(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 434 749 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
25.09.2024 Bulletin 2024/39

(21) Application number: **23207533.3**

(22) Date of filing: **02.11.2023**

(51) International Patent Classification (IPC):
B41J 2/14 $^{(2006.01)}$ ***B41J 2/16*** $^{(2006.01)}$

(52) Cooperative Patent Classification (CPC):
B41J 2/14274; B41J 2/1612; B41J 2/1623; B41J 2/1632; B41J 2/1643; B41J 2002/14403; B41J 2002/14491

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(30) Priority: **24.03.2023 JP 2023048753**

(71) Applicant: **Toshiba Tec Kabushiki Kaisha**
Shinagawa-ku
Tokyo 141-8562 (JP)

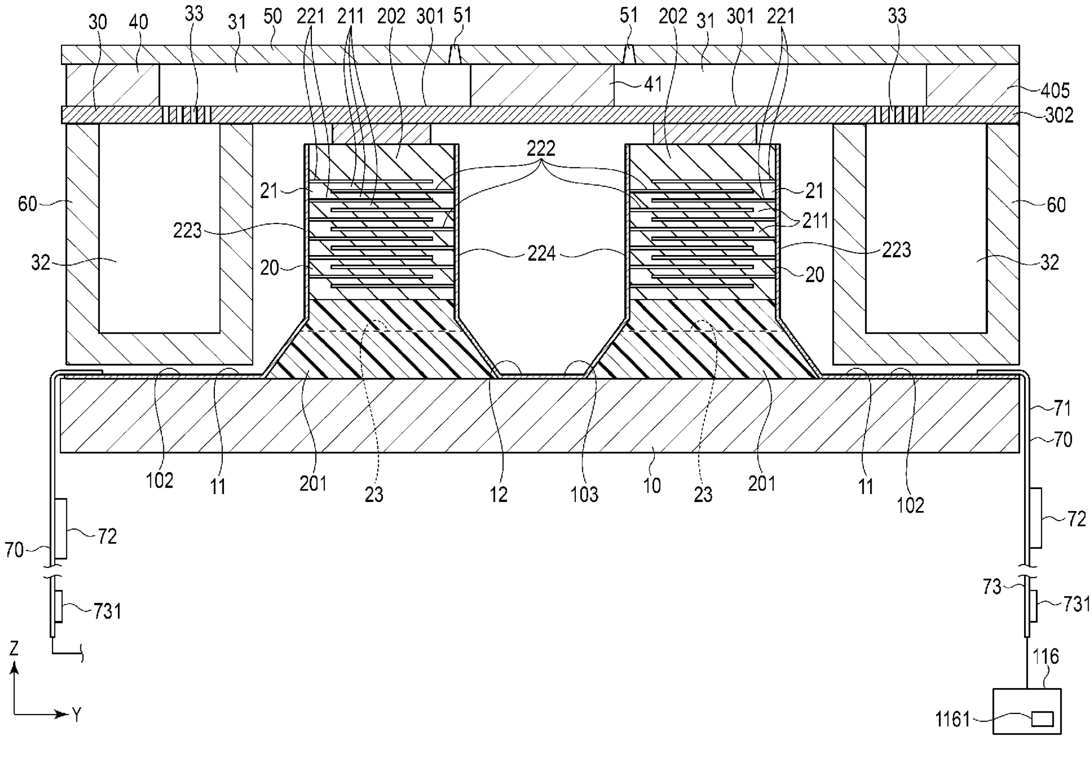
(72) Inventor: **Shimosato, Masashi**
141-8562 Tokyo (JP)

(74) Representative: **Bandpay & Greuter**
11 rue Christophe Colomb
75008 Paris (FR)

(54) LIQUID EJECTION HEAD AND LIQUID EJECTION DEVICE

(57) An objective is to provide a liquid ejection head and a liquid ejection device that can achieve improvement in installability and ejection performance. A liquid ejection head according to an embodiment includes a piezoelectric member, a substrate, an electrode, and a support member. The piezoelectric member is formed of a piezoelectric material and includes a plurality of grooves and a plurality of piezoelectric elements arranged via the grooves. A wiring is formed on the substrate. The support member is arranged between the substrate and the piezoelectric elements and is formed of a resin material. The electrode is formed on a surface of the piezoelectric member.

FIG. 1



EP 4 434 749 A1

Description

FIELD

[0001] Embodiments described herein relate generally to a liquid ejection head and a liquid ejection device.

BACKGROUND

[0002] As a drive source of a liquid ejection device such as an inkjet printer head, a piezoelectric actuator using a piezoelectric body such as PZT is used. For example, in a piston-type inkjet head, an actuator member that is processed in advance is arranged by bonding or the like at a movable part near a pressure chamber, on a per nozzle array basis. A plurality of columnar piezoelectric elements split by forming a plurality of grooves on each actuator member serve as an actuator corresponding to each nozzle. For example, one external electrode of the actuator serves as an individual electrode to which a drive voltage is individually applied and the other external electrode serves as a common electrode to which constantly the same voltage (including 0) is applied. The individual electrodes of the plurality of actuators are separated from each other and the common electrodes thereof are coupled together. For example, a corner on one side of the piezoelectric body may be cut out to separate the individual electrodes. Since the piezoelectric element is fragile and fine-shaped, it is difficult to secure the installability of such an actuator.

[0003] In such an inkjet head, if a common chamber communicating with a plurality of pressure chambers is small, disadvantages occur in terms of performance, such as the occurrence of a crosstalk due to a pressure wave leaking out of the pressure chamber, or a delay in the refilling of an ejection ink, obstructing high-speed drive. Therefore, the capacity of the common chamber needs to be secured. For example, if actuator members are arranged at a substrate and a common chamber communicating with a plurality of pressure chambers is arranged between the substrate and the pressure chambers, the height of the piezoelectric body limits the common chamber in the direction of height. Therefore, to increase the capacity of the common chamber, the common chamber needs to be expanded in a planar direction and the area of the head needs to be increased. Meanwhile, if the dimension in the direction of height of the piezoelectric member is increased, the piezoelectric body increases in size, which is disadvantageous in terms of costs. Also, since the depth of the grooves becomes larger, the processing becomes difficult and the columnar piezoelectric elements become fragile.

DISCLOSURE OF INVENTION

[0004] To this end, there is provided a liquid ejection head comprising: a piezoelectric member formed of a piezoelectric material and comprising a plurality of grooves and a plurality of piezoelectric elements arranged via the grooves; a substrate with a wiring formed thereon; a support member arranged between the substrate and the piezoelectric elements and formed of a resin material; and an electrode formed on a surface of the piezoelectric member.

[0005] Preferred embodiments of the liquid ejection head are set out in dependent claims.

[0006] There is also provided a liquid ejection device comprising the above liquid ejection head.

[0007] There is also provided a method for manufacturing the above liquid inkjet head. Preferred embodiments of the method are set out in dependent claims.

DESCRIPTION OF THE DRAWINGS

[0008]

FIG. 1 is a cross-sectional view showing the configuration of an inkjet head according to an embodiment.
FIG. 2 is a cross-sectional view showing the configuration of the inkjet head.
FIG. 3 is an explanatory view showing a manufacturing method for the inkjet head.
FIG. 4 is an explanatory view showing the manufacturing method.
FIG. 5 is an explanatory view showing the manufacturing method.
FIG. 6 is an explanatory view showing the manufacturing method.
FIG. 7 is an explanatory view showing the manufacturing method.
FIG. 8 is an explanatory view showing a schematic configuration of an inkjet recording device.

DETAILED DESCRIPTION

[0009] An embodiment described herein is to provide a liquid ejection head and a liquid ejection device that can achieve improvement in installability and ejection performance.

[0010] In general, according to one embodiment, a liquid ejection head includes a piezoelectric member, a substrate, an electrode, and a support member. The piezoelectric member is formed of a piezoelectric material and includes a plurality of grooves and a plurality of piezoelectric elements arranged via the grooves. A wiring is formed on the substrate. The support member is arranged between the substrate and the piezoelectric elements and is formed of a resin material. The electrode is formed on a surface of the piezoelectric member.

[0011] An inkjet head 1, which is a liquid ejection head according to an embodiment, and an inkjet recording device 100, which is a liquid ejection device, will now be described with reference to FIGS. 1 to 8. FIGS. 1 and 2 are cross-sectional views showing a schematic configuration of the inkjet head 1. FIGS. 3 to 7 are explanatory views showing a manufacturing method for the inkjet head. FIG. 8 is an explanatory view showing a schematic configuration of the inkjet recording device 100. In the drawings, X, Y, Z represent three directions orthogonal to each other. In the drawings, a configuration is enlarged, reduced, or omitted where appropriate, for the sake of explanation.

[0012] As shown in FIGS. 1 and 2, the inkjet head 1 has a substrate 10, a pair of actuator units 20, a flow path member 40, a nozzle plate 50 provided with a plurality of nozzles 51, a frame unit 60, and a drive circuit 70.

[0013] In an example, the inkjet head 1 has two actuator units 20 and has two nozzle arrays in which a plurality of nozzles 51 are arrayed in a direction of array (X-direction), two pressure chamber arrays in which a plurality of pressure chambers 31 are arrayed in the direction of array, and two element arrays in which a plurality of piezoelectric elements 21, 22 are arrayed in the direction of array. In this embodiment, an example where the direction in which a plurality of piezoelectric layers 211 are stacked, the direction of vibration of the piezoelectric element 21, and the direction of vibration of a vibration plate 30 are laid along the Z-direction, is described.

[0014] The substrate 10 is a circuit board that supports the pair of actuator units 20. The substrate 10 is made of, for example, alumina and formed in a plate-like shape, and has a mounting surface laid along a direction of extension and a direction of juxtaposition. On the mounting surface of the substrate 10, where the actuator units 20 are installed, electrode layers 11, 12 are formed. For example, on the mounting surface of the substrate 10, the electrode layer 11 forming an individual electrode is formed in an outer area on the side opposite to the side where the pair of actuator units 20 face each other, and the electrode layer 12 forming a common electrode is formed in an inner area where the pair of actuator units 20 face each other.

