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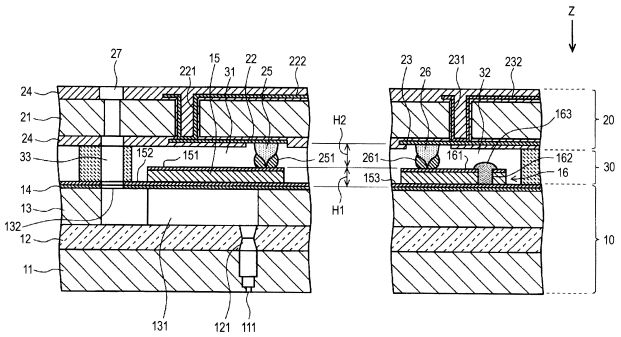
(54) INKJET HEAD AND INKJET HEAD MANUFACTURING METHOD

(57) The present invention addresses the problem of providing an inkjet head with which reliable electrical connections are possible as a result of a simple and novel configuration for making the heights of contact surfaces of electrodes on a head chip and wiring on a circuit board equal, and a manufacturing method for said inkjet head. The problem is solved by: a head chip (10) having a lead part (153) drawn to the outside of a piezoelectric element (15), on the upper surface of which a first electrode section (151) is formed and on the lower surface of which a second electrode section (152) is formed, the lead part being drawn from the second electrode section (152) of the piezoelectric element (15); a circuit board (20), which is disposed above the head chip (10), having a first connection member (25) obtained from a stud bump that is to be connected to the first electrode section (151) and a second connection member (26) obtained from a stud bump that is to be connected to the second electrode section (152) via the lead part (153); the lead part (153) being provided with an adjusting member (16), the upper surface of which is roughly the same height as the height of the first electrode section (151) and has electrical continuity with the lead part (153); and the first connection member (25) of the circuit board (20) being electrically connected to the upper surface of the first electrode section (151) and the second connection member (26) contacting the upper surface of the adjusting member (16) and being electrically connected to the second electrode section (152) via the adjusting member (16) and the lead part (153).

FIG. 3



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Description

Technical Field

[0001] The present invention relates to an inkjet head and a method for manufacturing the inkjet head, particularly relates to the inkjet head capable of reliably achieving electrical connection, with a simple method, in performing electrical connection between an electrode on a head chip and wiring on a wiring substrate by equalizing a height of a contact surface.

Background Art

[0002] In recent years, high accuracy and high quality are demanded for images formed by ink ejection from an inkjet head. In a case, for example, where an image is formed by using a line head including a plurality of recording heads arranged across a width direction of a recording medium and by conveying the recording medium to a recording region of the line head, an ejection defect on a nozzle on the line head might cause a stripe and unevenness and degrade the image. Therefore, in order to prevent image degradation and provide a high-accuracy and high-quality image, it is needed to prevent the ejection defect, or the like, in individual nozzles provided on the inkjet head.

[0003] There are various techniques for preventing ejection defects in the nozzle. In a case of an inkjet head that ejects the ink by pressurizing the ink within a pressure chamber communicating with the nozzle by driving piezoelectric elements, it is necessary to reliably supply power to each of the piezoelectric elements in order to reliably drive the piezoelectric elements. Therefore, it is important to achieve reliable electrical connection between each of a first electrode unit (individual electrode) into which driving potential is input and a second electrode unit (shared electrode) into which GND potential is input, formed so as to sandwich the piezoelectric element, with each of wiring of the wiring substrate stacked above the piezoelectric element.

[0004] Specifically, there is a known technique for reliably connecting the first electrode unit of the piezoelectric element with the wiring of the wiring substrate, for example, that uses a partition member formed of resin material to enclose the piezoelectric element so as to maintain a constant space between a head chip with a piezoelectric element and the wiring substrate including wiring, and that performs electrical connection between each of the wiring on the wiring substrate and the electrode formed on each of the piezoelectric elements by allowing a bump provided on a surface of the electrode formed on the piezoelectric element to come in contact with the wiring (Patent Literature 1).

[0005] There is another technique of performing electrical connection by building a bump on a lead-out unit electrically drawn from the second electrode unit formed on the piezoelectric element and allowing the bump to come in contact with the wiring of the wiring substrate, in addition to performing electrical connection by building a bump on the first electrode unit formed on the piezoelectric element and allowing the bump to come in contact with the wiring of the wiring substrate (Patent Literature 2).

[0006] Patent Literature 2 discloses a technique of equalizing the contact state of each of electrical connecting sites and preventing a partial contact failure by allowing the position where the first electrode unit comes in contact with the wiring and the position where the second electrode unit comes in contact with the wiring to have a same height in order to achieve reliable electrical connection between each of the first electrode unit and the second electrode unit formed on the piezoelectric element, with the wiring of the wiring substrate.

Citation List

Patent Literature

[0007]

Patent Literature 1: JP 2014-83705 A
Patent Literature 2: WO 2012/176875 A

Summary of Invention

Technical Problem

[0008] Any of Patent Literatures 1 and 2, however, has a configuration in which the bump is built on the first electrode unit formed on the piezoelectric element, and thus, an attempt to use high pressure to reliably achieve electrical connection in bonding when the wiring substrate is mutually pasted might cause the pressure to be concentrated on the bump on the surface of the first electrode unit and the damage the piezoelectric element. This leads to a problem of occurrence of demands for high-accuracy pressure control at the time of pressure bonding.

[0009] Furthermore, in Patent Literature 2, because of the configuration in which a bump provided on the first electrode unit and a bump provided on the second electrode unit, of the piezoelectric element, are connected with the wiring of the wiring substrate, there may be a case where bonding heights are not even and electrical connection becomes uncertain when the pressure at pressure bonding is not even.

[0010] Moreover, even when the pressure is applied evenly, since there are differences in size and height between the bump provided on the first electrode unit and the bump provided on the second electrode unit, this might lead to a different in a deforming amount when pressure bonding is performed. It is, however, difficult to equalize the height of individual contact surfaces by performing pressure control in consideration of the deforming amount.

[0011] Accordingly, an object of the present invention is to provide an inkjet head capable of reliably performing electrical connection using a novel and simple configuration that equalizes the height of the contact surface on the electrical connection between the electrode on the head chip and the wiring on the wiring substrate, and a method for manufacturing the inkjet head.

[0012] Other problems regarding the present invention will be made clear by the following description.

Solution to Problem

[0013] The above-described problem will be solved by the following invention.

1. An inkjet head including:

a head chip including a pressure chamber configured to contain ink ejected from a nozzle, a piezoelectric element that is provided corresponding to the pressure chamber and includes a first electrode unit on an upper surface and a second electrode unit on a lower surface, and a lead-out unit electrically drawn from the second electrode unit to the outside of the piezoelectric element; and

a wiring substrate arranged above the head chip and including a first connecting member formed with a stud bump electrically connected with the first electrode unit of the head chip, and a second connecting member formed with a stud bump electrically connected with the second electrode unit via the lead-out unit,

wherein the lead-out unit includes an adjustment member that includes an upper surface arranged at a height substantially equal to the height of the first electrode unit and in which at least the upper surface has electrical continuity with the lead-out unit, and

the first connecting member of the wiring substrate is electrically connected with the first electrode unit by coming into contact with an upper surface of the first electrode unit, and the second connecting member is electrically connected with the second electrode unit via the adjustment member and the lead-out unit by coming into contact with the upper surface of the adjustment member.

