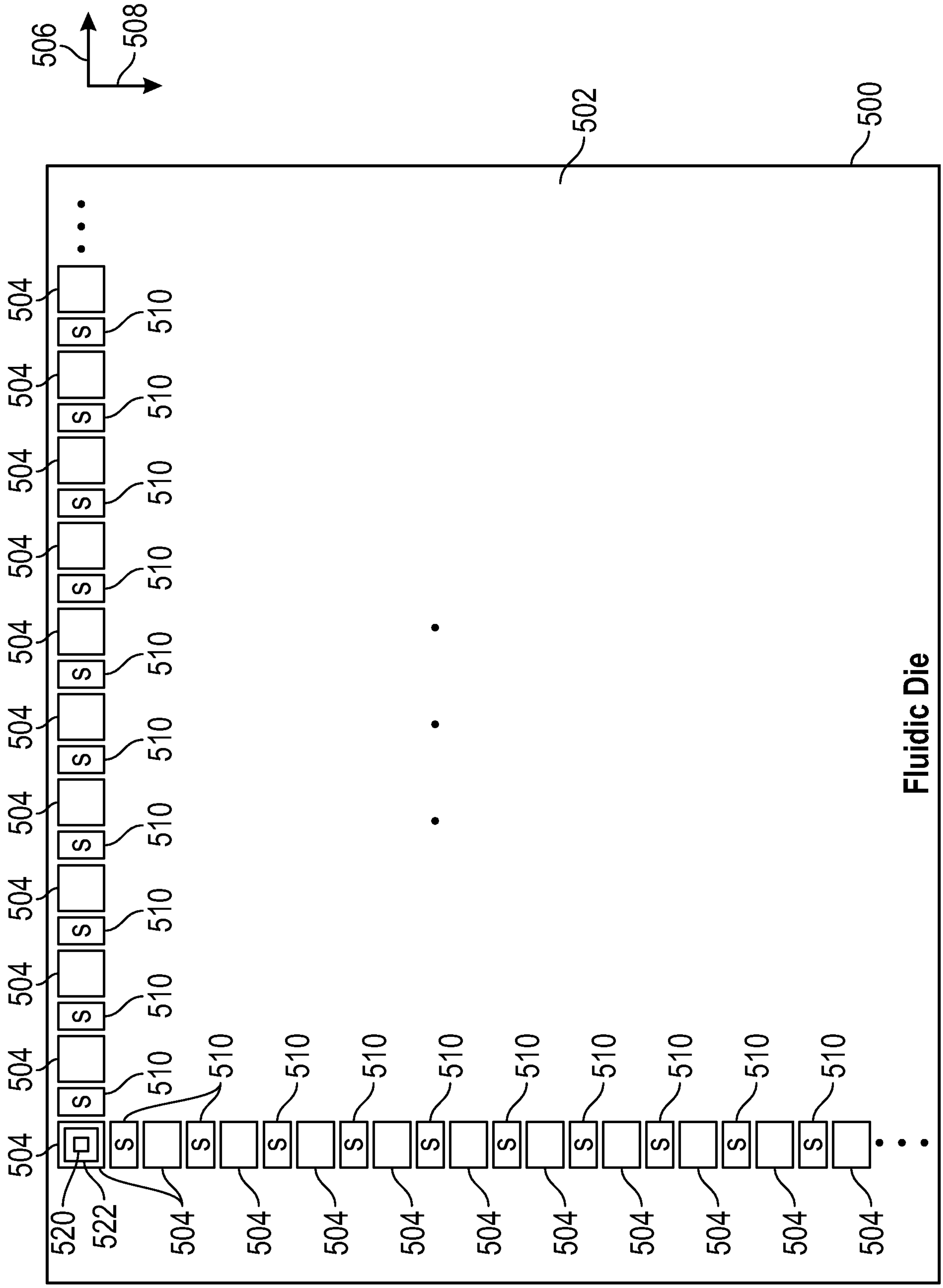

FIG. 5

INTERNATIONAL SEARCH REPORT	International application No. PCT/US 2020/057114

A. CLASSIFICATION OF SUBJECT MATTER

B41J 2/14 *(2006.01)*
B41J 2/045 *(2006.01)*
B41J 2/16 *(2006.01)*
B41J 29/393 *(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)

B41J 2/00-2/525, 29/393

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)

PatSearch (RUPTO Internal), USPTO, PAJ, Espacenet, Information Retrieval System of FIPS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2019/221707 A1 (HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.) 21.11.2019, paragraphs [0023], [0029], [0039], [0046]	1-15
A	WO 2018/186850 A1 (HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.) 11.10.2018, paragraphs [0033], [0044]	1-15
A	US 2020/0139709 A1 (HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P). 07.05.2020, abstract	1-15
A	US 2017/0355188 A1 (HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.) 14.12.2017, abstract	1-15

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

* Special categories of cited documents:

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"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
21 May 2021 (21.05.2021)	03 June 2021 (03.06.2021)

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