[0015] For example, as the electrode layer 11 is separated in the outer area at both ends in the direction of extension on the mounting surface of the substrate 10, a predetermined wiring pattern having a plurality of individual wirings 102 (wiring) is formed. For example, the individual wiring 102 continues to an external electrode 223 (electrode) formed at one side surface part of the surfaces of the actuator unit 20 and thus forms an individual electrode.

[0016] Also, on the mounting surface of the substrate 10, the electrode layer 12 formed in the inner area between the pair of actuator units 20 forms a common wiring 103 (wiring). The common wiring 103 continues to an external electrode 224 (electrode) formed at the other side surface part of the surfaces of the actuator unit 20 and thus forms a common electrode.

[0017] The actuator units 20 are joined to the mounting surface, which is on one side of the substrate 10. For example, the two actuator units 20 are arranged, juxtaposed in the Y-direction.

[0018] As shown in FIGS. 1 to 4, the actuator unit 20 has a support member 201 and a piezoelectric member 202. The actuator unit 20 has a plurality of drive piezoelectric elements 21 and a plurality of non-drive piezoelectric elements 22 arrayed alternately along the direction of array and serving as an actuator, and a coupling part 26 coupling these pluralities of piezoelectric elements 21, 22 as a unified body on the side of the substrate 10.

[0019] The support member 201 is a block-like member joined to the mounting surface of the substrate 10 and is formed in a trapezoidal shape increasing in width dimension toward the substrate 10. The support member 201 is formed of, for example, a resin material used for a PC board, and is formed of, for example, PPS (polyphenylene sulfide), glass epoxy or the like. The support member 201 is arranged between the piezoelectric member 202 and the substrate 10 and supports the piezoelectric member 202 on top of the substrate 10.

[0020] The piezoelectric member 202 is joined to the top of the support member 201. The piezoelectric member 202 is a multilayer piezoelectric member formed of a plurality of piezoelectric layers 211 and a plurality of internal electrodes 221, 222 stacked together.

[0021] In the actuator unit 20, the plurality of drive piezoelectric elements 21 and the plurality of non-drive piezoelectric elements 22 are arrayed at a predetermined interval in one direction.

[0022] In an example, the plurality of drive piezoelectric elements 21 and the plurality of non-drive piezoelectric elements 22 have a rectangular parallelepiped column part and a trapezoid part spreading toward the substrate. The actuator unit 20 is divided into a plurality of parts by a plurality of grooves 23. The plurality of drive piezoelectric elements 21 and non-drive piezoelectric elements 22 are arrayed at the same pitch in the direction of array, for example, via the grooves 23 with the same width.

[0023] The groove 23 divides the full length of the piezoelectric member 202 and is formed to a depth that reaches an intermediate part of the support member 201. For example, when forming the groove 23 from one side of the Z-direction of the piezoelectric member 202, the depth of the groover 23 is set to be deeper than the end part on the substrate 10 side of the piezoelectric member 202 and to reach the support member 201.

[0024] For example, in the plurality of drive piezoelectric elements 21 and the plurality of non-drive piezoelectric elements 22, each of the parts formed of the piezoelectric member is formed in a rectangular shape whose lateral direction is laid along the direction of array of the element array and whose longitudinal direction is laid along the direction of extension orthogonal to the direction of array and the Z-direction, as viewed in a plan view from the Z-direction. Also, in the plurality of drive piezoelectric elements 21 and the plurality of non-drive piezoelectric elements 22, the part formed of the support member 201 is formed in a trapezoidal shape spreading toward the substrate.

[0025] The drive piezoelectric elements 21 are arrayed at positions respectively facing the plurality of pressure chambers 31 formed in the flow path member 40, in the Z-direction. In an example, the center position in the direction of array and the direction of extension of the drive piezoelectric element 21 and the center position in the direction of array and the direction of extension of the pressure chamber 31 are arrayed, juxtaposed in the Z-direction.

[0026] The non-drive piezoelectric elements 22 are arrayed at positions respectively facing a plurality of partition parts 42 formed in the flow path member 40, in the Z-direction. In an example, the center position in the direction of array and the direction of extension of the non-drive piezoelectric element 22 and the center position in the direction of array and the direction of extension of the partition part 42 are arrayed, juxtaposed in the Z-direction.

[0027] For example, in the actuator unit 20, the piezoelectric member 202 and the support member 201 joined to the substrate 10 in advance are diced from the end surface on the side opposite to the substrate 10 side to form the groove 23, and the plurality of piezoelectric elements 21, 22 formed in the rectangular columnar shape are thus formed at a predetermined interval. The plurality of columnar piezoelectric elements 21, 22 thus formed and the support member 201 are provided with an electrode or the like. The plurality of drive piezoelectric elements 21 and the plurality of non-drive piezoelectric elements 22, which are alternately arranged, are thus formed. The plurality of drive piezoelectric elements 21 and the plurality of non-drive piezoelectric elements 22 are alternately juxtaposed and arranged via the groove 23 in the direction of array.

[0028] For example, the piezoelectric member 202 forming the actuator unit 20 is a multilayer piezoelectric member formed of a multilayer piezoelectric body and is formed by stacking and sintering sheet-like piezoelectric materials.

[0029] The piezoelectric member 202 is, for example, a multilayer piezoelectric member. The drive piezoelectric element 21 and the non-drive piezoelectric element 22 have the plurality of piezoelectric layers 211 stacked together and the internal electrodes 221, 222 formed at the main surface of each piezoelectric layer 211. In an example, the drive piezoelectric element 21 and the non-drive piezoelectric element 22 have the same multilayer structure. The drive piezoelectric element 21 and the non-drive piezoelectric element 22 have the external electrodes 223, 224 formed on the surface.

[0030] The piezoelectric layer 211 is, for example, formed in a thin plate-like shape and made of a piezoelectric ceramic material such as a PZT (lead zirconate titanate)-based material or a lead-free KNN (potassium sodium niobate)-based material. The plurality of piezoelectric layers 211 are stacked and bonded together with the direction of thickness laid along the direction of stacking. For example, in this embodiment, the direction of thickness and the direction of stacking of the piezoelectric layers 211 are laid along the direction of vibration (Z-direction).

[0031] The internal electrodes 221, 222 are conductive films formed in a predetermined shape and made of a conductive material that can be fired such as silver palladium. The internal electrodes 221, 222 are formed in a predetermined area on the main surface of each piezoelectric layer 211. The internal electrodes 221, 222 are different poles from each other. For example, the one internal electrode 221 is formed in an area that reaches one end part of the piezoelectric layer 211 and does not reach the other end part of the piezoelectric layer 211, in the direction of extension (Y-direction), which is a direction orthogonal to both the direction of array (X-direction), that is, the direction in which the plurality of drive piezoelectric elements 21 and the plurality of non-drive piezoelectric elements 22 are arrayed, and the direction of vibration (Z-direction). The other internal electrode 222 is formed in an area that does not reach the one end part of the piezoelectric layer 211 and reaches the other end part of the piezoelectric layer 211, in the direction of extension. The internal electrodes 221, 222 are coupled respectively to the external electrodes 223, 224 formed at the side surface of the piezoelectric elements 21, 22.

[0032] The piezoelectric member 202, which forms the drive piezoelectric element 21 and the non-drive piezoelectric element 22, may also have a dummy layer at one or both of the end part on the substrate 10 side and the end part on the nozzle plate 50 side.

[0033] The external electrodes 223, 224 are formed at the surface of the plurality of drive piezoelectric elements 21 and the plurality of non-drive piezoelectric elements 22 and formed of the end parts of the internal electrodes 221, 222 gathered together.

[0034] For example, the external electrode 223 is formed at one end surface in the direction of extension of the piezoelectric layer 211. The external electrode 223 is separated on a per element basis. The external electrodes 223 continue respectively to the individual wirings 102 formed of the electrode layer 11 on the substrate 10.

[0035] The external electrode 224 is formed at the other end surface in the direction of extension of the piezoelectric layer 211. The external electrode 224 continues to the common wiring 103 formed of the electrode layer 12 on the substrate 10 of the piezoelectric layer 211.

[0036] The external electrodes 223, 224 are formed as a film made of Ni, Cr, Au or the like by a method such as plating or sputtering. The external electrode 223 and the external electrode 224 are different poles. The external electrode 223 and the external electrode 224 are arranged respectively at different surface parts of the plurality of drive piezoelectric elements 21, the plurality of non-drive piezoelectric elements 22, and the support member 201.

[0037] In this embodiment, as an example, the external electrode 223 is an individual electrode and the external electrode 224 is a common electrode. In the external electrodes 223, which serve as the individual electrodes of the plurality of drive piezoelectric elements 21 and the plurality of non-drive piezoelectric elements 22, electrode layers 2230 formed at one side surface of the piezoelectric member 202 in a manufacturing processing shown in FIG. 7 are separated and arranged independently of each other. That is, the electrode layers 2230 are spaced apart from each other and independent of each other in the direction of juxtaposition and form the external electrodes 223 as a plurality of individual electrodes.

[0038] That is, at the side surface part on one side of the piezoelectric member 202, the external electrode 223 is divided into a plurality of parts to form a plurality of individual electrodes. At the other side surface part on the other side of the piezoelectric member 202, the external electrode 224, which serves as the common electrode, is coupled on the substrate 10 side, as shown in FIG. 6.

[0039] The external electrode 223 is coupled to the drive circuit 70 via an FPC 71 as a flexible board, which is an example of a wiring board, for example, via the individual wiring 102 on the substrate 10. For example, the individual external electrodes 223 are configured to be coupled to a control unit 116 as a drive unit via a drive IC 72 of the drive circuit 70 by the FPC 71 and to be able to be drive-controlled under the control of a control circuit 1611. The external electrode 224 may be laid on the side surface on the external electrode 223 side and may be coupled to the drive circuit 70 via the FPC 71.