2. The inkjet head according to the above-described 1, wherein the adjustment member is formed of a material having Poisson's ratio of 0.4 or below.

3. The inkjet head according to the above-described 1 or 2, wherein the upper surface of the adjustment member has an area that is equal to or larger than the area of the first electrode unit on the upper surface of the piezoelectric element provided corresponding to the pressure chamber.

4 . The inkjet head according to the above-described 1, 2, or 3, wherein the adjustment member is formed with the piezoelectric element including, on an upper surface, a third electrode unit having electrical continuity with the lead-out unit.

5. The inkjet head according to the above-described 4, wherein the piezoelectric element used in the adjustment member includes a hole penetrating in a height direction or a groove cut across the height direction, and

the third electrode unit and the lead-out unit are electrically connected with each other via a conductive material by filling the conductive material into the hole or the groove.

6. The inkjet head according to the above-described 5, wherein there is a plurality of the second connecting members, and a part of the second connecting members among the plurality of second connecting members is in contact solely with the conductive material filled into the hole or the groove.

7. The inkjet head according to any one of the above-described 1 to 5, wherein there is a plurality of the second connecting members, and the plurality of second connecting members is electrically connected with the upper surface of the adjustment member shared by the plurality of second connecting members.

8. The inkjet head according to any one of the above-described 1 to 7, wherein there is a plurality of the pressure chambers, and the individual second electrode units formed on a plurality of the piezoelectric elements provided corresponding to the pressure chambers are electrically drawn by the lead-out unit that is shared by the plurality of second electrode units.

9. The inkjet head according to any one of the above-described 1 to 8, wherein tip positions of the first connecting member and the second connecting member are arranged at substantially equal heights in a direction of arrangement of the head chip.

10. The inkjet head according to any one of the above-described 1 to 9, wherein each of the first connecting member and the second connecting member has a conductive material applied, and is electrically connected with the upper surface of the first electrode unit and the upper surface of the adjustment member, via the conductive material.

11. A method for manufacturing an inkjet head including:

a head chip including a pressure chamber configured to contain ink ejected from a nozzle, a piezoelectric element that is provided corresponding to the pressure chamber and includes a first electrode unit on an upper surface and a second electrode unit on a lower surface, and a lead-out unit electrically drawn from the second electrode unit to the outside of the piezoelectric

element; and
a wiring substrate arranged above the head chip and including a first connecting member electrically connected with the first electrode unit of the head chip, and a second connecting member electrically connected with the second electrode unit via the lead-out unit,
the method including:

a piezoelectric element formation step of forming, on the head chip, the piezoelectric element including the first electrode unit and the second electrode unit, corresponding to the pressure chamber;
a lead-out unit formation step of forming the lead-out unit on the head chip;
an adjustment member formation step of forming, on the lead-out unit, an adjustment member that includes an upper surface arranged at a height substantially equal to the height of the first electrode unit, the upper surface having electrical continuity with the lead-out unit; and
a bonding step of bonding the wiring substrate with the head chip so as to cause the first connecting member to be electrically connected with the first electrode unit by bringing the first connecting member into contact with an upper surface of the first electrode unit, and to cause the second connecting member to be electrically connected with the second electrode unit via the adjustment member by bringing the second connecting member into contact with the upper surface of the adjustment member.

12. The method for manufacturing an inkjet head according to the above-described 11,
wherein the adjustment member is formed with the piezoelectric element including, on an upper surface, a third electrode unit that has electrical continuity with the lead-out unit, and
the piezoelectric element used in the adjustment member is formed, in the adjustment member formation step, simultaneously at the time of forming the piezoelectric element corresponding to the pressure chamber by the piezoelectric element formation step.
13. The method for manufacturing an inkjet head according to the above-described 12,
wherein the piezoelectric element is a PZT thin film, and the piezoelectric element corresponding to the pressure chamber and the piezoelectric element used in the adjustment member are patterned simultaneously by etching the PZT thin film.
14. The method for manufacturing an inkjet head according to the above-described 11, 12, or 13, further including:

a connecting member formation step of forming, on the wiring substrate, the first connecting member and the second connecting member so as to have protruding shapes in a direction of arrangement of the head chip, and so as to allow tip positions of the connecting members to be arranged at substantially equal heights in the direction of arrangement of the head chip.

Brief Description of Drawings

[0014]

Fig. 1 is a cross-sectional diagram illustrating an exemplary inkjet head according to the present invention.
Fig. 2 is a plan view of a head chip of the inkjet head.
Fig. 3 is a partially enlarged cross-sectional diagram of the inkjet head.
Figs. 4(a) to 4(c) are cross-sectional diagrams illustrating other modes of connection configurations between a second connecting member of a wiring substrate and an adjustment member.
Figs. 5(a) to 5(c) are diagrams illustrating manufacturing steps of the inkjet head according to the present invention.
Figs. 6(a) to 6(c) are diagrams illustrating manufacturing steps of the inkjet head according to the present invention.
Figs. 7(a) and 7(b) are diagrams illustrating a method for manufacturing the inkjet head according to the present invention.
Fig. 8 is a diagram illustrating a method for manufacturing the inkjet head according to the present invention.
Fig. 9 is a partial plan view illustrating other mode of the adjustment member.

Description of Embodiments

[0015] Hereinafter, an embodiment of the present invention will be described in detail with reference to the drawings.

(Inkjet head)

[0016] Fig. 1 is a cross-sectional diagram illustrating an exemplary inkjet head according to the present invention. Fig. 2 is a plan view of a head chip of the inkjet head. Fig. 3 is a partially enlarged cross-sectional diagram of the inkjet head.
[0017] An inkjet head 1 has an integrated stacked configuration formed with a head chip 10 and a wiring substrate 20, having a spacer substrate 30 therebetween. On an upper surface of the wiring substrate 20, a box-shaped manifold 40 is arranged. The inside of the manifold 40 is an ink storage chamber 41.
[0018] Note that, in a case where "upper" or "lower" is

indicated in the present invention, a Z-direction indicated with an arrow represents "lower" and the opposite direction thereof represents "upper", relative to a state of the inkjet head 1 in Figs. 1 and 3. Accordingly, the direction with "above" or "up" represents a direction opposite to the Z-direction of the inkjet head 1 and the direction with "below " or "down" represent a direction along the Z-direction. Moreover, "upper surface" represents a surface arranged in the direction opposite to the Z-direction of the inkjet head 1 and "lower surface" is a direction arranged in the Z-direction.

[0019] The head chip 10 is configured with a nozzle plate 11, an intermediate plate 12, a pressure chamber plate 13, and a vibration plate layer 14, stacked from the lower side in Fig. 3.

[0020] The pressure chamber plate 13 is formed of a silicon (Si) substrate, for example. The pressure chamber plate 13 includes a pressure chamber 131 that contains ink ejected from a nozzle 111 formed on the nozzle plate 11. The number of pressure chambers 131 may be any, that is, it is sufficient to have at least one. The present embodiment exemplifies the inkjet head 1 including a plurality of the pressure chambers 131.

[0021] The plurality of pressure chambers 131 is arrayed in the X-Y direction of the head chip 10 (refer to Fig. 2) when the head chip 10 is seen in plan view. The pressure chamber 131 is formed so as to penetrate the pressure chamber plate 13. Accordingly, an upper wall of the pressure chamber 131 is formed with the vibration plate layer 14 and a lower wall is formed with the intermediate plate 12.

