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

(11) **EP 3 974 190 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
30.03.2022 Bulletin 2022/13

(21) Application number: **21168257.0**

(22) Date of filing: **14.04.2021**

(51) International Patent Classification (IPC):
B41J 2/14 *(2006.01)* ***B41J 2/16*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B41J 2/1606; B41J 2/14209

(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 MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **24.09.2020 JP 2020159451**

(71) Applicant: **Toshiba TEC Kabushiki Kaisha**
Tokyo 141-8562 (JP)

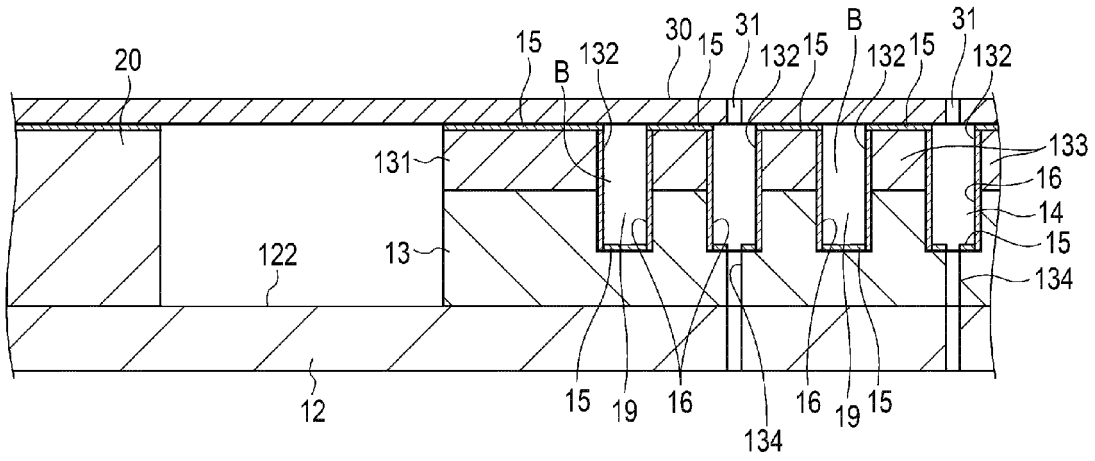
(72) Inventor: **SEKI, Masashi**
Shinagawa-ku, Tokyo 141-8562 (JP)

(74) Representative: **Bandpay & Greuter**
30, rue Notre-Dame des Victoires
75002 Paris (FR)

(54) **LIQUID DISCHARGE HEAD**

(57) According to one embodiment, there is provided a liquid discharge head including a nozzle plate on which nozzles are formed, an actuator disposed facing the nozzle plate and provided with grooves configuring a plurality of pressure chambers communicating with the nozzles, liquid-repellent films formed in a predetermined first region on a surface of the actuator, and electrode layers formed in a second region different from the first region in which the liquid-repellent films are formed on the surface of the actuator.

FIG. 3



EP 3 974 190 A1

Description

FIELD

[0001] Embodiments described herein relate generally to a liquid discharge head.

BACKGROUND

[0002] In an ink jet head that pressurizes ink with a piezoelectric member and discharges ink droplets from nozzles provided on a nozzle plate, electrodes are formed on the piezoelectric member in order to apply a voltage to the piezoelectric member. The electrodes are patterned after being formed by a liquid-phase film forming method such as a plating method, and are formed on the entire surface of the inside of a pressure chamber. Ink is supplied from a common ink chamber to the pressure chamber.

DESCRIPTION OF THE DRAWINGS

[0003]

FIG. 1 is a perspective view illustrating an ink jet head according to an embodiment;
FIG. 2 is an exploded perspective view illustrating a partial configuration of the ink jet head;
FIG. 3 is an enlarged cross-sectional view illustrating a partial configuration of the ink jet head;
FIG. 4 is an enlarged perspective view illustrating a partial configuration of the ink jet head;
FIG. 5 is an enlarged explanatory view illustrating a partial configuration of the ink jet head;
FIG. 6 is an explanatory view illustrating a method of manufacturing the ink jet head;
FIG. 7 is another explanatory view illustrating the method of manufacturing the ink jet head;
FIG. 8 is a table illustrating contact angles of a liquid repellent material and a piezoelectric material according to the embodiment to pure water; and
FIG. 9 is a schematic view illustrating an ink jet printer according to an embodiment.

DETAILED DESCRIPTION

[0004] Embodiments provide a liquid discharge head that is easy to manufacture.

[0005] In general, according to one embodiment, there is provided a liquid discharge head including a nozzle plate on which nozzles are formed, an actuator disposed facing the nozzle plate and provided with grooves configuring a plurality of pressure chambers communicating with the nozzles, liquid-repellent films formed in a predetermined first region on a surface of the actuator, and electrode layers formed in a second region different from the first region in which the liquid-repellent films are formed on the surface of the actuator.

[0006] Preferably, the actuator is provided with a plurality of drive element portions and the grooves formed between the plurality of drive element portions, and is provided on a base material. Each of the electrode layers is formed at a predetermined location on a side wall surface of each of the grooves, a main surface of the base material, and a side surface of the actuator, and each of the liquid-repellent films is formed at a location different from the electrode layer on a bottom surface portion of each of the grooves, the main surface of the base material, and the side surface of the actuator.

[0007] Preferably, a supply path for supplying a liquid to the pressure chamber is formed on the bottom surface portion of the groove configuring the pressure chamber.

[0008] Preferably, the liquid-repellent films are formed on a facing surface of the actuator facing the nozzle plate.

[0009] Preferably, the liquid discharge head further comprises a frame configured to surround the actuator and adhered to the nozzle plate, wherein liquid-repellent films are formed on the facing surface of the frame facing the nozzle plate.

[0010] Hereinafter, an ink jet head 1 which is a liquid discharge head according to the first embodiment and an ink jet printer 100 which is a liquid discharge device will be described with reference to FIGS. 1 to 8. FIG. 1 is a perspective view illustrating a schematic configuration of the ink jet head 1, and FIG. 2 is an exploded perspective view illustrating a partial configuration of the ink jet head 1. FIG. 3 is an enlarged cross-sectional view illustrating a partial configuration of the ink jet head 1. FIG. 4 is an enlarged perspective view illustrating a partial configuration of the ink jet head 1, in which an internal structure thereof is illustrated by omitting a part of a resin cover 19, for the sake of explanation. FIG. 5 is an explanatory diagram schematically illustrating a configuration of an actuator. In the following description, a Cartesian coordinate system composed of an X-axis, a Y-axis, and a Z-axis is used. In the figures, arrows X, Y, and Z indicate three directions orthogonal to each other. The X-axis is along a first direction, which is an arranging direction of nozzles, the Y-axis is along a second direction, which is an aligning direction of nozzle rows, the Z-axis is along a third direction, which is the direction in which droplets are discharged. For the sake of explanation, in each figure, the configuration is illustrated enlarged, reduced, or omitted as appropriate.

[0011] The ink jet head 1 includes an actuator base 10, a frame 20, a nozzle plate 30, and a manifold 40. The ink jet head 1 is, for example, an on-demand type ink jet head used in an ink jet printer by being mounted thereon, and is a circulation type ink jet head that circulates ink to and from an ink tank of the ink jet printer. In the ink jet head 1, a flow path is connected to an ink tank as a liquid storage portion provided in an ink jet printer 100, and the ink jet head 1 is disposed, for example, in a posture in which nozzles 31 along a third direction face downward.

[0012] The actuator base 10 includes a base material 12 which is an actuator substrate, and a plurality of ac-

tuators 13 provided on the base material 12.