[0040] In the external electrodes 224 formed at the end surface on the other side of the actuator, electrode layers 2240 continue to each other in an area more to the substrate 10 side than the bottom part of the groove 23 and thus form the common electrode. The external electrodes 224 are coupled to each other on the other side surface of the piezoelectric member 202 and are also coupled to the common wiring 103 on the substrate 10 and thus grounded, for example.

[0041] The dummy layer is made of the same material as the piezoelectric layer 211. The dummy layer has an electrode only on one side and no electric field is applied thereto. Therefore, the dummy layer is not deformed. That is, the dummy layer does not function as a piezoelectric body and serves as a base at the time of fixing or as a polishing pad for polishing in order to achieve precision during and after assembly.

[0042] The direction of vibration of the piezoelectric elements 21, 22 is laid along the direction of stacking. When an electric field is applied thereto, the piezoelectric elements 21, 22 are displaced in the direction of d33.

[0043] In an example, each of the piezoelectric elements 21, 22 is formed of three or more layers and 50 or fewer layers. The thickness of each layer is 10 μm or more and 40 μm or less. The product of the thickness and the total number of layers stacked is less than 1000 μm.

[0044] The drive piezoelectric element 21 vibrates as a volage is applied to the internal electrodes 221, 222 via the external electrodes 223, 224. In this embodiment, the drive piezoelectric element 21 longitudinally vibrates along the direction of stacking of the piezoelectric layer 211. The longitudinal vibration in this case refers to, for example, "vibration in the direction of thickness defined by a piezoelectric constant d33". By longitudinally vibrating, the drive piezoelectric element 21 displaces the vibration plate 30 and deforms the pressure chamber 31.

[0045] The flow path member 40 has the vibration plate 30 arranged facing one side of the actuator unit 20 in the direction of deformation, and a flow path substrate 405 stacked on one side of the vibration plate 30.

[0046] The vibration plate 30 is provided between the flow path substrate 405 and the actuator unit 20 in the direction of vibration. The vibration plate 30 together with the flow path substrate 405 forms the flow path member 40. The vibration plate 30 extends in a direction intersecting the side surfaces of the piezoelectric member 202 where the individual electrode and the common electrode are formed.

[0047] The vibration plate 30 extends along a surface orthogonal to the Z-direction, which is the direction of vibration, and is joined to a surface on one side of the direction of vibration of the plurality of piezoelectric elements 21, 22, that is, on the nozzle plate 50 side. The vibration plate 30 is formed, for example, deformably. The vibration plate 30 is joined to the drive piezoelectric element 21 and the non-drive piezoelectric element 22 of the actuator unit 20 and to the frame unit 60. For example, the vibration plate 30 has a vibration area 301 facing the piezoelectric elements 21, 22, and a support area 302 facing the frame unit 60.

[0048] The vibration area 301 is in the shape of a flat plate arranged, for example, in such a way that the direction of thickness is the direction of vibration of the piezoelectric layer 211. The planar direction of the vibration plate 30 extends in the direction of juxtaposition of the plurality of drive piezoelectric elements 21 and the plurality of the non-drive piezoelectric elements 22. The vibration plate 30 is, for example, a metal plate. The vibration plate 30 has a plurality of vibrating parts that face the individual pressure chambers 31 and that are deformable separately from each other. The vibration plate 30 is formed of the plurality of vibrating parts coupled together as a unified body.

[0049] In an example, the vibration plate 30 is formed of a nickel or SUS plate and is formed in such a way that the thickness dimension along the direction of vibration is approximately 5 μm to 15 μm. In the vibration area 301, a fold or a step may be formed between a vibrating part and an adjacent part or between vibrating parts adjacent to each other so that the plurality of vibrating parts can be easily displaced. The vibration area 301 is deformed as the part arranged facing the drive piezoelectric element 21 is displaced due to the expansion and contraction of the drive piezoelectric element 21. For example, the vibration plate 30 needs to have a very thin and complex shape and is therefore formed by electrocasting or the like. The vibration plate 30 is joined by bonding or the like to an upper end surface of the actuator unit 20.

[0050] The support area 302 is a plate-like member arranged between the frame unit 60 and the flow path substrate 405. The support area 302 has a communicating part 33 having a penetration hole communicating with a common chamber 32.

[0051] For example, the communicating part 33 has a filter member having multiple pores through which a liquid can pass, as penetration holes.

[0052] The flow path substrate 405 is arranged between the nozzle plate 50 and the vibration plate 30 in the direction of vibration. The flow path substrate 405 is joined to one side of the direction of vibration of the vibration plate 30.

[0053] The flow path substrate 405 has wall members such as a guide wall 41 and the partition part 42 and forms a predetermined ink flow path having a plurality of pressure chambers 31 separated from each other and a plurality of individual flow paths separated from each other and communicating with the pressure chamber 31 and the common chamber 32.

[0054] Inside the flow path substrate 405, the plurality of pressure chambers 31 are separated by the partition parts 42. That is, the two sides in the direction of juxtaposition of the pressure chamber 31 are formed by the partition parts 42. Each pressure chamber 31 communicates with the nozzle 51 formed in the nozzle plate 50 arranged on one side. Also, the pressure chamber 31 is closed on the side opposite to the nozzle plate 50 by the vibration plate 30.

[0055] The plurality of pressure chambers 31 are spaces formed on one side of the vibration area 301 of the vibration plate 30 and communicate with the common chamber 32 via the individual flow paths and the communicating part 33. The plurality of pressure chambers 31 communicate with the nozzles 51 formed in the nozzle plate 50. Also, the pressure chambers 31 are closed on the side opposite to the nozzle plate 50 by the vibration plate 30.

[0056] The plurality of pressure chambers 31 retain a liquid supplied from the common chamber 32 and eject the liquid from the nozzles 51 by being deformed due to the vibration of the vibration plate 30 forming a part of the pressure chambers 31.

[0057] The partition part 42 is a wall member that separates the plurality of pressure chambers 31 arrayed in the direction of juxtaposition and that forms the two sides of the pressure chamber 31. The partition part 42 is arranged facing the non-drive piezoelectric element 22 via the vibration plate 30 and supported by the non-drive piezoelectric element 22. A plurality of partition parts 42 are provided at the same pitch as the pitch at which the plurality of pressure chambers 31 are arrayed.

[0058] The nozzle plate 50 is formed, for example, in the shape of a square plate made of a metal such as SUS or Ni or a resin material such as polyimide and having a thickness of approximately 10 μm to 100 μm. The nozzle plate 50 is arranged on one side of the flow path substrate 405 in such a way as to close the opening on one side of the pressure chamber 31.

[0059] A plurality of nozzles 51 are arrayed in a first direction, which is the same as the direction of juxtaposition of the pressure chambers 31, and thus form a nozzle array. For example, two arrays of nozzles 51 are provided. The individual nozzles 51 are provided respectively at positions corresponding to the plurality of pressure chambers 31 arranged in two arrays. In this embodiment, the nozzles 51 are provided respectively at the positions of the end parts in the direction of extension of the pressure chambers 31.

[0060] The frame unit 60 is a structure joined to the vibration plate 30 along with the piezoelectric elements 21, 22. The frame unit 60 is provided on the opposite side of the vibration plate 30 from the flow path substrate 405, on the piezoelectric elements 21, 22. For example, in this embodiment, the frame unit 60 is arranged adjacently to the actuator unit 20. The frame unit 60 is joined to the other side of the vibration plate 30 and provided between the vibration plate 30 and the substrate 10 and thus forms the outline of the inkjet head 1. Also, the frame unit 60 forms a liquid flow path inside. In this embodiment, the frame unit 60 forms the common chamber 32.

[0061] The common chamber 32 is formed inside the frame unit 60 and communicates with the pressure chamber 31 through the communicating part 33 provided in the vibration plate 30, and the individual flow path.

[0062] The drive circuit 70 has the FPC 71 (flexible printed circuit) coupled to the actuator unit 20 via the individual wiring 102 and the common wiring 103 on the mounting surface of the substrate 10, the drive IC 72 installed in the FPC 71, and a printed wiring board 73 mounted at the other end of the FPC 71.

[0063] The drive circuit 70 applies a drive voltage to the external electrodes 223, 224 by the drive IC 72 and thus drives the drive piezoelectric element 21 to increase or decrease the capacity of the pressure chamber 31 and eject a droplet from the nozzle 51.

[0064] The FPC 71 is coupled to the mounting surface of the substrate 10 and coupled to the plurality of external electrodes 223, 224 of the actuator unit 20 via the individual wiring 102 and the common wiring 103. As the FPC 71, a COF (chip on film) with the drive IC 72 mounted thereon as an electronic component is used.

[0065] The drive IC 72 is coupled to the external electrodes 223, 224 via the FPC 71. The drive IC 72 is an electronic component used for ejection control.

[0066] The drive IC 72 generates a control signal and a drive signal to cause each drive piezoelectric element 21 to operate. The drive IC 72 generates a control signal for control such as selecting the timing of ej ecting an ink and the drive piezoelectric element 21 to eject an ink, according to an image signal inputted from the control unit 116 of the inkjet recording device 100 equipped with the inkjet head 1. The drive IC 72 also generates a voltage to be applied to the drive piezoelectric element 21, that is, a drive signal, according to the control signal from the control unit 116. As the drive IC 72 applies the drive signal to the drive piezoelectric element 21, the drive piezoelectric element 21 is driven to displace the vibration plate 30 and change the capacity of the pressure chamber 31. Thus, the ink that fills the pressure chamber 31 generates pressure vibration. Due to the pressure vibration, the ink is ejected from the nozzle 51 communicating with the pressure chamber 31. The inkjet head 1 may be configured to be able to implement a gradation expression by changing the amount of ink droplets landing on one pixel. Also, the inkjet head 1 may be configured to be able to change the amount of ink droplets landing on one pixel by changing the number of ink ejections. In this way, the drive IC 72 is an example of an application unit that applies the drive signal to the drive piezoelectric element 21.