[0022] The vibration plate layer 14 is formed of a silicon oxide (SiO_2) film, for example. The vibration plate layer 14 includes, corresponding to the pressure chamber 131, an ink inflow port 132 that opens onto an upper surface of the head chip 10.

[0023] The intermediate plate 12 is formed of a glass substrate, for example. The intermediate plate 12 includes, corresponding to the pressure chamber 131, a plurality of communication passages 121 that communicates with the inside of the pressure chamber 131.

[0024] The nozzle plate 11 is formed of a Si substrate, for example. The nozzle plate 11 includes, corresponding to each of the communication passages 121 of the intermediate plate 12, a plurality of nozzles 111 opening onto a lower surface of the nozzle plate 11. Accordingly, the inkjet head 1 according to the present embodiment ejects ink downward from the nozzle 111.

[0025] The piezoelectric element 15 is provided on the upper surface of the head chip 10. Corresponding to each of the pressure chambers 131, the piezoelectric element 15 is arranged on an upper surface of the vibration plate layer 14 that forms an upper wall of the pressure chamber 131. The piezoelectric element 15 according to the present embodiment is formed of a PZT thin film having a predetermined thickness. Since it is possible to etch the PZT thin film using a photolithography technology, making it possible to easily form a plurality of piezoelectric elements 15 arrayed in a predetermined pattern.

[0026] The piezoelectric element 15 includes a first electrode unit 151 and a second electrode unit 152. The first electrode unit 151 is an individual electrode provided individually for each of the piezoelectric elements 15, formed on an upper surface of the piezoelectric element 15. The second electrode unit 152 is a shared electrode for GND provided for the shared use by the plurality of piezoelectric elements 15, formed on a lower surface of the piezoelectric element 15. The second electrode unit 152 is formed on the upper surface of the vibration plate layer 14, and the piezoelectric element 15 is mounted on an upper surface of the second electrode unit 152.

[0027] With this configuration, an upper surface of the first electrode unit 151 is arranged at a predetermined height H1 (refer to Fig. 3). Note that, in the present invention, the height H1 at which the upper surface of the first electrode unit 151 is arranged is defined as a height from the upper surface of the vibration plate layer 14 just below the piezoelectric element 15 to the upper surface of the first electrode unit 151, relative to the upper surface of the vibration plate layer 14. There is no bump provided on the upper surface of the first electrode unit 151

[0028] The second electrode unit 152 is formed so as to significantly protrude to the outside of a forming region of the piezoelectric element 15. Specifically, the second electrode unit 152 is formed toward an end portion arranged in a Y-direction of the head chip 10 and toward an end portion arranged in a direction opposite to the Y-direction, illustrated in Fig. 2, so as to protrude to the outside of the forming region of piezoelectric element 15. With this configuration, a lead-out unit 153 is formed on the upper surface of the vibration plate layer 14. The lead-out unit 153 is formed of an electrode film same as that of the second electrode unit 152 (refer to Fig. 3). That is, the second electrode unit 152 is electrically drawn to the outside of the forming region of the piezoelectric element 15 by the lead-out unit 153, on the upper surface of the vibration plate layer 14.

[0029] Moreover, the second electrode unit 152 is electrically drawn from the lead-out unit 153 shared by the plurality of piezoelectric elements 15. This configuration can integrate the second electrode unit 152 formed on the plurality of piezoelectric elements 15, onto the lead-out unit 153, making it possible to simplify electrical connection toward a plurality of the second electrode units 152.

[0030] An adjustment member 16 is provided on an upper surface of the lead-out unit 153. The adjustment member 16 is a member for adjusting the height of an electrical connecting site for achieving electrical continuity between the lead-out unit 153 and a connecting member of the wiring substrate 20 to be described below. For example, the adjustment member 16 according to the present embodiment is formed so as to extend along the X-direction illustrated in Fig. 2, on the upper surface of the lead-out unit 153 drawn in the vicinity of both end portions of the head chip 10.

[0031] The adjustment member 16 may be formed of a single member on the upper surface of the lead-out unit 153, or may be formed by stacking a plurality of layers on the upper surface of the lead-out unit 153.

[0032] Each of the adjustment members 16 in the vicinity of the both end portions of the head chip 10 is divided into two in the X-direction. With this configuration, it is possible to prevent the adjustment member 16 from being deformed or damaged by becoming too elongated. However, it is sufficient to have at least one adjustment member 16 in the present invention.

[0033] The adjustment member 16 is preferably formed of a material having Poisson's ratio of 0.4 or below. Typical Poisson's ratio of the piezoelectric element 15 is approximately 0.3. In addition, Poisson's ratio of gold bump typically used as a first connecting member 25 and a second connecting member 26, to be described below, of the wiring substrate 20 is approximately 0.44. Accordingly, it is possible to allow the first connecting member 25 and the second connecting member 26, connected with the piezoelectric element 15 and the adjustment member 16, to be more easily crushed compared with the piezoelectric element 15 and the adjustment member 16. With this configuration, it is possible to enhance reliability of electrical connection and reduce the load on the piezoelectric element 15.

[0034] A more preferable value is defined as the Poisson' s ratio of the above-described material used as the adjustment member 16, in relation with the piezoelectric element 15. That is, it is more preferable that the adjustment member 16 uses a material having Poisson's ratio substantially equal to the Poisson's ratio of the piezoelectric element 15. This enables the degree of crush in both the connecting members 25 and 26 to be about the same degree when each of the first connecting member 25 and the second connecting member 26 is electrically connected with each of the upper surface of the first electrode unit 151 of the piezoelectric element 15 and an upper surface of the adjustment member 16. Accordingly, it is possible to substantially equalize the pressure applied to the piezoelectric element 15 and the pressure applied to the adjustment member 16, and thus to further enhance reliability of electrical connection and to further reduce the load on the piezoelectric element 15.

[0035] The adjustment member 16 according to the present embodiment exemplifies a preferred mode using a piezoelectric element of a same material as the piezoelectric element 15 provided for each of the pressure chambers 131, that is, using the PZT thin film. This makes it possible to easily substantially equalize the Poisson' s ratio of the material used as the adjustment member 16 and the piezoelectric element 15. Moreover, it is possible to pattern the both with a same step.

[0036] The adjustment member 16 according to the present embodiment is formed by providing a third electrode unit 161 on the upper surface of the piezoelectric element. The third electrode unit 161 can be formed with a step same as the steps of forming the first electrode unit 151 on the upper surface of the piezoelectric element 15. Specifically, the piezoelectric element 15 and the adjustment member 16 are patterned with a same step, including the first electrode unit 151 and the third electrode unit 161.

[0037] Note that, while the first electrode unit 151 is provided on the upper surface of the piezoelectric element 15 and the third electrode unit 161 is provided on the upper surface of the adjustment member 16, these electrode units 151 and 161 are formed into sufficiently thin films compared with the piezoelectric element positioned below. Therefore, existence of these electrode units 151 and 161 can be disregarded in the hardness (Poisson's ratio) of the piezoelectric element 15 and the adjustment member 16 in a case where each of the first connecting member 25 and the second connecting member 26 of the wiring substrate 20 is connected with each of the first electrode unit 151 and the third electrode unit 161, respectively.