[0013] The base material 12 is formed in a shape of a square plate. The base material 12 is preferably made of PZT, ceramics, glass, free-cutting ceramics, or a material containing these. As an example, two actuators 13 extending in a first direction are provided on one surface of the base material 12, and a plurality of ink discharge paths 121 are provided side by side at along the first direction between the two actuators 13. An ink discharge path 121 is a circular hole penetrating the base material 12 in the Z-direction, and communicates with a common ink chamber formed in the manifold 40 on the back side of the base material 12.

[0014] Pattern electrodes 17 and liquid-repellent films 15 are formed at predetermined locations on a main surface 122 of the base material 12, respectively. That is, the main surface 122 of the base material 12 has a liquid-repellent area on which the liquid-repellent films 15 are formed and an electrode area on which electrode layers forming the pattern electrodes 17 are formed.

[0015] The pattern electrode 17 is on the base material 12, reaches the outside of the frame 20, is connected to a flexible printed board 60 on the outside of the frame 20, and is connected to a drive IC chip 61 mounted on the flexible printed circuit board 60. A protective film may be further formed on the surface of the base material 12.

[0016] The pattern electrode 17 is a conductive film formed of a conductive material such as nickel and having a predetermined pattern shape. The pattern electrode 17 is patterned in a predetermined shape in which an electrode layer 16 arranged on a side wall surface 1322 of a groove 132 of the actuator 13 is pulled out and is guided to a mounting portion such as a drive circuit. For example, the pattern electrode 17 is formed in a region of each actuator 13 opposite to a region where the ink discharge path 121 is arranged. A conductive material is formed on the pattern electrode 17 by a method such as a vacuum vapor deposition method or an electroless plating method, and the pattern electrode 17 is patterned into a predetermined pattern shape. The pattern electrode 17 may be formed at the same time as the electrode layer 16.

[0017] The actuator 13 includes a plurality of piezoelectric members 131 provided on the base material 12. The piezoelectric member 131 is configured with a first piezoelectric body and a second piezoelectric body that are laminated. Examples of the material of the first and second piezoelectric bodies include lead zirconate titanate (PZT), lithium niobate ($LiNbO_3$), lithium tantalate ($LiTaO_3$) and the like. The first and second piezoelectric bodies are polarized in opposite directions to each other along the thickness direction.

[0018] A side surface portion 1312 of the piezoelectric member 131 has an inclined surface that is inclined with respect to the second direction and the third direction. That is, the piezoelectric member 131 is formed to have a trapezoidal shape in cross-sectional view orthogonal to the second direction. A bottom surface portion 1321 of the groove 132 and the main surface 122 of the base material 12 are connected by the inclined side surface portion 1312.

[0019] A plurality of grooves 132 aligned in the first direction are formed on a top surface portion 1311 of the piezoelectric member 131, which is an end surface facing the nozzle plate 30. That is, the piezoelectric member 131 is formed in a comb-teeth shape, and a support column-shaped portion formed between the adjacent grooves 132 configures a laminated piezoelectric element 133 that serves as a drive element portion for changing the volume of the groove 132. In other words, in the piezoelectric member 131 which is a laminated piezoelectric body, a plurality of laminated piezoelectric elements 133 are aligned in one direction, and the groove 132 is formed between adjacent laminated piezoelectric elements 133. Each of the grooves 132 is formed over the entire length of the piezoelectric member 131 in the second direction. The groove 132 is opened to the nozzle plate 30 side. Among the plurality of grooves 132 aligned in the first direction, grooves 132 arranged every other one configure pressure chambers 14, and the grooves 132 arranged between the pressure chambers 14 form air chambers B as dummy chambers.

[0020] Ink supply paths 134 are formed in the bottom surface portions 1321 of the grooves 132 forming the pressure chambers 14 disposed every other one. The ink supply path 134 is a circular hole that penetrates the piezoelectric member 131 and the base material 12 in the Z-direction, and communicates with a common ink chamber formed in the manifold 40 on the back side of the base material 12. Ink is supplied from the ink supply path 134 along the Z-direction, which is the depth direction of the groove 132.

[0021] A liquid-repellent film 15 is formed on the bottom surface 1321 of the groove 132. The liquid-repellent film 15 is a layer in which a liquid-repellent material 151 having high liquid repellency is formed to a predetermined thickness. As illustrated in FIG. 8, for example, the liquid-repellent film 15 has a larger contact angle, which is an angle formed by a liquid surface and a solid surface, than that of PZT. A contact angle of PZT is 70 degrees, and the contact angle of the liquid-repellent film 15 is 110 degrees. Accordingly, since the liquid-repellent film 15 repels a plating solution forming the electrode, the electrode is not formed on the liquid-repellent film 15. That is, an area where the liquid-repellent film 15 is formed configures a separation portion for separating the electrodes. As the liquid repellent material 151, for example, a fluorine-based coating agent manufactured by AGC, SF Coat, or the like can be used.

[0022] The electrode layer 16 is formed on both side wall surfaces 1322 of the groove 132. The electrode layer 16 is a conductive film made of a conductive material such as nickel and having a predetermined shape. The electrode layer 16 is patterned by removing a part of the electrodes by laser processing after the conductive material is formed by a method such as a vacuum vapor deposition method or an electroless nickel plating meth-

od. In the present embodiment, nickel is used as the conductive material of the electrode layer 16, but is not limited thereto. For example, the electrode layer 16 may be formed of gold, copper, or the like. Alternatively, the electrode layer 16 may be laminated with a film of two or more kinds of conductive materials.

[0023] The electrode layer 16 is connected to a wiring formed on a circuit board or a flexible wiring board through the pattern electrode 17 formed on the side surface portion 1312 of the piezoelectric member 131 and the main surface 122 of the base material 12. The electrode layer 16 is electrically connected to various electronic components such as a drive IC through the circuit board and the flexible board.

[0024] A pattern electrode 18 is formed on the side surface portion 1312 of the piezoelectric member 131, which is an inclined surface following the groove 132. The pattern electrode 18 is connected to the electrode layer 16 on the side wall surface 1322 of the groove 132, and is also connected to the pattern electrode 17 formed on the main surface 122 of the base material 12.

[0025] The pattern electrode 18 is a conductive film formed of a conductive material such as nickel and having a predetermined pattern shape. The pattern electrode 18 is patterned in a predetermined shape in which the electrode layer 16 arranged on the side wall surface 1322 of each of the grooves 132 of the actuator 13 is pulled out and guided to a mounting portion such as a drive circuit. A conductive material is formed on the pattern electrode 18 by a method such as a vacuum vapor deposition method or an electroless plating method, and the pattern electrode 18 is patterned into a predetermined pattern shape. The pattern electrode 18 may be formed at the same time as the electrode layer 16.

[0026] The surface of the actuator base 10 has liquid-repellent areas as first regions in each of which the liquid-repellent film 15 is formed, electrode areas as second regions in each of which the electrode layer 16 and the pattern electrode 17 are formed. The liquid repellent area and the electrode area are disposed in different portions. For example, on the surface of the actuator base 10, an electrode area is formed at a portion where the liquid-repellent area is not formed.

[0027] For example, the liquid-repellent areas on which the liquid-repellent film 15 is formed are formed at predetermined locations on the bottom surface portion 1321 of the groove 132 of the actuator 13, the top surface portion 1311 of the laminated piezoelectric element 133, the inclined side surface portion 1312 of the piezoelectric member 131, and the main surface 122 of the base material 12, respectively.

[0028] The electrode areas on which the electrode layer 16 or the pattern electrodes 17 and 18 are formed are formed at predetermined locations on the side wall surface 1322 of the groove 132, the side surface portion 1312 of the piezoelectric member 131 which is an inclined surface, and the main surface 122 of the base material 12, respectively. The electrode layer 16 is not formed on the bottom surface portion 1321 of the groove 132, and the electrode layers 16 formed on both side wall surfaces 1322 are separated from each other.