[0067] For example, the drive IC 72 has a data buffer, a decoder, and a driver. The data buffer saves print data in time series on a per drive piezoelectric element 21 basis. The decoder controls the driver, based on the print data saved in the data buffer, on a per drive piezoelectric element 21 basis. The driver outputs the drive signal to cause each drive piezoelectric element 21 to operate, based on the control of the decoder. The drive signal is, for example, a voltage applied to each drive piezoelectric element 21.

[0068] The printed wiring board 73 is a PWA (printed wiring assembly) equipped with various electronic components and connectors and has a head control circuit 731. The printed wiring board 73 is coupled to the control unit 116 of the inkjet recording device 100.

[0069] In the inkjet head 1 configured as described above, the nozzle plate 50, the frame unit 60, the flow path substrate 405, and the vibration plate 30 together form the ink flow path having the plurality of pressure chambers 31 communicating with the nozzles 51 and the common chamber 32 communicating with each of the plurality of pressure chambers 31. For example, the common chamber 32 communicates with a cartridge and an ink is supplied to each pressure chamber 31 via the common chamber 32. All the drive piezoelectric elements 21 are coupled via a wiring in such a way that a voltage is applicable thereto. In the inkjet head 1, for example, as the control unit 116 of the inkjet recording device 100 applies a drive voltage to the electrodes 221, 222 by the drive IC 72, the drive piezoelectric element 21 of the drive target vibrates, for example, in the direction of stacking, that is, in the direction of thickness of each piezoelectric layer 211. That is, the drive piezoelectric element 21 longitudinally vibrates.

[0070] Specifically, the control unit 116 applies a drive voltage to the internal electrodes 221, 222 of the drive piezoelectric element 21 of the drive target and thus selectively drives the drive piezoelectric element 21 of the drive target. Then, a deformation in the direction of tension and a deformation in the direction of compression by the drive piezoelectric element 21 of the drive target are combined to deform the vibration plate 30 and change the capacity of the pressure chamber 31. Thus, the liquid is guided from the common chamber 32 and ejected from the nozzle 51.

[0071] An example of the manufacturing method for the inkjet head 1 according to this embodiment will now be described with reference to FIGS. 3 to 7. First, the internal electrodes 221, 222 are formed by printing on a piezoelectric material formed in the shape of a sheet. A plurality of piezoelectric layers 211 having the internal electrodes 221, 222 are stacked together and then fired and polarized, thus forming the piezoelectric member 202, which is a multilayer piezoelectric member.

[0072] As shown in FIG. 3, the support member 201 is bonded to the top of the substrate 10 with an adhesive or the like. Also, the piezoelectric element 21 of the piezoelectric member 202 with the internal electrodes 221, 222 formed therein in advance is polarized and the piezoelectric member 202 is bonded to the top of the support member 201 with an adhesive or the like (Act 11).

[0073] Then, the surface of the substrate 10, the support member 201, and the piezoelectric member 202 is processed in the state where the support member 201 and the piezoelectric member 202 are stacked on top of the substrate 10, and the mounting surface and the outer surface of the piezoelectric member 202 and the support member 201 are thus shaped (Act 12). For example, a continuous surface without any step is formed by machining from the side surface of the piezoelectric member 202 to the surface of the substrate 10 via the side surface of the support member 201. The surface treatment in Act 12 is, for example, grinding with a whetstone. If a burr or the like is formed on the substrate of the support member 201 when a whetstone that can process the substrate 10 and the piezoelectric body is used, it is preferable to perform surface treatment such as buff polishing or sandblasting for the finishing.

[0074] Subsequently, as shown in FIGS. 4 and 5, a metal film is formed by plating on the surface of the piezoelectric member 202, the surface of the support member 201, and the mounting surface of the substrate 10 (Act 13). An electrode is formed by electroless nickel plating or the like at least on the entirety of the surfaces. That is, the electrode layers 2230, 2240 serving as the external electrodes 223, 224 are formed. Also, the electrode layers 11, 12 are formed on the mounting surface of the substrate 10. Then, the top part of the actuator unit 20 is polished (Act 14) to remove the electrode at the top part and also form a joining surface of the top part. In Act 14, the planarity of the top surface of the actuator unit 20, to which the vibration plate 30 is joined in a later process, is secured by the polishing.

[0075] Subsequently, a tool such as a diamond cutter is moved in the Z-direction to perform processing to form a plurality of grooves 23 on the actuator unit 20. Thus, the piezoelectric member 202 is divided into a plurality of parts to form a plurality of columnar elements (Act 15). The plurality of grooves 23 are formed simultaneously at a predetermined pitch and a plurality of drive piezoelectric elements 21 and non-drive piezoelectric elements 22 arrayed at the same pitch are thus formed. At this point, the depth of the groove 23 is formed to a position covering a part of the tapered part of the support member 201.

[0076] FIGS. 5 and 6 are perspective views showing the columnar element as viewed from the common electrode side. FIG. 7 is a perspective view from the individual electrode side. In Act 14, a metal film similar to the metal film the common electrode side in FIG. 5 is formed on the individual electrode side. In Act 15, the metal film on the individual electrode side is divided by the grooves 23 on the top side of the actuator unit 20, similarly to the common electrode side in FIG. 6.

[0077] Also, in Act 16, the wiring is patterned by the PEP method or the like. That is, a predetermined site of the plated film formed on the entire surface in Act 12 is removed and the electrode layer 11 on one end side that is the individual wiring 102 side is divided into a plurality of parts, as shown in FIG. 7. At this point, since the surface of the support member 201 is tapered, the surface having a sloped surface of the support member 201 and the surface of the substrate 10, which together form a continuous surface, can be simultaneously patterned by the PEP processing. That is, the electrode layer 11, formed on the surface of the support member 201 having the sloped surface of the tapered shape and on the mounting surface of the substrate 10, is divided on a per element basis. The individual electrode 102 is thus formed.

[0078] In the external electrode 223, the parts on the nozzle plate 50 side of the support member 201 and the piezoelectric member 202 are separated by the grooves 23, and the part on the substrate 10 side of the support member 201 is separated by patterning.

[0079] Meanwhile, as shown in FIG. 6, the electrode layer 12 on the other end side is not divided by patterning and forms the common wiring 103 in a continuous state. Thus, the plurality of individual wirings 102 divided on a per element basis are formed on the one end side of the piezoelectric member 202, and the continuous common wiring 103 is formed on the other end side.

[0080] Also, the FPC 71 with an electronic component such as the drive IC 72 mounted thereon, as a control component, is coupled, for example, by soldering or with an anisotropic conductive film or the like, to the wiring patterns such as the individual wiring 102 and the common wiring 103 shaped in a predetermined shape on the substrate 10. Moreover, the printed wiring board 73 having the head control circuit 731 is coupled to the FPC 71.

[0081] Then, the vibration plate 30, the flow path substrate 405, and the nozzle plate 50 are stacked and positioned with a joining member provided between these components, over the actuator unit 20. The frame unit 60 is arranged at the outer circumference of the actuator unit 20. The plurality of these members are joined together. The inkjet head 1 is thus completed.

[0082] An example of the inkjet recording device 100 having the inkjet head 1 will now be described with reference to FIG. 8. The inkjet recording device 100 has a casing 111, a medium supply unit 112, an image forming unit 113, a medium discharge unit 114, a conveyer device 115, and the control unit 116.

[0083] The inkjet recording device 100 is a liquid ejection device that ejects a liquid such as an ink while conveying, for example, a paper P as a print medium that is an ejection target along a predetermined conveyance path R from the medium supply unit 112 to the medium discharge unit 114 via the image forming unit 113 and thus performs image forming processing on the paper P.

[0084] The casing 111 forms the outline of the inkjet recording device 100. A discharge port to discharge the paper P outward is provided at a predetermined site on the casing 111.

[0085] The medium supply unit 112 has a plurality of paper feed cassettes and is configured to be able to hold a plurality of papers P with various sizes stacked together.

[0086] The medium discharge unit 114 has a paper discharge tray configured to be able to hold the paper P discharged from the discharge port.

[0087] The image forming unit 113 has a support part 117 supporting the paper P, and a plurality of head units 130 arranged facing each other above the support part 117.

[0088] The support part 117 has a conveyer belt 118 provided in a looped shape in a predetermined area where image formation is performed, a support plate 119 supporting the conveyer belt 118 from the back side, and a plurality of belt rollers 120 provided on the back side of the conveyer belt 118.

[0089] In image formation, the support part 117 supports the paper P on a support surface, which is the upper surface of the conveyer belt 118, and moves the conveyer belt 118 at a predetermined timing by the rotation of the belt rollers 120, and thus conveys the paper P downstream.

[0090] The head units 130 include: a plurality of inkjet heads 1 (four colors); ink tanks 132 as liquid tanks installed above the inkjet heads 1, respectively; coupling flow paths 133 coupling the inkjet heads 1 and the ink tanks 132; and supply pumps 134.

[0091] In this embodiment, the inkjet heads 1 for the four colors of cyan, magenta, yellow, and black, and the ink tanks 132 containing inks of these colors, respectively, are provided. The ink tanks 132 are coupled to the inkjet heads 1 by the coupling flow paths 133.

[0092] A negative pressure control device such as a pump, not illustrated, is coupled to the ink tank 132. The negative pressure control device controls the inside of the ink tank 132 to negative pressure in response to the hydraulic head value of the inkjet head 1 and the ink tank 132. Thus, the ink supplied to each nozzle 51 in the inkjet head 1 is formed into a meniscus in a predetermined shape.