[0038] The upper surface of the adjustment member 16 is arranged to be substantially equal to the height H1 of the upper surface of the first electrode unit 151. If both surfaces can be patterned with a same step, it would be easy to form the both surfaces such that the height of the upper surfaces of the both can be arranged at a substantially equal height. Accordingly, it is possible to equalize, with a simple method, the height of the upper surface of the first electrode unit 151 and the height of the upper surface of the third electrode unit 161, on the head chip 10 electrically connected with the wiring of the wiring substrate 20.

[0039] Note that, in the present invention, the height of the upper surface of the adjustment member 16 is defined as a height from the upper surface of the vibration plate layer 14 just below the piezoelectric element 15 to the upper surface of the third electrode unit 161 of the adjustment member 16, relative to the height of the upper surface of the vibration plate layer 14. There is no bump provided on the upper surface of the third electrode unit 161.

[0040] Note that, the height of the upper surface of the adjustment member 16 being "substantially equal" to the height H1 of the upper surface of the first electrode unit 151 means that there may be variation in the height between the two heights, to the degree that can solve the problem of the present invention. Specifically, this mean that the value obtained by subtracting the height of the upper surface of the adjustment member 16 from the value of the height H1 of the upper surface of the first electrode unit 151 is within $\pm 3\%$ of the value of the height H1 of the upper surface of the first electrode unit 151. Of course, it is preferable that the height of the upper surface of the adjustment member 16 is equal to the height H1 of the upper surface of the first electrode unit 151.

[0041] Note that, in a case where the number of each of the piezoelectric element 15 and the adjustment member 16 is more than one, the height of the upper surface of each of the first electrode unit 151 and the adjustment

member 16 corresponds to an individual average value.

[0042] As illustrated in Fig. 2, the upper surface of the adjustment member 16 has sufficiently a large area. Specifically, the third electrode unit 161 on the upper surface of the adjustment member 16 has an area equal or greater than the area of the first electrode unit 151 on the upper surface of one piezoelectric element 15. This facilitates positioning in the X-Y direction at the time of performing electrical connection with the connecting member of the wiring substrate 20 to be described below, making it possible to perform bonding operation of the wiring substrate 20 easily.

[0043] A through hole 162 that vertically penetrates the adjustment member 16 is formed on at least a part of the adjustment member 16. This configuration causes the lead-out unit 153 to face the inside of the through hole 162. In addition, a sufficient amount of conductive material 163 is filled inside the through hole 162. Preferably, the conductive material 163 is a conductive material that is pasty when being filled and that is cured by heating after being filled, and more preferably, the conductive material 163 is conductive adhesive.

[0044] Part of the filled conductive material 163 overflows from the through hole 162, expanding over the third electrode unit 161 around the through hole 162. This allows electrical continuity between the third electrode unit 161 and the lead-out unit 153 via the conductive material 163. There is electrical continuity between the lead-out unit 153 and the second electrode unit 152 on the lower surface of the piezoelectric element 15, leading to electrical continuity between the third electrode unit 161 and second electrode unit 152 via the lead-out unit 153. Note that the conductive material 163 filled within the through hole 162 is cured after bonding of the wiring substrate 20.

[0045] The wiring substrate 20 includes a substrate main body 21 formed of a Si substrate, for example. On the lower surface of the substrate main body 21, there are first wiring 22 and second wiring 23. The first wiring 22 is used to achieve electrical connection individually toward the first electrode unit 151 of the plurality of piezoelectric elements 15. The second wiring 23 is used to achieve electrical connection that is shared by the second electrode unit 152 of the plurality of piezoelectric elements 15.

[0046] The first wiring 22 is drawn to the upper surface of the substrate main body 21 via a penetrating wiring unit 221 that penetrates the substrate main body 21, and is electrically connected to a first upper wiring unit 222. Moreover, the second wiring 23 is drawn to the upper surface of the substrate main body 21 via a penetrating wiring unit 231 that penetrates the substrate main body 21, and is electrically connected to a second upper wiring unit 232. On an end portion of the wiring substrate 20, the first upper wiring unit 222 and the second upper wiring unit 232 are electrically connected with an FPC 50 illustrated in Fig. 1.

[0047] In Fig. 3, a reference sign 24 represents a protection layer formed of SiO_2 and polyimide, for example, provided on upper and lower surfaces of the substrate main body 21 and used for protecting the first wiring 22, the second wiring 23, the first upper wiring unit 222, and the second upper wiring unit 232.

[0048] The first connecting member 25 and the second connecting member 26 are provided on the lower surface of the wiring substrate 20. The first connecting member 25 is an electrical connection member connected with the first electrode unit 151 on the head chip 10. The second connecting member 26 is an electrical connection member connected with the second electrode unit 152 via the third electrode unit 161 and the lead-out unit 153 on the head chip 10. The protection film 24 for the sites on which the first connecting member 25 and the second connecting member 26 are provided is removed, and the first wiring 22 and the second wiring 23 are exposed on the lower surface of the wiring substrate 20. The first connecting member 25 has electrical continuity with the first wiring 22 and the second connecting member 26 has electrical continuity with the second wiring 23.

[0049] Each of the first connecting member 25 and the second connecting member 26 is formed in a shape of protrusion, from the lower surface of the wiring substrate 20, in the Z-direction in which the head chip 10 is arranged. Moreover, each of the tip position of the first connecting member 25 and the tip position of the second connecting member 26 is arranged to have a substantially equal height H2 (refer to Fig. 3) in the Z-direction in which the head chip 10 is arranged. This configuration facilitates electrical connection with the first electrode unit 151 and the third electrode unit 161, on the head chip 10.

[0050] Note that the height of the tip position of each of the first connecting member 25 and the second connecting member 26 is defined, relative to a contact surface between the first connecting member 25 and the lower surface of the first wiring 22, as a height from the contact surface to the tip position of the first connecting member 25, and a height from the contact surface to the tip position of the second connecting member 26.

[0051] Note that the tip position of the first connecting member 25 and the tip position of the second connecting member 26 being "substantially equal" means that there may be variation in the height between them, to the degree that can solve the problem of the present invention. Specifically, this means that the value obtained by subtracting the height of the tip position of the second connecting member 26 from the height of the tip position of the first connecting member 25 falls within $\pm 10\%$ of the height of the tip position of the first connecting member 25. Of course, it is preferable that the height of the tip positions of the first connecting member 25 is equal to the height of the second connecting member 26.

[0052] Note that, in a case where there is a plurality of the first connecting member 25 and a plurality of the second connecting members 26, the height of each of the first connecting member 25 and the second connecting member 26 corresponds to an individual average value.

[0053] Each of the first connecting member 25 and the

second connecting member 26 is formed of a conductive member. The conductive member is preferably a bump, more preferably, a stud bump. An exemplary stud bump is formed by first making a metal ball by applying electric discharge and melting to a tip of thin wire of metal such as Au, bonding the metal ball with the surface of each of the first wiring 22 and the second wiring 23 using heat and ultrasound, and tearing the metal thin wire off the metal ball so as to form the bump at a predetermined height of protrusion. This achieve a shape of the stud bump, including, at its base, a plateau-shaped or knob-shaped shoulder portion derived from the metal ball, and a conical shaped side surface. Additionally, the tip portion side of the stud bump includes a protrusion formed of a portion of metal thin wire protruding from the shoulder portion. The protrusion is easily plastically deformable and therefore is free from the risk of damaging the piezoelectric element. While the stud bumping can easily form bumps with various heights of shoulder portion by varying the size of the metal ball, the size of the tip portion and the shoulder portion might differ depending on the size of the stud bump, leading to a difference in the degree of plastic deformation. Accordingly, in view of performing electrical connection more reliably by making plastic deformation on the first connecting member and the second connecting member to be on a similar level at the time of performing electrical connection, it would be preferable that the sizes of the first connecting member and the second connecting member are on a similar level. Note that the tip position of the stud bump is a tip position of the protrusion, formed by the metal thin wire torn off from the metal ball.