[0029] In the actuator 13, the inclined surface on one end side in the second direction is covered with a resin cover 19. Of the actuator 13, the other end side in the second direction, that is, the ink discharge port 121 side is partially covered with the resin cover 19. Specifically, one side of the groove 132 configuring the pressure chamber 14 in the second direction is closed by the resin cover 19, and the other side is opened to communicate with the ink discharge path 121. Both ends of air chamber B in the second direction are covered with the resin cover 19 and are closed.

[0030] For example, the resin cover 19 is an adhesive made of an epoxy resin material, and is formed by thermosetting after applying the adhesive to the side surface of the actuator 13. The resin cover 19 covers the surface of the inclined surface on which the wiring is formed, and closes an opening of the groove 132 so that ink does not flow from the groove 132 to the wiring area. That is, the pressure chamber 14 opens on one side in the second direction to communicate with the ink supply path 134, communicate with a nozzle hole 31, and further communicate with the ink discharge port 121. The air chamber B is closed by the nozzle plate 30 and the resin covers 19 at both ends.

[0031] The frame 20 is provided on the actuator base 10, surrounds an outer periphery of the actuator 13, and covers an outer periphery of a partial region of the actuator base 10. The frame 20 is made of, for example, a ceramic material and is bonded to the end face of the actuator base 10 in the first direction. The frame 20 has an opening that is smaller than the base material 12 and larger than the region of the base material 12 where the actuator 13 is provided. The frame 20 is bonded to the base material 12 by, for example, an adhesive. For example, the frame 20 is adhered to the main surface of the base material 12 on which the liquid-repellent film is formed through a sheet of thermoplastic resin. The frame 20 serves as a guide function for guiding a liquid such as ink. The end face of an opening edge on one side of the frame 20, which is the upper part in Fig. 1, forms a nozzle facing surface to be disposed the nozzle plate 30. In the present embodiment, as an example, the liquid-repellent films 15 are also formed on the nozzle facing surface of the frame 20. The nozzle facing surface forms a flat plane surface along the XY-plane and is on the same plane with the nozzle facing surface of the actuator 13. The nozzle facing surface of the frame 20 is boned to the outer periphery of the nozzle plate 30 through an adhesive.

[0032] The nozzle plate 30 is formed in the shape of a square plate. The nozzle plate 30 is made of a resin film such as polyimide, for example. The nozzle plate 30 has a thickness of 10 μm to 100 μm, and nozzle rows each of which includes a plurality of nozzles 31 penetrating in the thickness direction are formed in the nozzle plate 30.

The nozzle plate 30 is disposed to face one side in the Z-direction to cover openings on one side in the Z-direction of groove rows of the actuator base 10. The nozzles 31 are respectively provided at positions corresponding to the plurality of pressure chambers 14. That is, the nozzle plate 30 includes the nozzles 31 communicating with the pressure chambers formed by the grooves 132. The nozzle plate 30 is larger than the opening of the frame 20. The nozzle plate 30 is bonded to the frame 20 by, for example, an adhesive. The nozzles 31 form two rows corresponding to the pressure chambers. The diameter of the nozzle 31 increases as the nozzle 31 advances from a recording medium facing surface toward the pressure chamber. The dimension of the nozzle 31 is set to a predetermined value according to an amount of ink discharge. The nozzle 31 can be formed, for example, by performing laser processing using an excimer laser.

[0033] The manifold 40 is arranged on one side of the actuator base 10 and configures a common ink chamber. The manifold 40 includes a supply port that communicates with the common ink chamber and allows ink to flow into the common ink chamber from the outside, and a discharge port that discharges ink from the common ink chamber to the outside. The supply port and the discharge port are connected to a connection flow path.

[0034] In the ink jet head 1, the manifold 40, the actuator base 10, the frame 20, and the nozzle plate 30 are assembled as one to form an ink flow path inside thereof. Ink is supplied from the common ink chamber formed in the manifold 40 to the pressure chamber 14 through the ink supply path 134, passes through the pressure chamber 14, and circulates so that excess ink returns from the ink discharge path 121 to the manifold 40. A part of the ink is discharged from the nozzle 31 while flowing through the pressure chamber 14 due to a volume change of the pressure chambers 14 by the control based on image data. For example, by setting the electrode layer 16 of the pressure chamber 14 is set to GND and applying a voltage to the electrode layer 16 of the adjacent air chamber B, the volume of the pressure chamber 14 is changed and a droplet is discharged from the nozzle 31 communicating with the pressure chamber 14.

[0035] Hereinafter, a method for manufacturing the ink jet head 1 according to the present embodiment will be described with reference to FIGS. 1 to 7. FIGS. 6 and 7 are explanatory diagrams illustrating a patterning process in the method for manufacturing the ink jet head 1. FIG. 6 is an explanatory diagram illustrating an electrode forming process on the side wall surface of the groove, and FIG. 7 is an explanatory diagram illustrating an electrode forming process on the base material and the side surface portion of the actuator.

[0036] In the method for manufacturing the ink jet head 1 according to the present embodiment, a plurality of piezoelectric members 131 forming a plurality of grooves are attached to the plate-shaped base material 12 with an adhesive or the like, and are subjected to machining using a dicing saw, a slicer, or the like to form the actuator base 10 having a predetermined outer shape. For example, a plurality of block-shaped base members having a thickness corresponding to a plurality of sheets may be formed in advance and then divided to manufacture a plurality of actuator bases 10 having a predetermined shape.

[0037] As illustrated in Act 1 of FIGS. 6 and 7, the liquid-repellent material 151 cured by UV is applied to the entire surface of the base material 12. Subsequently, as illustrated in Act 2, after applying the liquid-repellent material 151, a UV-irradiated location is cured by irradiating a location where the electrode is to be formed with ultraviolet rays from the nozzle plate 30 side using an LED lamp 192 that irradiates UV light. Light to be irradiated is preferably UV light having high linearity, and preferably has a long wavelength of 330 nm or more. As an example, a mask 191 is disposed at a portion where the liquid-repellent film is not formed, that is, a portion where the electrode layer 16 and the pattern electrodes 17 and 18 should be formed, and the portion is irradiated with UV. That is, the mask is disposed on the location where the pattern electrodes 17 and 18 should be formed on the main surface 122 of the base material 12 and the side surface portion 1312 of the piezoelectric member 131 and the portion is irradiated with UV. Here, by irradiating the piezoelectric member 131 with UV light having high linearity and a long wavelength from the direction in which the nozzle plate 30 is arranged, the bottom surface portion 1321 of the groove 132 and the top surface portion 1311 can be irradiated with UV light without disposing the mask 191. With the configuration described above, the portion where the mask is not formed on the main surface 122 of the base material 12 and the side surface portion 1312, the bottom surface portion 1321 of the groove 132, and the top surface portion 1311 are cured, and the liquid-repellent film 15 is formed (Act 3). That is, liquid repellency is developed on the liquid-repellent film 15 at the cured portion. Subsequently, as illustrated in Act 4, the liquid-repellent material 151 at the portion where UV light is not irradiated and the liquid repellency is not developed is removed. After that, when the plating method is performed, the liquid-repellent film 15 repels the plating solution, and thus the electrode layer 16 and the pattern electrodes 17 and 18 are formed only on the area, where the liquid-repellent film 15 is not formed, of the side wall surface 1322 of the groove 132, the base material 12, and the side surface portion 1312 (Act 5). As illustrated in FIG. 8, the contact angle of the liquid repellent material 151 forming the liquid-repellent film 15 is 110 degrees, and the contact angle of the PZT is 70 degrees. Since the contact angle of the liquid repellent material 151 is larger than that of the PZT, the portion where the liquid repellent film 15 is formed repels the plating solution. Thus, the electrode layer 16 and the pattern electrodes 17 and 18 are not formed on the liquid-repellent film 15. The ink supply path 134 is formed at the bottom portion of the groove 132 forming the pressure chamber 14 (Act 5).