[0093] The supply pump 134 is a liquid feed pump formed of, for example, a piezoelectric pump. The supply pump 134 is provided in a supply flow path. The supply pump 134 is coupled to the control circuit 1611 of the control unit 116 via a wiring and is configured to be controllable by the control unit 116. The supply pump 134 supplies a liquid to the inkjet head 1.

[0094] The conveyer device 115 conveys the paper P along the conveyance path R from the medium supply unit 112 to the medium discharge unit 114 via the image forming unit 113. The conveyer device 115 has a plurality of guide plate pairs 121 arranged along the conveyance path R, and a plurality of conveyance rollers 122.

[0095] Each of the plurality of guide plate pairs 121 has a pair of plate members arranged facing each other via the paper P that is conveyed, and guides the paper P along the conveyance path R.

[0096] The conveyance rollers 122 are driven to rotate under the control of the control unit 116 and thus feed the paper P downstream along the conveyance path R. In the conveyance path R, a sensor that detects the state of conveyance of the paper is arranged at various positions.

[0097] The control unit 116 has the control circuit 1611 such as a CPU (central processing unit), which is a controller, a ROM (read-only memory) storing various programs or the like, a RAM (random-access memory) temporarily storing various variable data and image data or the like, and an interface unit that inputs data from outside and outputs data to outside.

[0098] In the inkjet recording device 100 configured as described above, for example, when a print instruction based on an operation of an operation input unit by the user is detected at the interface, the control unit 116 drives the conveyer device 115 to convey the paper P and outputs a print signal to the head unit 130 at a predetermined timing, and thus drives the inkjet head 1. As an ejection operation, the inkjet head 1 sends a drive signal to the drive IC 72, based on an image signal corresponding to image data, applies a drive voltage to the internal electrode 221, 222 to selectively drive the drive piezoelectric element 21 of the ejection target so as to longitudinally vibrate, for example, in the direction of stacking, thus changes the capacity of the pressure chamber 31 to eject the ink from the nozzle 51, and thus forms an image on the paper P held on the conveyer belt 118. As a liquid ejection operation, the control unit 116 drives the supply pump 134 and thus supplies the ink from the ink tank 132 to the common chamber 32 in the inkjet head 1.

[0099] The drive operation to drive the inkjet head 1 will now be described. The inkjet head 1 according to this embodiment has the drive piezoelectric elements 21 arranged facing the pressure chambers 31. These drive piezoelectric elements 21 are coupled in such a way that a voltage is applicable thereto via a wiring. The control unit 116 sends a drive signal to the drive IC 72, based on an image signal corresponding to image data, applies a drive voltage to the internal electrodes 221, 222 of the drive piezoelectric element 21 of the drive target, and thus selectively deforms the drive piezoelectric element 21 of the drive target. Then, the deformation in the direction of tension and the deformation in the direction of compression of the vibration plate 30 are combined to change the capacity of the pressure chamber 31, thus causing the liquid to be ejected.

[0100] For example, the control unit 116 alternately performs a tension operation and a compression operation. At the time of tension to increase the inner capacity of the target pressure chamber 31 in the inkjet head 1, the drive piezoelectric element 21 of the drive target is compressed and the drive piezoelectric element 21 that is not the drive target is not deformed. Meanwhile, at the time of compression to reduce the inner capacity of the target pressure chamber 31 in the inkjet head 1, the target drive piezoelectric element 21 is expanded. The non-drive piezoelectric element 22 is not deformed.

[0101] In the inkjet head 1 and the inkjet recording device 100 according to the foregoing embodiment, the support member 201 can secure the height dimension of the actuator unit 20 and therefore can improve installability and ejection performance. That is, as the support member 201 secures the height dimension of the actuator unit 20, the capacity of the common chamber 32 can be secured without increasing the size of the inkjet head 1 in the direction of the nozzle face. Also, as the support member 201 formed of a resin substrate is arranged between the piezoelectric member 202 and the substrate 10 to raise the actuator unit 20, the dimension in the Z-direction between the substrate 10 and the flow path member 40 can be expanded without increasing the amount of piezoelectric body used, and the common chamber 32 formed between the substrate 10 and the flow path member 40 can be expanded in the direction of height. Therefore, the capacity of the common chamber 32 can be secured without expanding the nozzle face and at a low cost.

[0102] The present disclosure is not limited to the foregoing embodiment itself. In practice, the present disclosure can be embodied, modifying components without departing from the scope of the present disclosure.

[0103] The specific material and configuration of the piezoelectric elements 21, 22 in the embodiment are not limited to the foregoing material and configuration and can be changed according to need.

[0104] In the foregoing embodiment, a configuration where a plurality of piezoelectric layers 211 are stacked and where the drive piezoelectric element 21 is driven using the longitudinal vibration (d33) in the direction of stacking, is employed. However, this is not limiting. For example, the present disclosure is also applicable to a configuration where the drive piezoelectric element 21 is formed of a single piezoelectric member, and is also applicable to a configuration where the drive piezoelectric element 21 is driven by lateral vibration to generate displacement in a d31 direction.

[0105] The arrangements of the nozzles 51 and the pressure chambers 31 are not limited to the arrangements in the foregoing embodiment. For example, the nozzles 51 may be arranged in two or more arrays. Also, an air chamber that serves as a dummy chamber may be formed between a plurality of pressure chambers 31. The inkjet head is not limited to a circulation type but may be a non-circulation type.

[0106] Also, the configurations and positional relationship between various components including the flow path member 40, the nozzle plate 50, and the frame unit 60 are not limited to the foregoing examples and can be changed according to need.

[0107] In the foregoing embodiment, an example where two actuator units 20 are juxtaposed on the substrate 10 is described. However, this is not limiting. A single actuator unit 20 may be employed.

[0108] The liquid to be ejected is not limited to an ink for printing. For example, a device that ejects a liquid containing conductive particles to form a wiring pattern on a printed wiring board, or the like, may be employed.

[0109] In the foregoing embodiment, an example where the inkjet head 1 is used for a liquid ejection device such as an inkjet recording device is described. However, this is not limiting. For example, the inkjet head 1 can also be used for a 3D printer, an industrial manufacturing machine or a medical application, and can be reduced in size, weight, and cost.

[0110] According to at least one embodiment described above, a liquid ejection head and a liquid ejection device that can achieve improvement in installability can be provided.

[0111] While some embodiments of the present disclosure have been described, these embodiments are presented simply as examples and are not intended to limit the scope of the present disclosure. These novel embodiments can be implemented in various other forms and can include various omissions, replacements, and changes without departing from the scope of the present disclosure. These embodiments and modifications thereof are included in the scope of the present disclosure and also included in the scope of the claims.

Claims

1. A liquid ejection head comprising:

    a piezoelectric member (202) formed of a piezoelectric material and comprising a plurality of grooves (23) and a plurality of piezoelectric elements arranged via the grooves;
    a substrate (10) with a wiring formed thereon;
    a support member (201) arranged between the substrate and the piezoelectric elements and formed of a resin material; and
    an electrode formed on a surface of the piezoelectric member.

2. The head according to claim 1, further comprising:

    a vibration plate arranged facing the piezoelectric member and extending in a direction intersecting the surface where the electrode is formed;
    a plurality of pressure chambers at least a part of which faces the vibration plate; and
    a plurality of nozzles communicating with the plurality of pressure chambers, wherein
    the support member comprises a tapered surface comprising a sloped surface spreading toward the substrate, and
    a wiring continuing onto the substrate from a surface of the support member is formed.

3. The head according to claim 1 or 2, wherein

    the grooves are formed, reaching to the support member, and
    at least a part of the electrodes formed on the surface of the piezoelectric member and the support member are separated from each other by the grooves.

4. The head according to any one of claims 1 to 3, wherein
    the piezoelectric member is formed of a multilayer piezoelectric body formed of a plurality of piezoelectric layers and a plurality of internal electrodes (221, 222) stacked together.

5. The head according to any one of claims 1 to 4, wherein
    the electrode formed on a surface of the piezoelectric member comprises a plurality of external electrodes (223, 224).

6. The head according to claim 5, wherein

    one external electrode (223) of the a plurality of external electrodes (223, 224) is formed at one end surface of the piezoelectric member in the direction of extension of the piezoelectric member, and
    another external electrode (224) of the a plurality of external electrodes (223, 224) is formed at the other end surface of the piezoelectric member in the direction of extension of the piezoelectric member.

7. The head according to any one of claims 1 to 6, wherein
    the support member is formed in a trapezoidal shape increasing in width dimension toward the substrate.

8. The head according to any one of claims 1 to 7, wherein the resin material is a resin material used for a PC board.

9. The head according to any one of claims 1 to 8,

wherein the resin material is PPS (polyphenylene sulfide), glass epoxy or the like.

10. A liquid ejection device comprising:
the liquid ejection head according to any one of claims 1 to 9.

11. A method for manufacturing the liquid inkjet head according to any one of claims 1 to 9, comprising:

- attaching a support member (201) formed of a resin material to the top of a substrate (10) with a wiring formed thereon,
- polarizing a piezoelectric member (202) formed of a piezoelectric material,
- attaching the polarized piezoelectric member (202) to the top of the support member (201), and
- forming a metal film on the surface of the piezoelectric member (202).

12. The method for manufacturing the liquid inkjet head according to claim 11, further comprising, before forming a metal film on the surface of the piezoelectric member:

- processing the surface of the substrate (10), the support member (201), and the piezoelectric member (202) in the state where the support member (201) and the piezoelectric member (202) are stacked on top of the substrate (10), and
- shaping a mounting surface and an outer surface of the piezoelectric member (202) and the support member (201).