[0054] It would be preferable, as illustrated in Fig. 3, each of conductive materials 251 and 261 is applied onto each of the first connecting member 25 and a second connecting portion 26, respectively. With this configuration, even when there is a slight error between the height of the first connecting member 25 and the height of the second connecting portion 26, it is possible to absorb the error, and thus, to further ensure electrical connection between the first connecting member 25 and the first electrode unit 151, and between the second connecting portion 26 and the third electrode unit 161. Moreover, there would be no need to apply excessive pressure at electrical connection.

[0055] Preferably, each of the conductive materials 251 and 261 is a conductive material that is pasty when being applied and that is cured by heating after being applied, and more preferably, each of the conductive materials 251 and 261 is conductive adhesive. By using conductive adhesive, simultaneous pasting is possible between the first connecting member 25 and the first electrode unit 151, and between the second connecting portion 26 and the third electrode unit 161, in addition to electrical connection between them. This leads to further facilitation of the production steps of the inkjet head 1, including connection of the head chip 10 with the wiring substrate 20.

[0056] Note that in Fig. 3, a reference sign 27 indicates an ink flow path for supplying the ink within the ink storage chamber 41 (refer to Fig. 1) to each of the pressure chambers 131 of the head chip 10 after penetrating the wiring substrate 20.

[0057] The spacer substrate 30 maintains a space between the head chip 10 and the wiring substrate 20 to a predetermined space and ensures a connection region therebetween, for connecting the piezoelectric element 15 with the first connecting member 25, and for connecting the adjustment member 16 with the second connecting member 26. In order to ensure this connection region, the spacer substrate 30 includes openings 31 and 32. The opening 31 is formed corresponding to the arrangement position of the piezoelectric element 15 on the head chip 10. The opening 32 is formed corresponding to the arrangement position of the adjustment member 16.

[0058] The openings 31 and 32 penetrate the spacer substrate 30, as illustrated in Fig. 3. The piezoelectric element 15 on the head chip 10 and the first connecting member 25 on the wiring substrate 20 are contained within the opening 31. The adjustment member 16 on the head chip 10 and the second connecting member 26 on the wiring substrate 20 are contained within the opening 32.

[0059] In the head chip 10 according to the present embodiment, as illustrated in Fig. 2, eight piezoelectric elements 15 are arrayed in the X-direction, and four rows of the eight piezoelectric elements 15 are arrayed in the Y-direction. One opening 31 is formed in a size that includes the eight piezoelectric elements 15 arrayed in the X-direction. Accordingly, the four openings 31 are arrayed in the Y-direction. Moreover, each of the openings 32 is formed into a size that includes the two adjustment members 16 near each of the end portions of the head chip 10.

[0060] Additionally, the spacer substrate 30 includes a through hole 33 configured to connect the ink inflow port 132 that opens onto the upper surface of the head chip 10, with the ink flow path 27 formed on the wiring substrate 20.

[0061] The spacer substrate 30 may be formed of any material. Herein, the spacer substrate 30 uses alloy formed of 42 alloy (42Ni). Suitable surface treatment such as insulation treatment and rustproofing is applied to the spacer substrate 30.

[0062] In Fig. 2, a reference sign 34 indicates an air release groove for releasing the air within the openings 31 and 32 at the time of bonding of the head chip 10 and the wiring substrate 20, with the spacer member 30 sandwiched therebetween. Moreover, a reference sign 35 indicates a suction groove for sucking the spacer substrate 30 when moving the spacer substrate 30 by a moving apparatus (not illustrated). The air release groove 34 and the suction groove 35 are formed at a depth that would not penetrate the spacer substrate 30, from the upper surface of the spacer substrate 30.

[0063] The head chip 10 and the wiring substrate 20

are bonded with each other, sandwiching the spacer substrate 30 therebetween. This bonding enables contact of the first connecting member 25 on the wiring substrate 20 onto the first electrode unit 151 on the piezoelectric element 15 so as to allow electrical connection, and at the same time, and simultaneously enables contact of the second connecting member 26 on the wiring substrate 20 onto the third electrode unit 161 of the adjustment member 16 so as to allow electrical connection.

[0064] At this time, the upper surface of the first electrode unit 151 of the piezoelectric element 15 and the upper surface of the third electrode unit 161 of the adjustment member 16 are arranged at the substantially equal height H1, and thus, the heights of the contact surfaces of both are substantially even. Moreover, there is no bump provided on the upper surface of each of the first electrode unit 151 and the third electrode unit 161. Accordingly, at pressure bonding of the head chip 10 with the wiring substrate 20, no uneven pressure is applied to the first electrode unit 151 and the third electrode unit 161. With this configuration, there is no need to perform high-accuracy pressure control to prevent damage on the piezoelectric element 15, or the like, leading to facilitation of reliable electrical connection.

[0065] Moreover, the tip position of the first connecting member 25 and the tip position of the second connecting member 26 are arranged at a substantially equal height H2, making it possible to further facilitate reliable electrical connection.

[0066] The number of the second connecting member 26 electrically connected with the third electrode unit 161 of one adjustment member 16 is preferably more than one, as illustrated in Fig. 4(a). By using the plurality of second connecting members 26, it is possible to reduce current density. It is also possible to prevent the pressure at the time of pressure bonding of the second connecting member 26 with the third electrode unit 161 from being concentrated at one point.

[0067] It would be also preferable that a part of the second connecting members 26 among the plurality of second connecting members 26 is arranged so as to come in contact solely with the conductive material 163 filled into the through hole 162 to achieve electrical connection, as illustrated in Fig. 4(b). By allowing a part of the second connecting member 26 to come in contact with the conductive material 163 prior to curing, it is possible to achieve electrical connection between the second connecting portion 26 and the third electrode unit 161 and simultaneously achieve ensured fixing between the second connecting portion 26 and the third electrode unit 161.

[0068] Furthermore, in addition to allowing the second connecting member 26 to come in contact with the upper surface of the third electrode unit 161, it would be also allowable to achieve electrical connection of the second wiring 23 of the wiring substrate 20 with the conductive material 163 of the adjustment member 16 by direct contact, as illustrated in Fig. 4(c). In this case, a removal portion 241 is formed on the protection layer 24 covering the second wiring 23 so as to expose the second wiring 23 of a site that corresponds to the conductive material 163. Moreover, the conductive material 163 is formed at a height sufficient enough to be able to come in contact with the second wiring 23 exposed within the removal portion 241 when the second connecting portion 26 is electrically connected with the third electrode unit 161.

(Method for manufacturing inkjet head)

[0069] Next, an exemplary method for manufacturing an inkjet head will be described with reference to Figs. 5 to 8.

[0070] First, the wiring substrate 20 will be described.