[0038] With the configuration described above, the liquid-repellent film 15, the electrode layer 16, and the pattern electrodes 17 and 18 are formed at predetermined locations on the surface of the actuator base 10, respectively. By forming the resin cover 19 at a predetermined location, one end side of the pressure chamber 14 and both ends of air chamber B are closed. Then, the actuator base 10 is assembled to the manifold 40, and the frame 20 is attached to one surface of the actuator base 10 with an adhesive sheet of thermoplastic resin.

[0039] The nozzle plate 30 is adhered to and attached to the actuator base 10 to cover the groove 132. Here, positioning is performed so that the nozzles 31 face the grooves 132. As illustrated in FIG. 1, the ink jet head 1 is completed by connecting the drive IC chip 61 and the circuit board to the pattern electrode 17 formed on the main surface of the base material 12 through the flexible printed circuit board 60.

[0040] Next, the ink jet printer 100 including the ink jet head 1 will be described with reference to FIG. 9. FIG. 9 is an explanatory diagram illustrating the configuration of the ink jet printer 100. As illustrated in FIG. 9, the ink jet printer 100 includes a casing 101, a medium supply unit 102, an image forming unit 103, a medium discharge unit 104, a conveyance device 105, and a control unit 106.

[0041] The ink jet printer 100 is a liquid discharge apparatus that performs an image forming process on paper P by discharging a liquid such as ink while conveying, for example, paper P as a recording medium, that is an object to be discharged, along a predetermined conveyance path A from the medium supply unit 102 to the medium discharge unit 104 through the image forming unit 103.

[0042] The medium supply unit 102 includes a plurality of paper feed cassettes 1021. The medium discharge unit 104 includes a paper discharge tray 1041. The image forming unit 103 includes a support unit 107 for supporting paper, and a plurality of head units 200 that are disposed above the support unit 107 to face the support unit 107.

[0043] The support unit 107 includes a conveyance belt 108 provided in a loop shape in a predetermined region for performing image formation, a support plate 109 that supports a conveyance belt 108 from the back side, and a plurality of belt rollers 110 provided on the back side of the conveyance belt 108.

[0044] The head units 200 include a plurality of ink jet heads 1, a plurality of ink tanks 202 as liquid tanks respectively mounted on the ink jet heads 1, connection flow paths 203 that connect the ink jet heads 1 and the ink tanks 202, and circulation pumps 204 that are circulation units. The head unit 200 is a circulation type head unit that circulates a liquid.

[0045] In the present embodiment, the head units 200 include the inkjet heads 1 for four colors of cyan, magenta, yellow, and black as the inkjet heads 1, and the ink tanks 202 that respectively contain inks of these colors. The ink tank 202 is connected to the ink jet head 1 by the connection flow path 203. The connection flow path 203 includes a supply side flow path connected to the supply port of the ink jet head 1 and a recovery side flow path connected to the discharge port of the ink jet head 1.

[0046] A negative pressure control device such as a pump (not illustrated) is connected to the ink tank 202. Then, by controlling the inside of the ink tank 202 with the negative pressure control device corresponding to water head pressure between the ink jet head 1 and the ink tank 202, the ink supplied to each nozzle of the ink jet head 1 is formed into a meniscus having a predetermined shape.

[0047] A circulation pump 204 is a liquid feed pump composed of, for example, a piezoelectric pump. The circulation pump 204 is provided in the supply side flow path. The circulation pump 204 is connected to a drive circuit of the control unit 106 by wiring. A central processing unit (CPU) 1061 is configured to be able to control the circulation pump 204. The circulation pump 204 circulates the liquid in a circulation flow path including the ink jet head 1 and the ink tank 202.

[0048] The conveyance device 105 conveys paper P along a conveyance path A from the paper feed cassette 1021 of the medium supply unit 102 to the paper discharge tray 1041 of the medium discharge unit 104 through the image forming unit 103. The conveyance device 105 includes a plurality of guide plate pairs disposed along the conveyance path A, and a plurality of conveyance rollers.

[0049] The control unit 106 includes a CPU 1061 which is a controller, a read only memory (ROM) that stores various programs and the like, and a random access memory (RAM) that temporarily stores various variable data, image data, and the like, and an interface unit that receives data from the outside and outputs data to the outside.

[0050] In the ink jet head 1 and the ink jet printer 100, when driving to discharge the liquid from the nozzle 31, the control unit 106 applies a drive voltage through the pattern electrode 17 by the drive circuit to bend and deform the drive element portion, thereby discharging the droplet from the nozzle 31 due to the volume change of the pressure chamber 14.

[0051] According to the embodiment described above, an ink jet head easy to manufacture can be provided. That is, according to the embodiment described above, since the electrode layer is not formed at the position where the liquid-repellent film 15 is formed, patterning of the electrode layer 16 can be easily performed. By irradiating with UV light having high linearity, a liquid-repellent film can be formed at a predetermined location of the groove 132 except for the side surface of the groove 132 with high positional accuracy even without using a mask. By using UV light having a long wavelength of 330 nm or more, the bottom surface portion 1321 of the groove 132 can be irradiated. Therefore, the electrodes can be arranged at predetermined locations with high

accuracy, and high ink discharge performance can be ensured.

[0052] According to the embodiment described above, since the liquid-repellent film 15 is also formed on the top surface portion 1311 of the actuator 13, extrusion of the adhesive can be suppressed when the adhesive is applied. Since the extrusion of the adhesive can be reduced, the thickness of the adhesive can be controlled and the distance from the nozzle plate 30 can be controlled in the adhesion between the nozzle plate 30 and the actuator 13. Accordingly, heights of the laminated piezoelectric elements 133 configuring the plurality of drive element portions can be made uniform to reduce inclination and distortion of the nozzle plate 30. In the embodiment described above, by forming the liquid-repellent film 15 on the nozzle facing surface of the frame 20 as well, the thickness of the adhesive layer on the frame 20 can be controlled in addition to the actuator 13. Then, for example, since the dimension from the main surface of the base material 12 to the nozzle facing surface of the frame 20 can be controlled by adhering to the main surface of the base material 12 through an adhesive sheet of thermoplastic resin, the height of the adhesive between the nozzle plate 30 and the frame 20 can be controlled. Thus, the heights of the actuator 13 and the frame 20 with respect to the nozzle surface can be easily aligned, and flatness of the nozzle plate 30 can be ensured. Since the electrode is not provided on the bottom surface portion of the groove 132, the dimension of the bottom portion of the groove 132 can be reduced.

[0053] According to the embodiment described above, ink can be supplied from the bottom surface portion of the groove 132 by configuring the ink supply path 134 in the bottom surface portion 1321 of the groove 132 configuring the pressure chamber 14. Accordingly, by closing both ends of the groove 132 that configures the air chamber B and setting the electrode of the groove 132 that configures the pressure chamber 14 to which the ink is supplied to the GND, electrolysis and redox reaction can be prevented. That is, in a structure in which ink is supplied from a common ink chamber in the longitudinal direction of the pressure chamber, when a voltage is applied to the electrodes of the pressure chamber, a voltage difference may occur in the common ink chamber. When conductive ink such as water-based ink is used, electrolysis may occur due to the potential difference, and the ink may not be discharged. But, according to the embodiment described above, the actuator 13 can be driven without applying a voltage to the ink and generating a potential difference, by setting the electrode of the groove 132 configuring the pressure chamber 14 to the GND and applying a voltage to the air chamber B as the dummy chamber. Therefore, even when ink having high conductivity or containing an oxidizing agent or a reducing agent is used, electrolysis or a redox reaction does not occur.