13. The method for manufacturing the liquid inkjet head according to claim 11 or 12, further comprising:

- preparing the piezoelectric member (202), comprising:
    - forming internal electrodes (221, 222) by printing on the piezoelectric material in the shape of a sheet, thereby forming a plurality of piezoelectric layers (211) having the internal electrodes (221, 222),
    - stacking together the plurality of piezoelectric layers (211) having the internal electrodes (221, 222), thereby forming a multilayer piezoelectric body,
    - firing and polarizing the multilayer piezoelectric body, thereby forming the piezoelectric member (202).

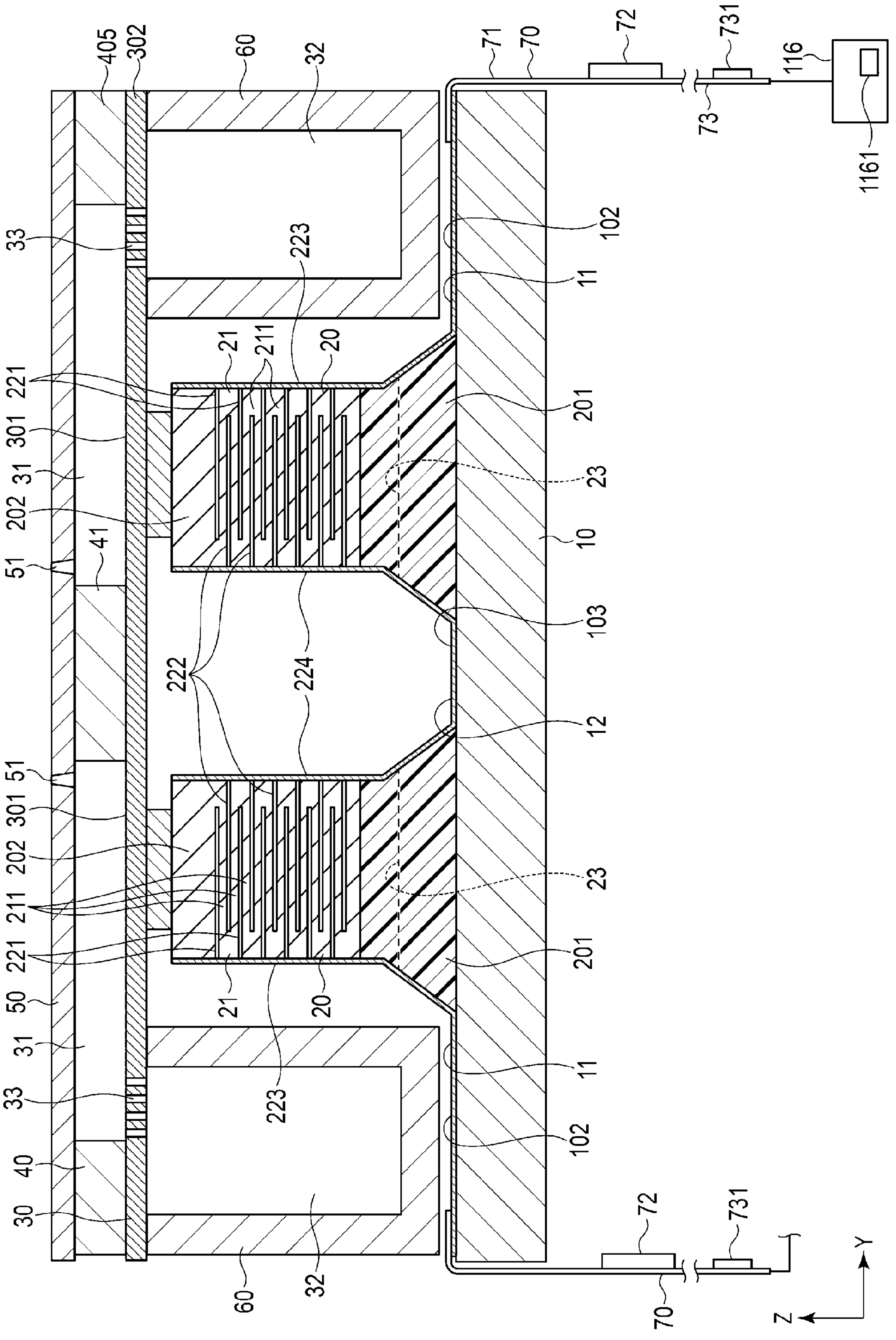

405
302
60
32
71
70
72
731
116
73
1161
33
223
102
11
21
211
20
221
301
31
202
41
51
201
23
10
222
224
103
12
50
40
30
Z
Y