[0071] Using a known method, the wiring substrate 20 within which the first wiring 22 and the second wiring 23 are formed on the substrate main body 21, is prepared (Fig. 5(a)).

[0072] Subsequently, using the stud bump, a first connecting portion 25 and the second connecting portion 26 are formed (Fig. 5(b)) respectively for each of the first wiring 22 and the second wiring 23 exposed on the lower surface of the wiring substrate 20. Specifically, the first connecting member 25 and the second connecting member 26 are formed (connecting member formation step) such that they have protruding shapes in the direction of arrangement of the head chip 10, and that the tip position of the first connecting portion 25 and the tip position of the second connecting portion 26 are arranged at the substantially equal height H2 in the Z-direction in which the head chip 10 is arranged.

[0073] After formation of the stud bump, each of the conductive materials 251 and 261 is applied to each of the first connecting member 25 and the second connecting member 26, as illustrated in Fig. 5(c).

[0074] The conductive materials 251 and 261 can be applied in the following manner, for example. First, a film, with a predetermined thickness, of the conductive material is formed on a glass substrate. Then, the wiring substrate 20 is stacked on the glass substrate, allowing the tips of the first connecting member 25 and the second connecting member 26 to come in contact with the film of the conductive material. Thereafter, the conductive material on the glass substrate is transferred to the tip of the first connecting member 25 and the second connecting member 26 by separating the wiring substrate 20 from the glass substrate. With this procedure, it is possible to apply conductive material collectively onto tips of a plurality of the first connecting member 25 and a plurality of the second connecting member 26.

[0075] Next, the head chip 10 will be described.

[0076] First, using a known method, the head chip 10 on which the nozzle plate 11, the intermediate plate 12, the pressure chamber plate 13, and the vibration plate layer 14 are stacked, is prepared (Fig. 6(a)).

[0077] Subsequently, the second electrode unit 152 is stacked on the upper surface of the vibration plate layer

14 of the head chip 10. The second electrode unit 152 can be formed by a sputtering method, for example, to have a predetermined pattern. At this time, the lead-out unit 153 electrically drawn from the second electrode unit 152 to the outside of the forming region of the piezoelectric element 15 is simultaneously formed (lead-out unit formation step; Fig. 6(b)) by extending the pattern of the second electrode unit 152 up to the neighborhood of the both end portions of the head chip 10. This can simplify the lead-out unit formation step.

[0078] Next, the piezoelectric element 15 is stacked on the upper surface of the second electrode unit 152, and adjustment member 16 is stacked on an upper surface of the lead-out unit 153. Specifically, a PZT thin film with a predetermined thickness is stacked on the upper surface of the second electrode unit 152, and then, an electrode film to be the first electrode unit 151 is stacked with a predetermined thickness on a whole upper surface of the PZT thin film. The PZT thin film and the electrode film are simultaneously stacked also on the upper surface of the lead-out unit 153.

[0079] Thereafter, the first electrode unit 151 and the third electrode unit 161 are patterned by etching the electrode film so as to achieve arrangement modes and shapes of the piezoelectric element 15 and the adjustment member 16, illustrated in Fig. 2. Subsequently, the piezoelectric element 15 on the pressure chamber 131 and the adjustment member 16 on the lead-out unit 153 are formed (piezoelectric element formation step, adjustment member formation step; Fig. 6(c)) by etching the PZT thin film using the first electrode unit 151 and the third electrode unit 161 as masks.

[0080] With this procedure, corresponding to the pressure chamber 131, the piezoelectric element 15 and the first electrode unit 151 on the second electrode unit 152, and the adjustment member 16 on the lead-out unit 153 are simultaneously formed with a same step, on the upper surface of the head chip 10. This can simplify the manufacturing steps and easily form the piezoelectric element 15 and the adjustment member 16, for which the height of the upper surface of the first electrode unit 151 and the height of the upper surface of the third electrode unit 161 are equalized at the substantially equal height H1.

[0081] Next, the spacer substrate 30 is bonded onto the upper surface of the head chip 10 (Fig. 7(a)). The openings 31 and 32, and the through hole 33, are formed on the spacer substrate 30 beforehand. The piezoelectric element 15 and the adjustment member 16 on the head chip 10 are contained within the openings 33 and 32, and the through hole 33 communicates with the ink inflow hole 132.

[0082] Thereafter, a conductive material 162 is filled into the through hole 162 of the adjustment member 16 using a needle 60, for example (Fig. 7(b)). By filling a sufficient amount of the conductive material 162, it is possible to allow it to overflow from the upper end of the through hole 162 and to expand over the third electrode unit 161 around the through hole 162.

[0083] This allows electrical continuity between the third electrode unit 161 and the lead-out unit 153 easily via the conductive material 163. Moreover, since the adjustment member 16 is arranged within the opening 32, the adjustment member 16 is surrounded by a spacer member 30. This
configuration can keep the conductive material 162 within the opening 32 even when it overflows from the upper surface of the adjustment member 16 and thus, can prevent a short circuit.

[0084] Next, the wiring substrate 20 is bonded to the stack of the head chip 10 and the spacer substrate 30, from above (bonding step; Fig. 8). At this time, the first connecting member 25 on the wiring substrate 20 comes in contact with the first electrode unit 151 on the piezoelectric element 15, and the second connecting member 26 comes in contact with the third electrode unit 161 of the adjustment member 16, leading to electrical connection respectively.

[0085] The upper surface of the first electrode unit 151 on the piezoelectric element 15 and the upper surface of the third electrode unit 161 of the adjustment member 16 have
substantially an equal height on the head chip 10. Moreover, the tip position of the first connecting member 25 and the tip position of the second connecting member 26 have substantially an equal height on the wiring substrate 20. Therefore, these contact surfaces have a substantially even height.
Accordingly, when the head chip 10 is pressure bonded with the wiring substrate 20, no uneven pressure is applied to each of electrical connecting sites. With this configuration, there is no need to perform high-accuracy pressure control to prevent damage on the piezoelectric element 15, or the like, leading to further facilitation of reliable electrical connection.

[0086] Thereafter, the manifold 40 illustrated in Fig. 1 is bonded on the upper surface of the wiring substrate 20, such that all ink supply holes 27 that open onto the upper surface of the wiring substrate 20 face the ink storage chamber 41 within the manifold 40. This configuration completes the inkjet head 1 in which ink is supplied to all the pressure chambers 131 in a shared manner from the ink storage chamber 41.

(Other modes of adjustment member)

[0087] While the above-described adjustment member 16 forms the through hole 162, it would also allowable to form, in place of the through hole 162, a groove 164 cut across a height direction of the adjustment member 16 such that it forms a recess inwardly from a side surface of the adjustment member 16, as illustrated in Fig. 9. In this case, the conductive material 163 is filled into the groove 164 such that the lead-out unit 153 is electrically connected with the third electrode unit 161.

[0088] Moreover, the piezoelectric element 15 may be

a bulk piezoelectric element formed into a predetermined size and thickness in advance. The bulk piezoelectric element is individually pasted at a position that corresponds to the pressure chamber 131 on the vibration plate layer 14. In this case, a bulk piezoelectric element having a thickness equal to the thickness of the piezoelectric element 15 is preferably used as the piezoelectric element used in the adjustment member 16, and the adjustment member 16 is preferably formed by pasting the bulk piezoelectric element on the upper surface of the lead-out unit 153. This makes it possible to easily align the height of the upper surface of the first electrode unit 151 of the piezoelectric element 15 with the height of the upper surface of the adjustment member 16, at a substantially equal height.