[0054] The exemplary embodiment is not limited to the embodiments described above as it is, and at the implementation stage, can be embodied by modifying the constitutional elements without departing from the gist thereof.

[0055] In the embodiment described above, a so-called side shooter type ink jet head 1 is illustratively described, but is not limited thereto. For example, the embodiment may also be applied to an end shooter type ink jet head. For example, a configuration in which a comb-shaped actuator base including grooves that open in two different directions blocks a predetermined direction different from the surface facing the nozzle plate by a plate-shaped member as a first member may be adopted.

[0056] In the embodiment described above, although an example in which the piezoelectric member 131 having a plurality of grooves 132 is disposed on the main surface portion of the base material 12 is illustratively described, but is not limited thereto. For example, a configuration in which an actuator is provided on the end face of the base material 12 may also be adopted. The number of nozzle rows is not limited to the embodiment described above, a configuration in which one row or three or more rows are provided may be adopted.

[0057] An example is illustratively described in which the liquid-repellent film 15 to be irradiated with UV is formed without using a mask when the bottom surface portion 1321 in the groove 132 and the top surface portion 1311 are irradiated with UV light to form the liquid-repellent film 15, but is not limited thereto. For example, a mask may be disposed as needed to perform patterning when subjecting the bottom surface portion 1321 and the top surface portion 1311 to UV irradiation.

[0058] In the embodiment described above, the actuator base 10 including the laminated piezoelectric body composed of the piezoelectric members 131 on the base material 12 is illustratively described, but is not limited thereto. For example, the actuator base 10 may be formed only by a piezoelectric member without using a substrate. One piezoelectric member may be used instead of two piezoelectric members.

[0059] For example, a liquid to be discharged is not limited to ink for printing, and, for example, an apparatus that discharges a liquid containing conductive particles for forming a wiring pattern of a printed wiring board may also be adopted.

[0060] In the embodiment described above, an example in which the ink jet head is used for a liquid discharge apparatus such as an ink jet recording apparatus is illustratively described, but is not limited thereto. For example, the ink jet head can also be used for 3D printers, industrial manufacturing machines, and medical applications, and can be reduced in size, weight, and cost.

[0061] According to at least one embodiment described above, a liquid discharge head that is easy to manufacture can be provided.

[0062] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other

forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the scope of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope of the inventions.

Claims

1. A liquid discharge head comprising:

a nozzle plate on which nozzles are formed;
an actuator disposed facing the nozzle plate and provided with grooves configuring a plurality of pressure chambers communicating with the nozzles;
liquid-repellent films formed in a predetermined first region on a surface of the actuator; and
electrode layers formed in a second region different from the first region in which the liquid-repellent films are formed on the surface of the actuator.

2. The liquid discharge head according to claim 1, wherein
the actuator is provided with a plurality of drive element portions and the grooves formed between the plurality of drive element portions, and is provided on a base material,
each of the electrode layers is formed at a predetermined location on a side wall surface of each of the grooves, a main surface of the base material, and a side surface of the actuator, and
each of the liquid-repellent films is formed at a location different from the electrode layer on a bottom surface portion of each of the grooves, the main surface of the base material, and the side surface of the actuator.

3. The liquid discharge head according to claim 1 or 2, wherein
a supply path for supplying a liquid to the pressure chamber is formed on the bottom surface portion of the groove configuring the pressure chamber.

4. The liquid discharge head according to any one of claims 1 to 3, wherein
the liquid-repellent films are formed on a facing surface of the actuator facing the nozzle plate.

5. The liquid discharge head according to any one of claims 1 to 4, further comprising:

a frame configured to surround the actuator and adhered to the nozzle plate, wherein
liquid-repellent films are formed on the facing surface of the frame facing the nozzle plate.

6. A printer comprising:

the liquid discharge head according to any one of claims 1 to 5; and
a conveyance device for conveying a medium in a conveying direction in the printer.