FIG. 1

FIG. 2

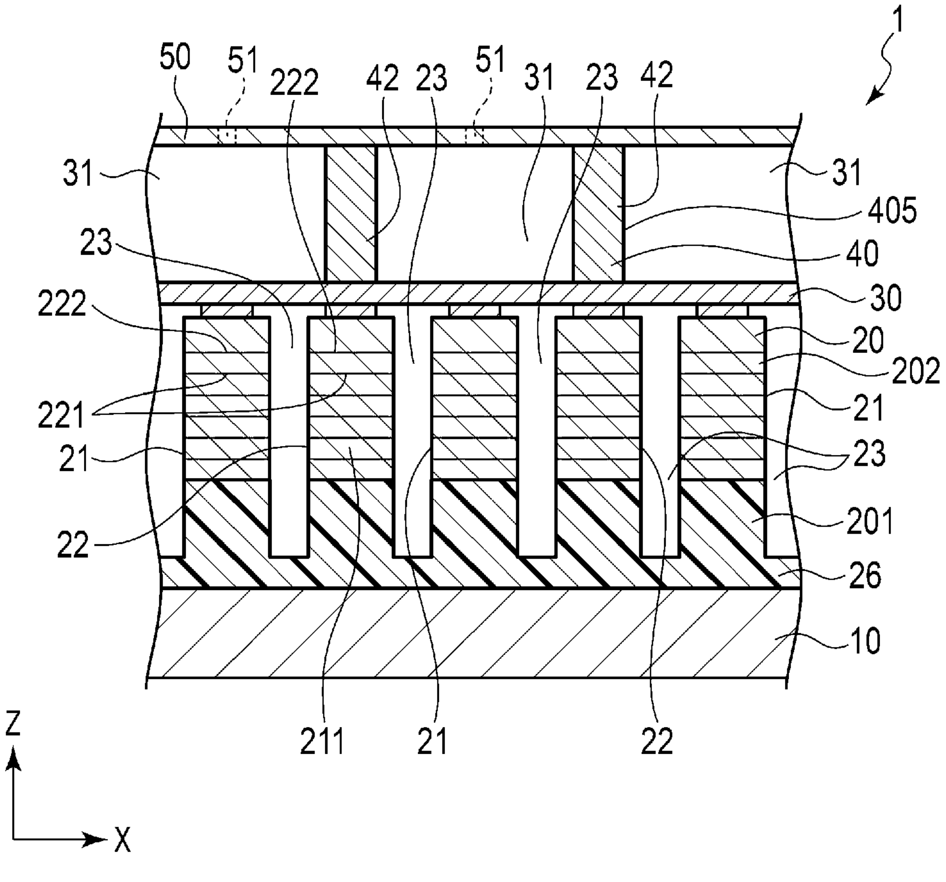

1
50
51
222
42
23
51
31
23
42
31
31
405
23
40
30
222
20
202
221
21
21
23
201
22
26
10
211
21
22
Z
X

FIG. 3

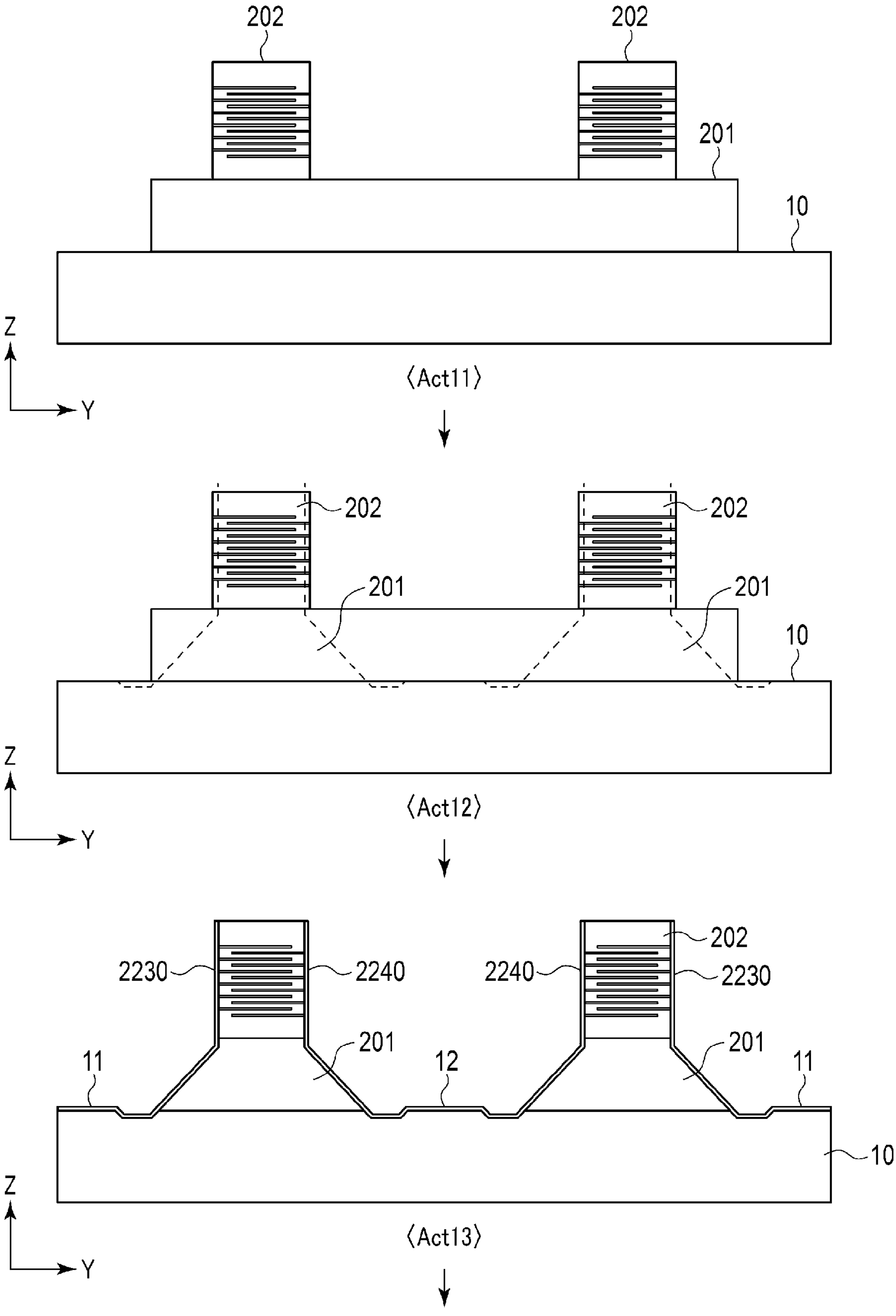
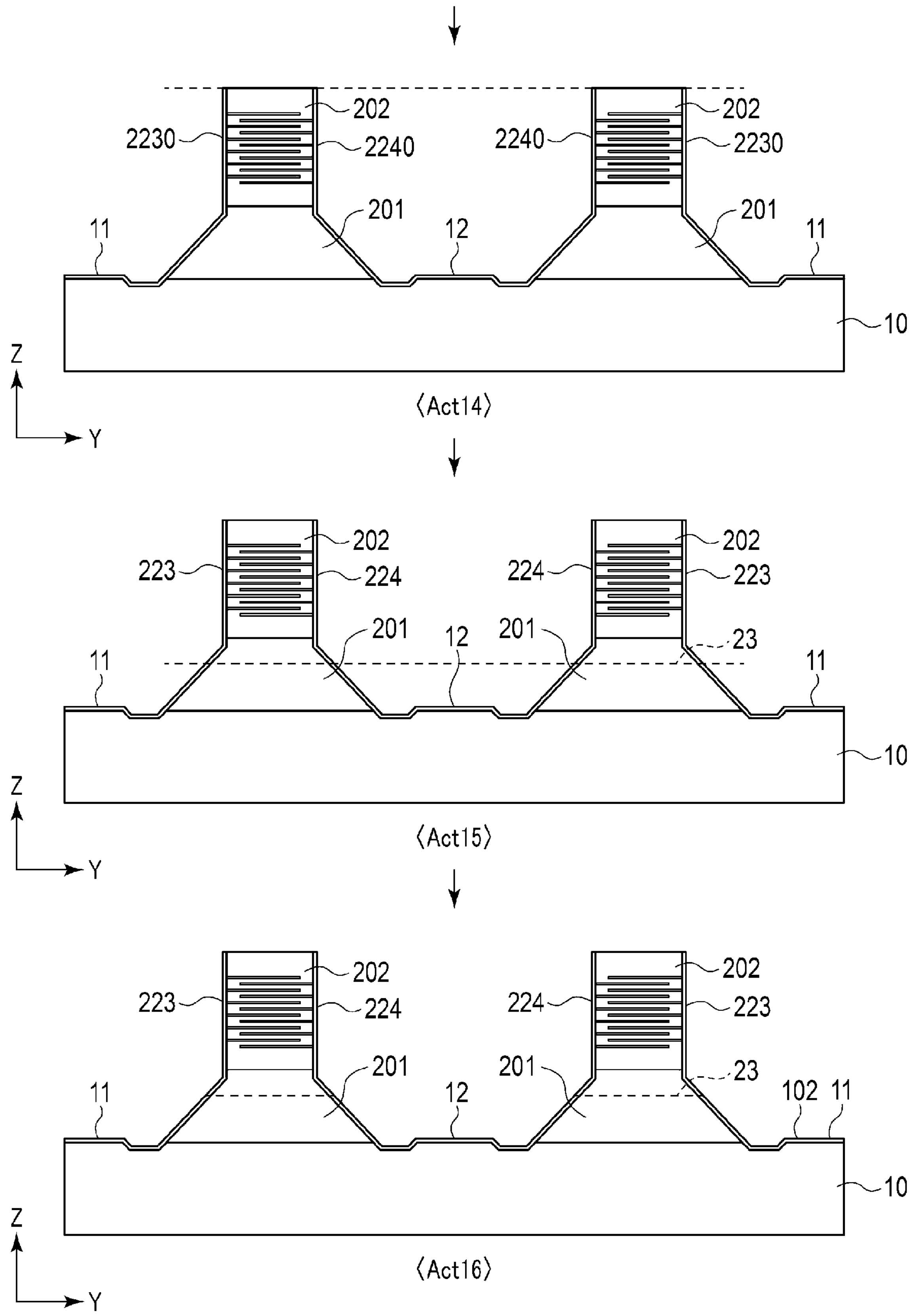

202
202
201
10
Z
Y
〈Act11〉
202
202
201
201
10
Z
Y
〈Act12〉
202
2230
2240
2240
2230
201
201
11
12
11
10
Z
Y
〈Act13〉

FIG. 4



202
2230
2240
202
2240
2230
201
201
11
12
11
10
Z
Y
⟨Act14⟩
202
223
224
202
224
223
201
12
201
23
11
11
10
Z
Y
⟨Act15⟩
202
223
224
202
224
223
201
201
23
11
12
102
11
10
Z
Y
⟨Act16⟩