[0089] Moreover, in a case where the adjustment member 16 is made from a single material, it is possible to form with metal as a whole. By stacking a metallic material formed into a predetermined shape with a predetermined thickness using metal such as Ni, Cu, and Al, on the lead-out unit 153, it is possible to provide electrical continuity between the adjustment member 16 itself and the lead-out unit 153. By providing a metallic material on the upper surface of the lead-out unit 153 and thereafter grinding it so as to be a height substantially equal to the height of the upper surface of the piezoelectric element 15, it is possible to adjust the height of the upper surface of the adjustment member 16 to be a height substantially equal to the height of the upper surface of the first electrode unit 151 of the piezoelectric element 15. By forming the whole of the adjustment member 16 with metal, operation of filling the conductive material 163 can be omitted.

Reference Signs List

[0090]

1	inkjet head
10	head chip
11	nozzle plate
111	nozzle
12	intermediate plate
121	communication passage
13	pressure chamber plate
131	pressure chamber
132	ink inflow hole
14	vibration plate layer
15	piezoelectric element
151	first electrode unit
152	second electrode unit
153	lead-out unit
16	adjustment member
161	third electrode unit
162	through hole
163	conductive material
164	groove
20	wiring substrate
21	substrate main body
22	first wiring
221	penetrating wiring unit
222	first upper wiring unit
23	second wiring
231	penetrating wiring unit
232	second upper wiring unit
24	protection layer
241	removal portion
25	first connecting member
251	conductive material
26	second connecting member
261	conductive material
27	ink supply hole
30	spacer substrate
31, 32	opening
33	through hole
34	air release groove
35	suction groove
40	manifold
41	ink storage chamber
50	FPC
60	needle

Claims

1. An inkjet head comprising:

a head chip including a pressure chamber configured to contain ink ejected from a nozzle, a piezoelectric element that is provided corresponding to the pressure chamber and includes a first electrode unit on an upper surface and a second electrode unit on a lower surface, and a lead-out unit electrically drawn from the second electrode unit to the outside of the piezoelectric element; and

a wiring substrate arranged above the head chip and including a first connecting member formed with a stud bump electrically connected with the first electrode unit of the head chip, and a second connecting member formed with a stud bump electrically connected with the second electrode unit via the lead-out unit,

wherein the lead-out unit includes an adjustment member that includes an upper surface arranged at a height substantially equal to the height of the first electrode unit and in which at least the upper surface has electrical continuity with the lead-out unit, and

the first connecting member of the wiring substrate is electrically connected with the first electrode unit by coming into contact with an upper surface of the first electrode unit, and the second connecting member is electrically connected with the second electrode unit via the adjustment member and the lead-out unit by coming into

contact with the upper surface of the adjustment member.

2. The inkjet head according to claim 1, wherein the adjustment member is formed of a material having Poisson's ratio of 0.4 or below.

3. The inkjet head according to claim 1 or 2, wherein the upper surface of the adjustment member has an area that is equal to or larger than the area of the first electrode unit on the upper surface of the piezoelectric element provided corresponding to the pressure chamber.

4. The inkjet head according to claim 1, 2, or 3, wherein the adjustment member is formed with the piezoelectric element including, on an upper surface, a third electrode unit having electrical continuity with the lead-out unit.

5. The inkjet head according to claim 4, wherein the piezoelectric element used in the adjustment member includes a hole penetrating in a height direction or a groove cut across the height direction, and
the third electrode unit and the lead-out unit are electrically connected with each other via a conductive material by filling the conductive material into the hole or the groove.

6. The inkjet head according to claim 5, wherein there is a plurality of the second connecting members, and a part of the second connecting members among the plurality of second connecting members is in contact solely with the conductive material filled into the hole or the groove.

7. The inkjet head according to any one of claims 1 to 5, wherein there is a plurality of the second connecting members, and the plurality of second connecting members is electrically connected with the upper surface of the adjustment member shared by the plurality of second connecting members.

8. The inkjet head according to any one of claims 1 to 7, wherein there is a plurality of the pressure chambers, and the individual second electrode units formed on a plurality of the piezoelectric elements provided corresponding to the pressure chambers are electrically drawn by the lead-out unit that is shared by the plurality of second electrode units.

9. The inkjet head according to any one of claims 1 to 8, wherein tip positions of the first connecting member and the second connecting member are arranged at substantially equal heights in a direction of arrangement of the head chip.

10. The inkjet head according to any one of claims 1 to 9, wherein each of the first connecting member and the second connecting member has a conductive material applied, and is electrically connected with the upper surface of the first electrode unit and the upper surface of the adjustment member, via the conductive material.

11. A method for manufacturing an inkjet head comprising:

a head chip including a pressure chamber configured to contain ink ejected from a nozzle, a piezoelectric element that is provided corresponding to the pressure chamber and includes a first electrode unit on an upper surface and a second electrode unit on a lower surface, and a lead-out unit electrically drawn from the second electrode unit to the outside of the piezoelectric element; and
a wiring substrate arranged above the head chip and including a first connecting member electrically connected with the first electrode unit of the head chip, and a second connecting member electrically connected with the second electrode unit via the lead-out unit,
the method comprising:

a piezoelectric element formation step of forming, on the head chip, the piezoelectric element including the first electrode unit and the second electrode unit, corresponding to the pressure chamber;
a lead-out unit formation step of forming the lead-out unit on the head chip;
an adjustment member formation step of forming, on the lead-out unit, an adjustment member that includes an upper surface arranged at a height substantially equal to the height of the first electrode unit, the upper surface having electrical continuity with the lead-out unit; and
a bonding step of bonding the wiring substrate with the head chip so as to cause the first connecting member to be electrically connected with the first electrode unit by bringing the first connecting member into contact with an upper surface of the first electrode unit, and to cause the second connecting member to be electrically connected with the second electrode unit via the adjustment member by bringing the second connecting member into contact with the upper surface of the adjustment member.

12. The method for manufacturing an inkjet head according to claim 11, wherein the adjustment member is formed with the

piezoelectric element including, on an upper surface, a third electrode unit that has electrical continuity with the lead-out unit, and
the piezoelectric element used in the adjustment member is formed, in the adjustment member formation step, simultaneously at the time of forming the piezoelectric element corresponding to the pressure chamber by the piezoelectric element formation step.

13. The method for manufacturing an inkjet head according to claim 12,
wherein the piezoelectric element is a PZT thin film, and the piezoelectric element corresponding to the pressure chamber and the piezoelectric element used in the adjustment member are patterned simultaneously by etching the PZT thin film.

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

a connecting member formation step of forming, on the wiring substrate, the first connecting member and the second connecting member so as to have protruding shapes in a direction of arrangement of the head chip, and so as to allow tip positions of the connecting members to be arranged at substantially equal heights in the direction of arrangement of the head chip.