FIG. 1

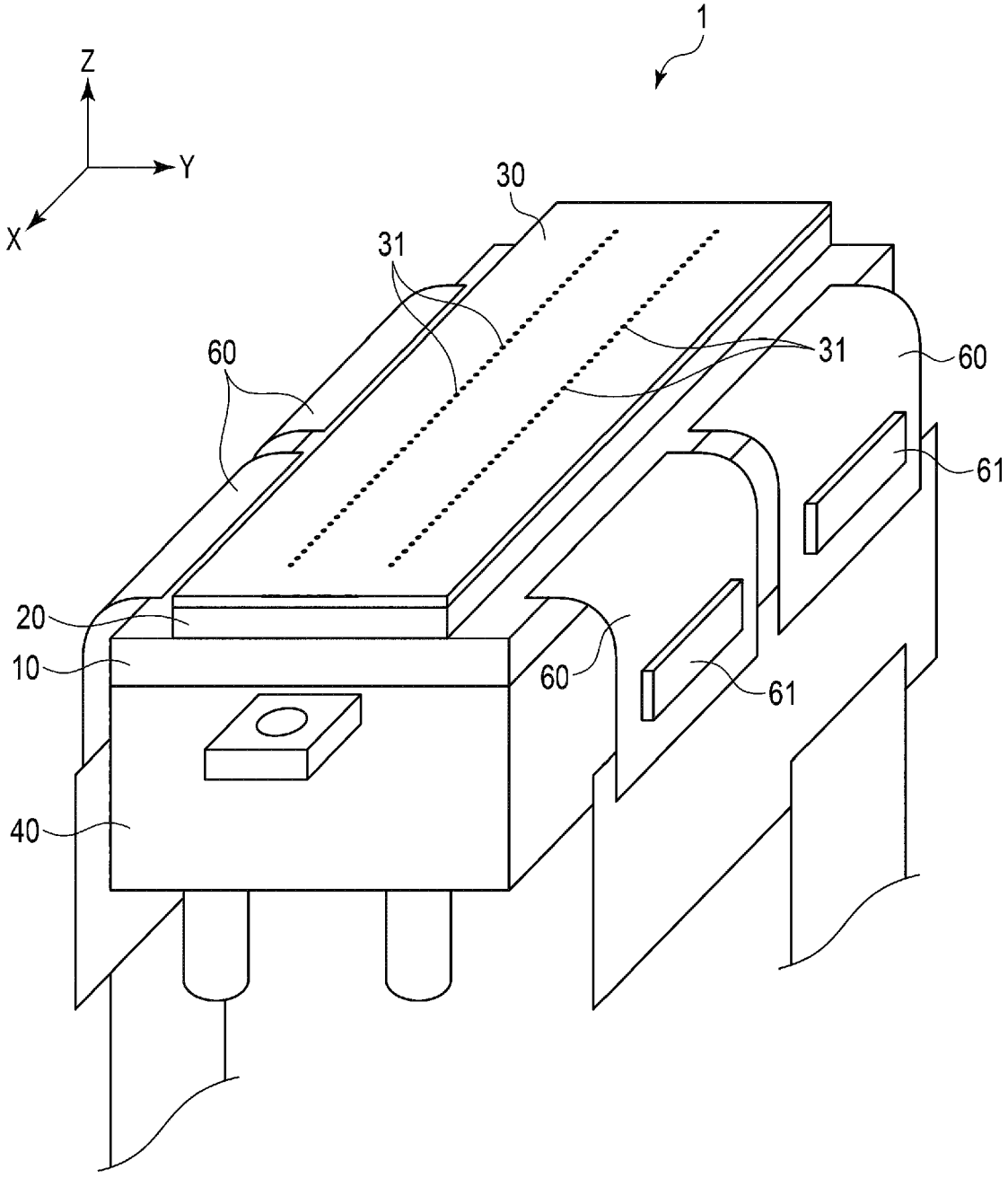


FIG. 2

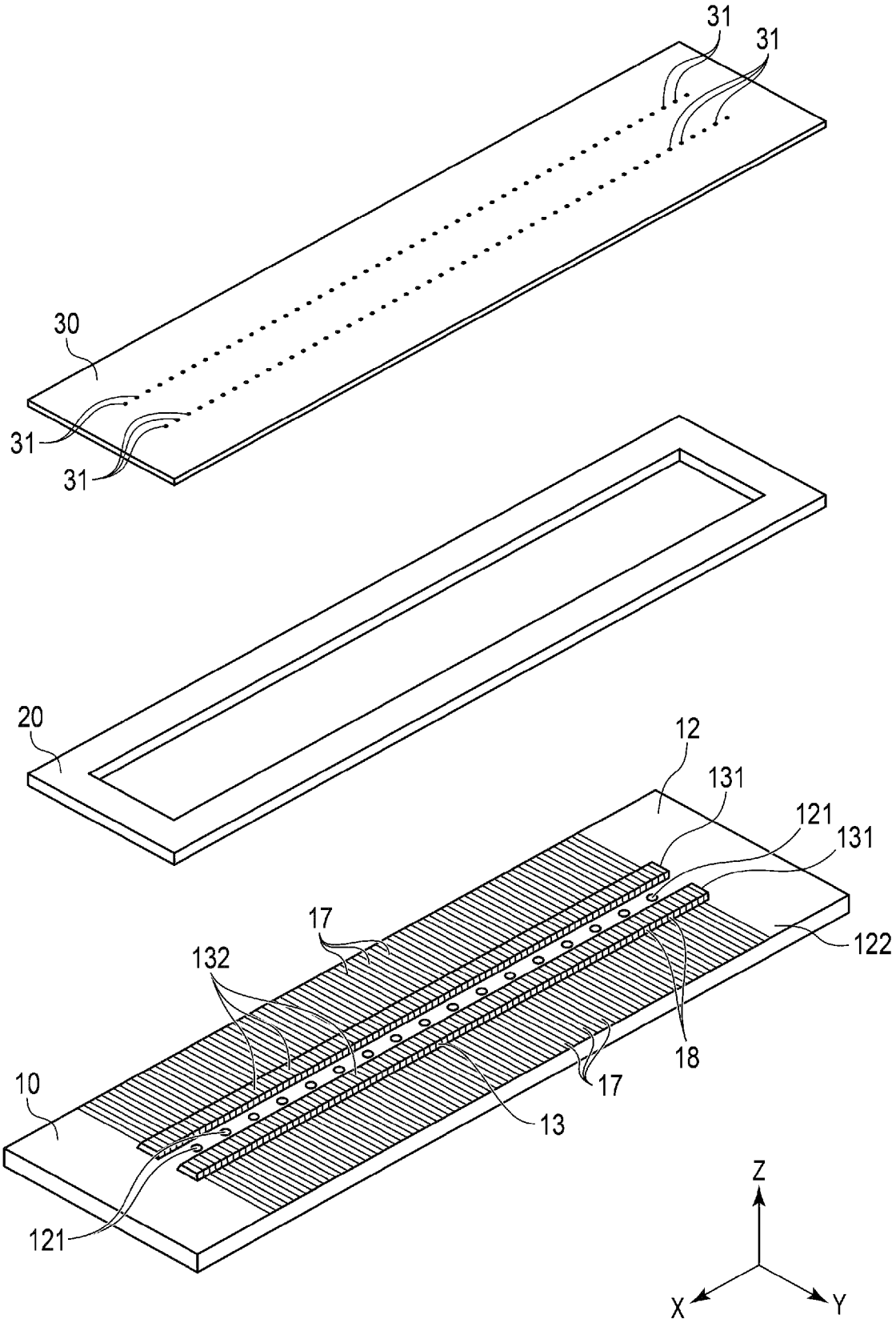


FIG. 3

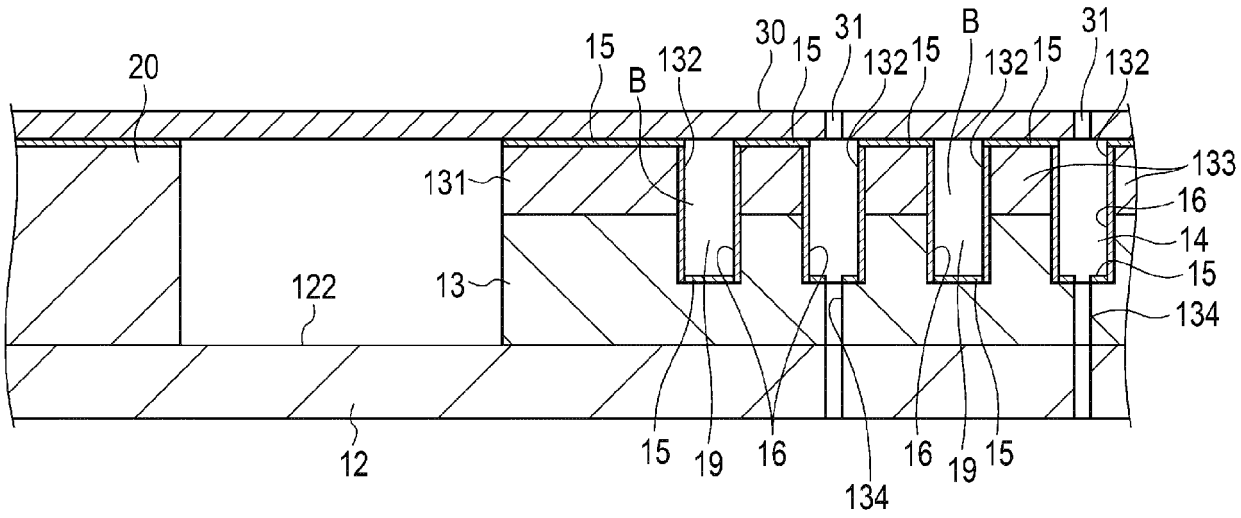

20
15
B
132
30
15
31
132
15
B
132
15
31
132
133
16
14
15
134
131
13
122
12
15
19
16
134
16
19
15

FIG. 4

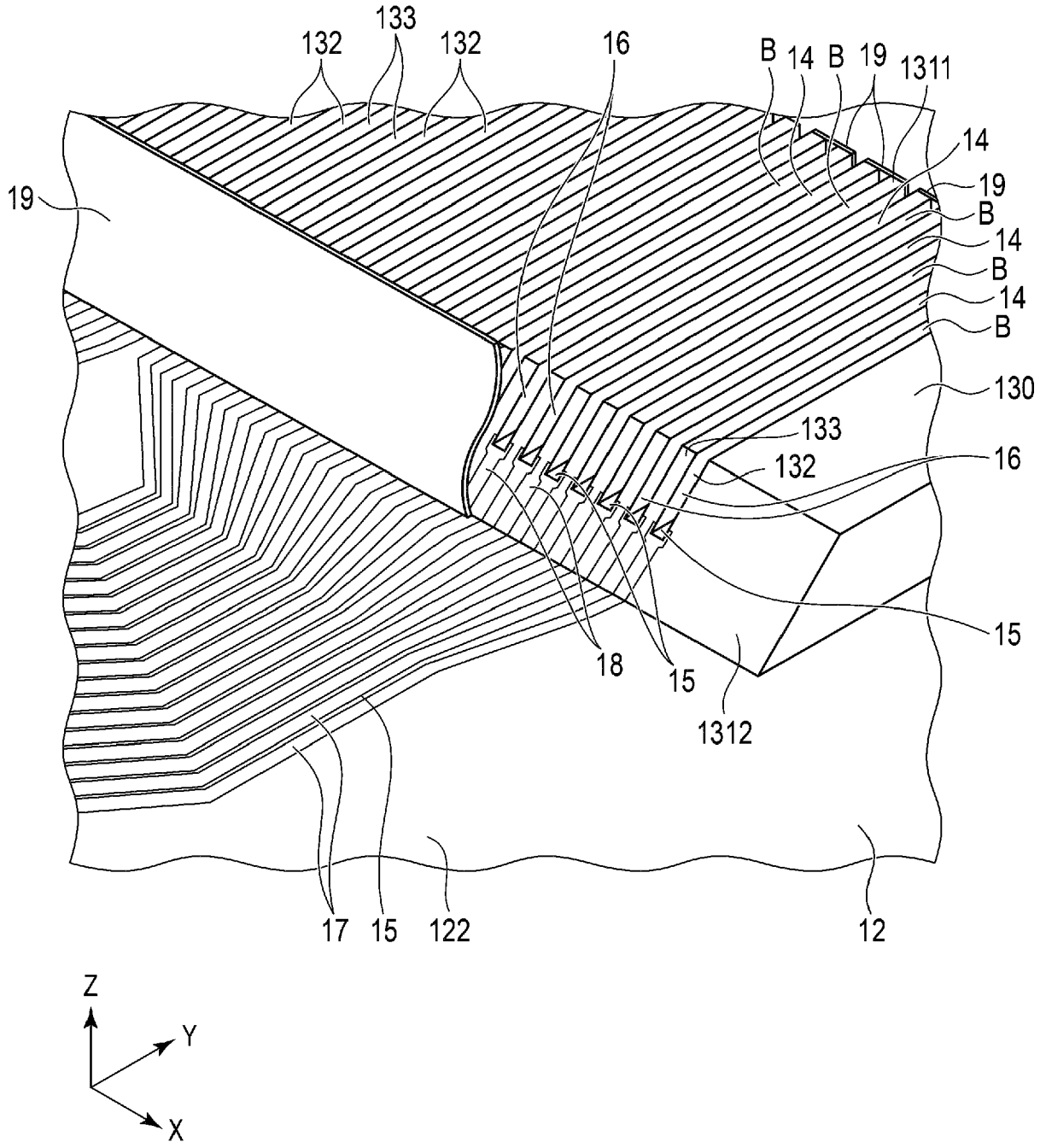

133
132
132
16
B
14
B
19
1311
14
19
B
14
B
14
B
19