FIG. 5

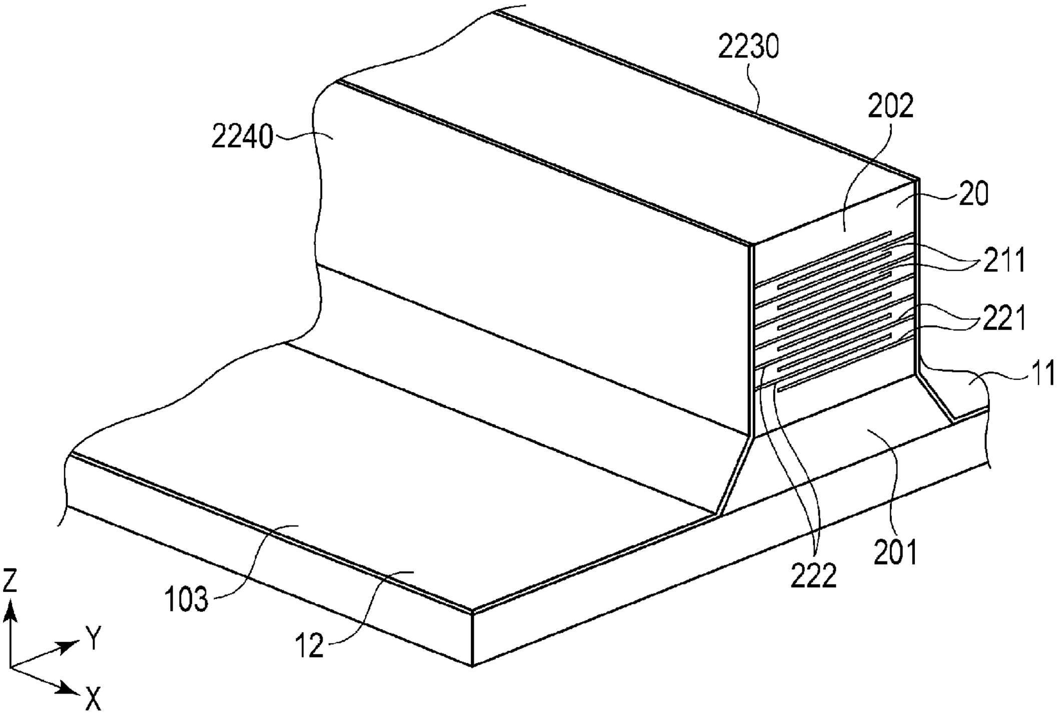

2230
202
2240
20
211
221
11
222
201
103
12
Z
Y
X

FIG. 6

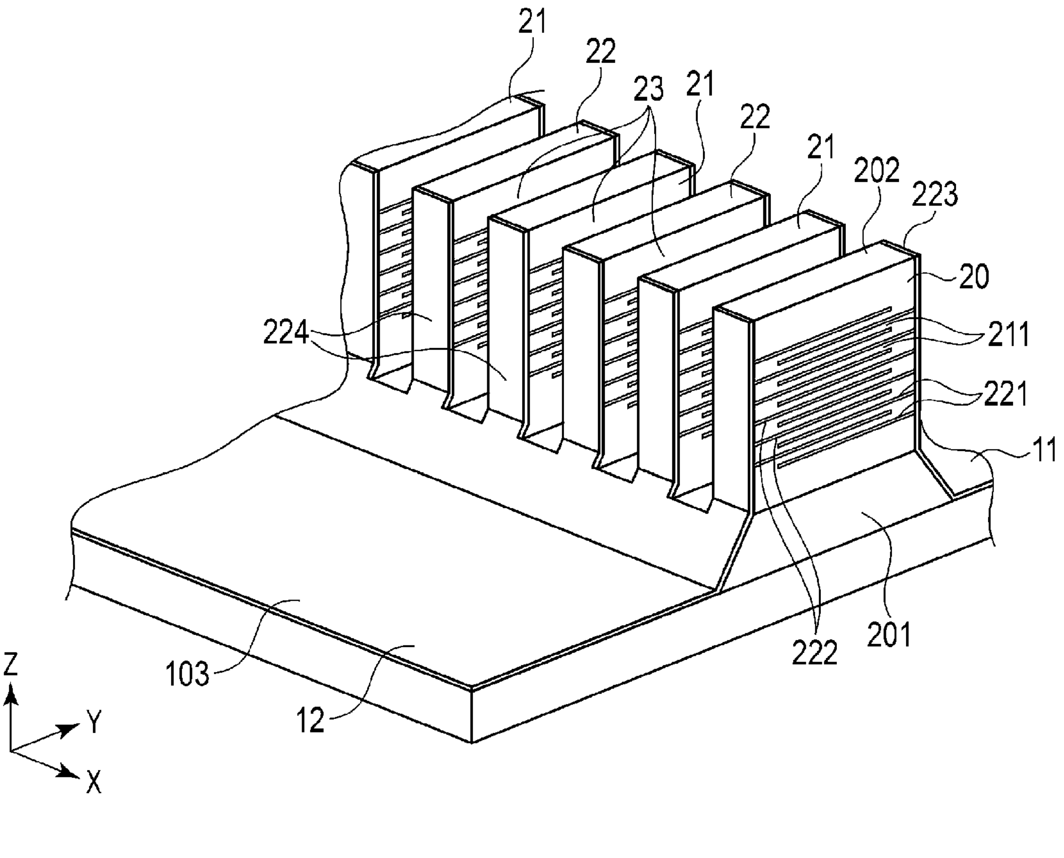

21
22
23
21
22
21
202
223
20
224
211
221
11
222
201
103
12
Z
Y
X

FIG. 7

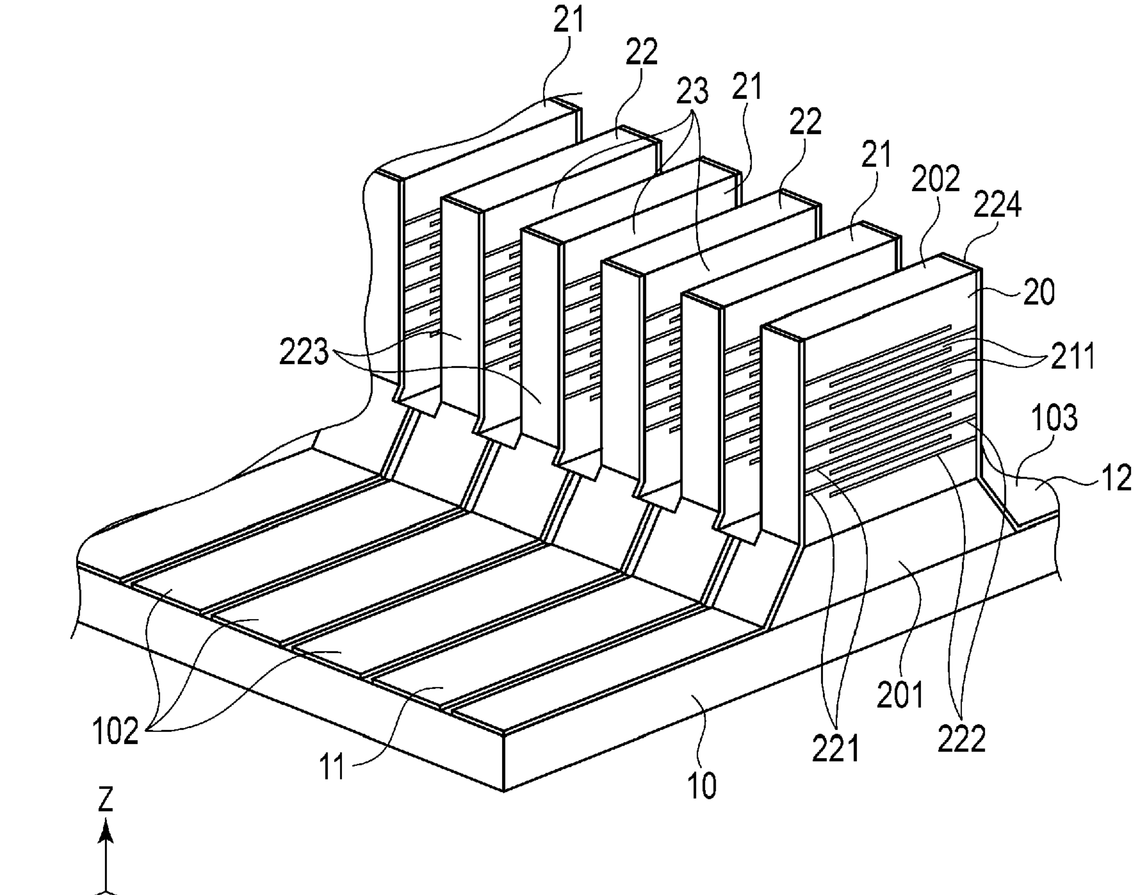
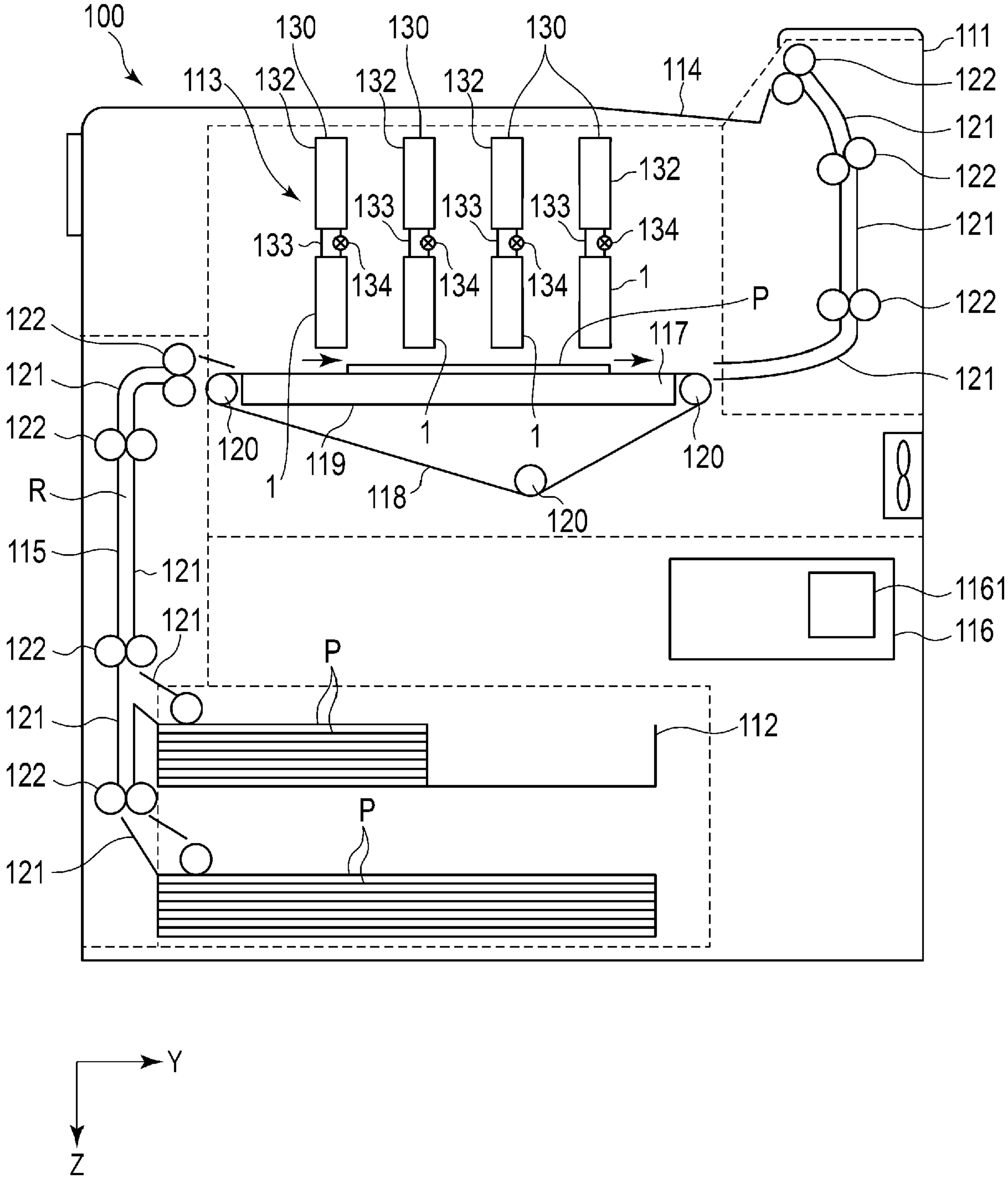

21
22
23
21
22
21
202
224
20
211
223
103
12
102
11
10
201
221
222
Z
Y
X

FIG. 8


100
130
130
130
113
132
132
132
114
111
122
121
122
121
132
133
133
133
133
134
134
134
134
134
1
P
122
117
121
122
121
120
120
1
1
119
1
118
120
R
115
121
1161
121
116
122
P
121
112
122
P
121
Y
Z

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 23 20 7533

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 2004/129051 A1 (AKAHANE FUJIO [JP] ET AL) 8 July 2004 (2004-07-08) * paragraphs [0118], [0120], [0122]; figures 5,6 *	1,4,5, 8-13 2	INV. B41J2/14 B41J2/16
X A	US 5 631 680 A (SUGAHARA HIROTO [JP]) 20 May 1997 (1997-05-20) * column 6, lines 35-40; figure 6 *	1,3,6-8, 11 2	
X A	EP 0 678 384 A1 (SEIKO EPSON CORP [JP]) 25 October 1995 (1995-10-25) * figures 6,10 *	1,11 2	
			TECHNICAL FIELDS SEARCHED (IPC)
			B41J

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	5 April 2024	Öztürk, Serkan

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 23 20 7533

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

05-04-2024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2004129051 A1	08-07-2004	CN 1475353 A	18-02-2004
		JP 3736550 B2	18-01-2006
		JP 2004122762 A	22-04-2004
		US 2004129051 A1	08-07-2004
US 5631680 A	20-05-1997	JP 3183017 B2	03-07-2001
		JP H07232431 A	05-09-1995
		US 5631680 A	20-05-1997
EP 0678384 A1	25-10-1995	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82