130
133
132
16
15
18
15
1312
17
15
122
12
Z
Y
X

FIG. 5

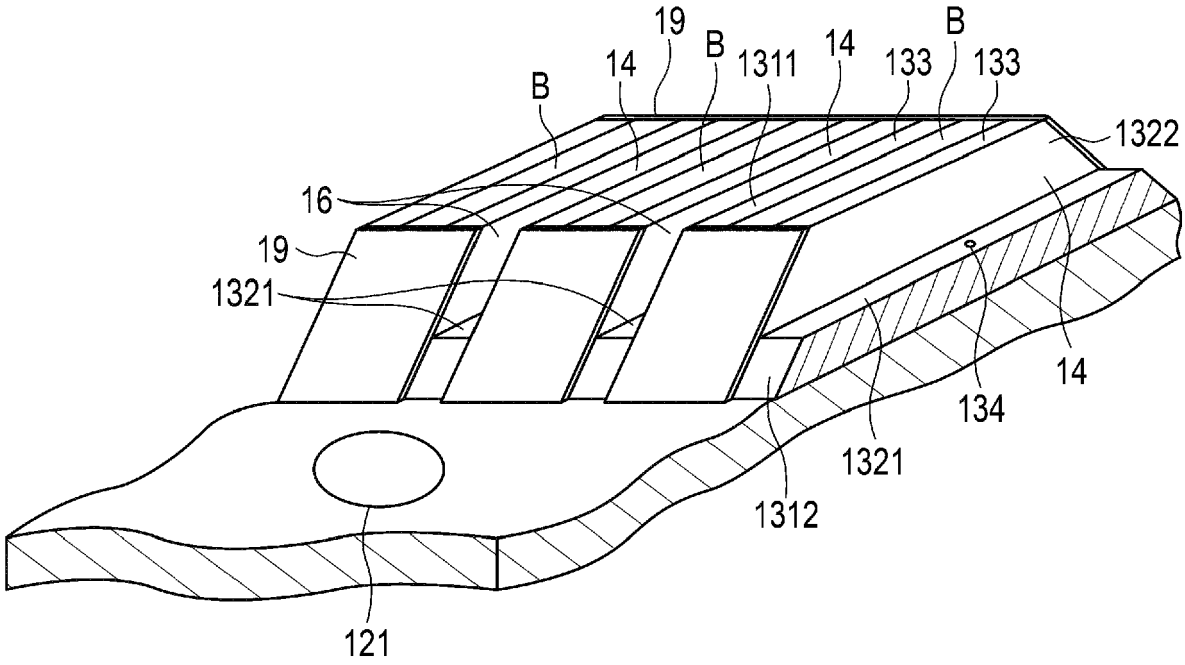


FIG. 6

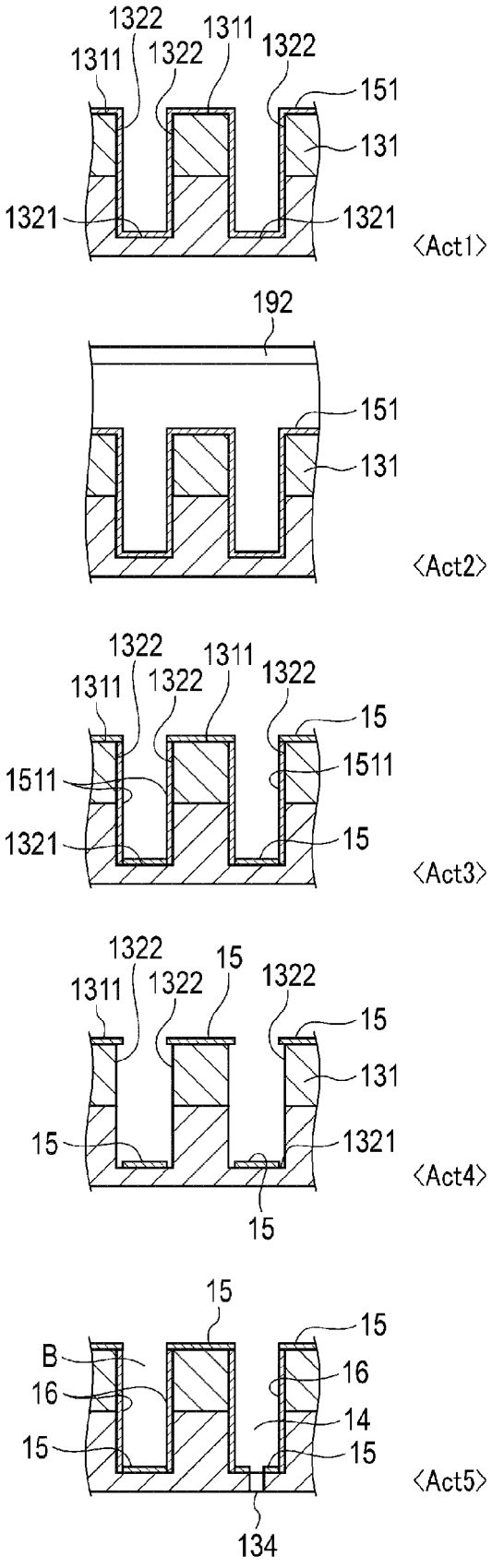

1322
1311
1322
1311
1322
151
131
1321
1321
〈Act1〉
192
151
131
〈Act2〉
1322
1311
1322
1311
1322
15
1511
1511
1321
15
〈Act3〉
1322
1311
1322
15
1322
15
131
15
1321
15
〈Act4〉
15
15
B
16
16
14
15
15
134
〈Act5〉

FIG. 7

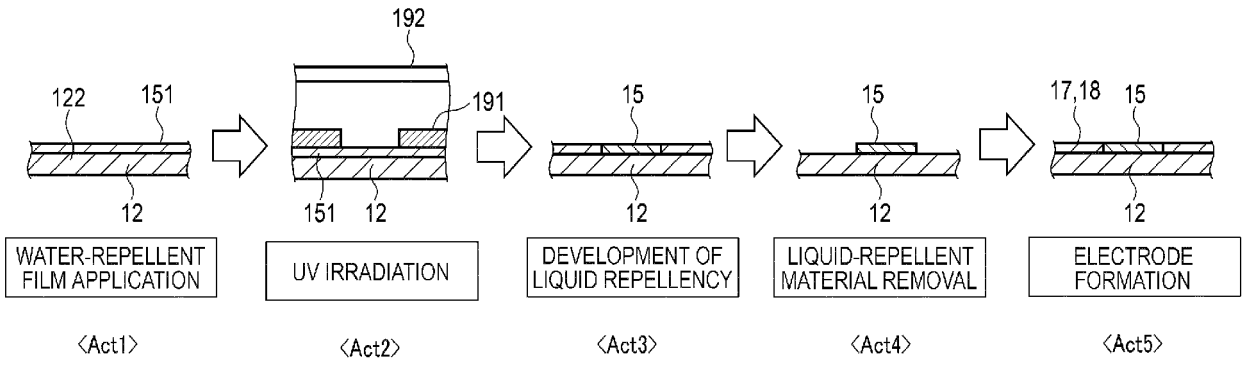
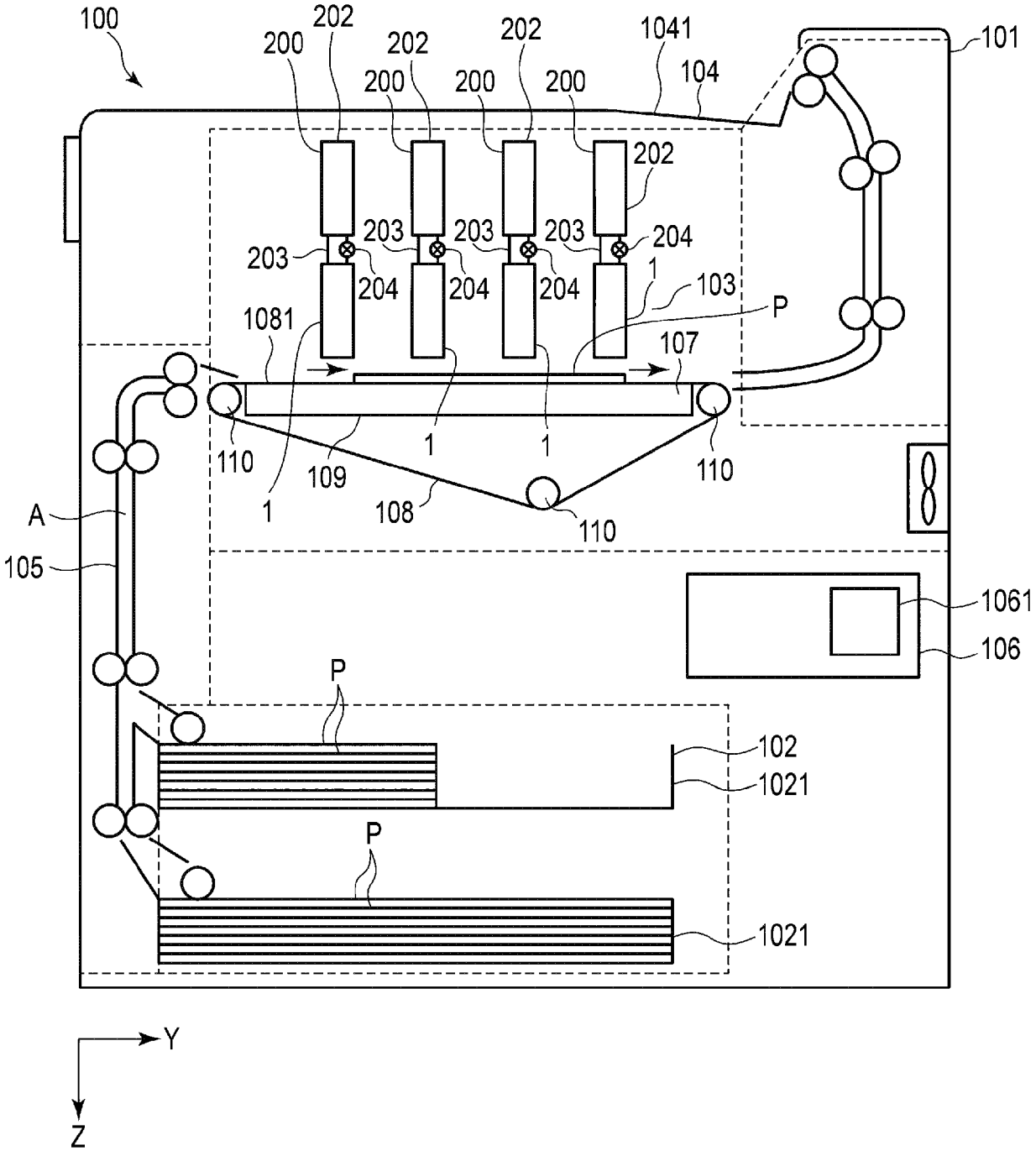

192
122
151
191
15
15
17,18
15
12
151
12
12
12
12
WATER-REPELLENT FILM APPLICATION
UV IRRADIATION
DEVELOPMENT OF LIQUID REPELLENCY
LIQUID-REPELLENT MATERIAL REMOVAL
ELECTRODE FORMATION
〈Act1〉
〈Act2〉
〈Act3〉
〈Act4〉
〈Act5〉

FIG. 8

SUBSTRATE SURFACE	CONTACT ANGLE TO PURE WATER
PZT	70°
LIQUID-REPELLENT FILM	110°

FIG. 9



Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 21 16 8257

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	EP 3 663 091 A1 (SII PRINTEK INC [JP]) 10 June 2020 (2020-06-10) * paragraph [0076]; figures 8,21 * -----	1,3,4,6	INV. B41J2/14 B41J2/16
X	JP 2002 160364 A (SEIKO INSTR INC) 4 June 2002 (2002-06-04) * paragraph [0025]; figure 5 * -----	1,2,6	
X	EP 3 711 956 A1 (TOSHIBA TEC KK [JP]) 23 September 2020 (2020-09-23) * paragraph [0031]; figures 2,4 * -----	1,5	

TECHNICAL FIELDS SEARCHED (IPC)

B41J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	8 September 2021	Bardet, Maude

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

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 21 16 8257

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.

08-09-2021

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 3663091 A1	10-06-2020	CN 111284135 A	16-06-2020
		EP 3663091 A1	10-06-2020
		JP 2020090054 A	11-06-2020
		US 2020180311 A1	11-06-2020
JP 2002160364 A	04-06-2002	NONE	
EP 3711956 A1	23-09-2020	CN 111703206 A	25-09-2020
		EP 3711956 A1	23-09-2020
		JP 2020151863 A	24-09-2020
		US 2020298565 A1	24-09-2020

EPO FORM P0459

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