FIG. 1

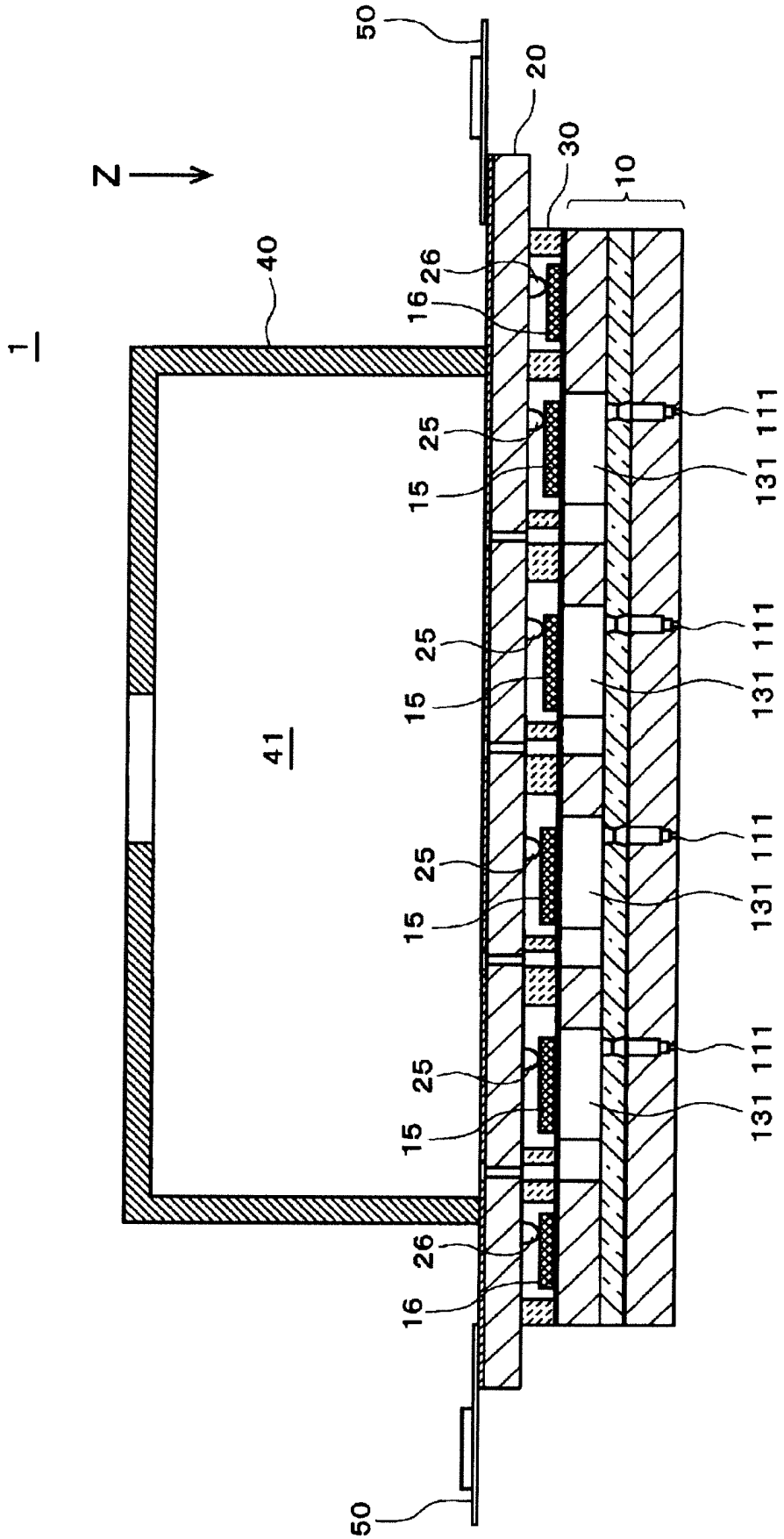

FIG. 2

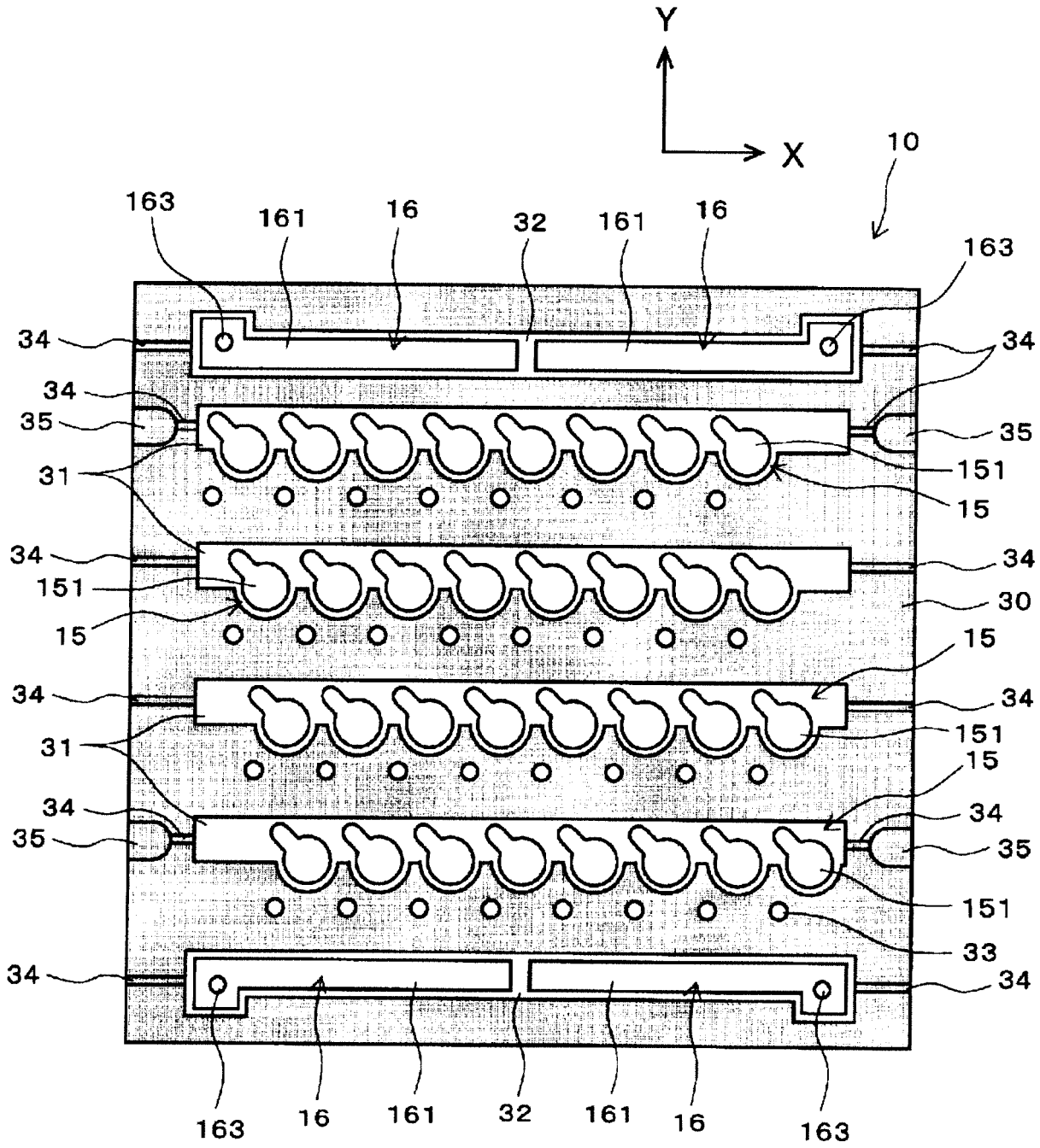
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FIG. 3

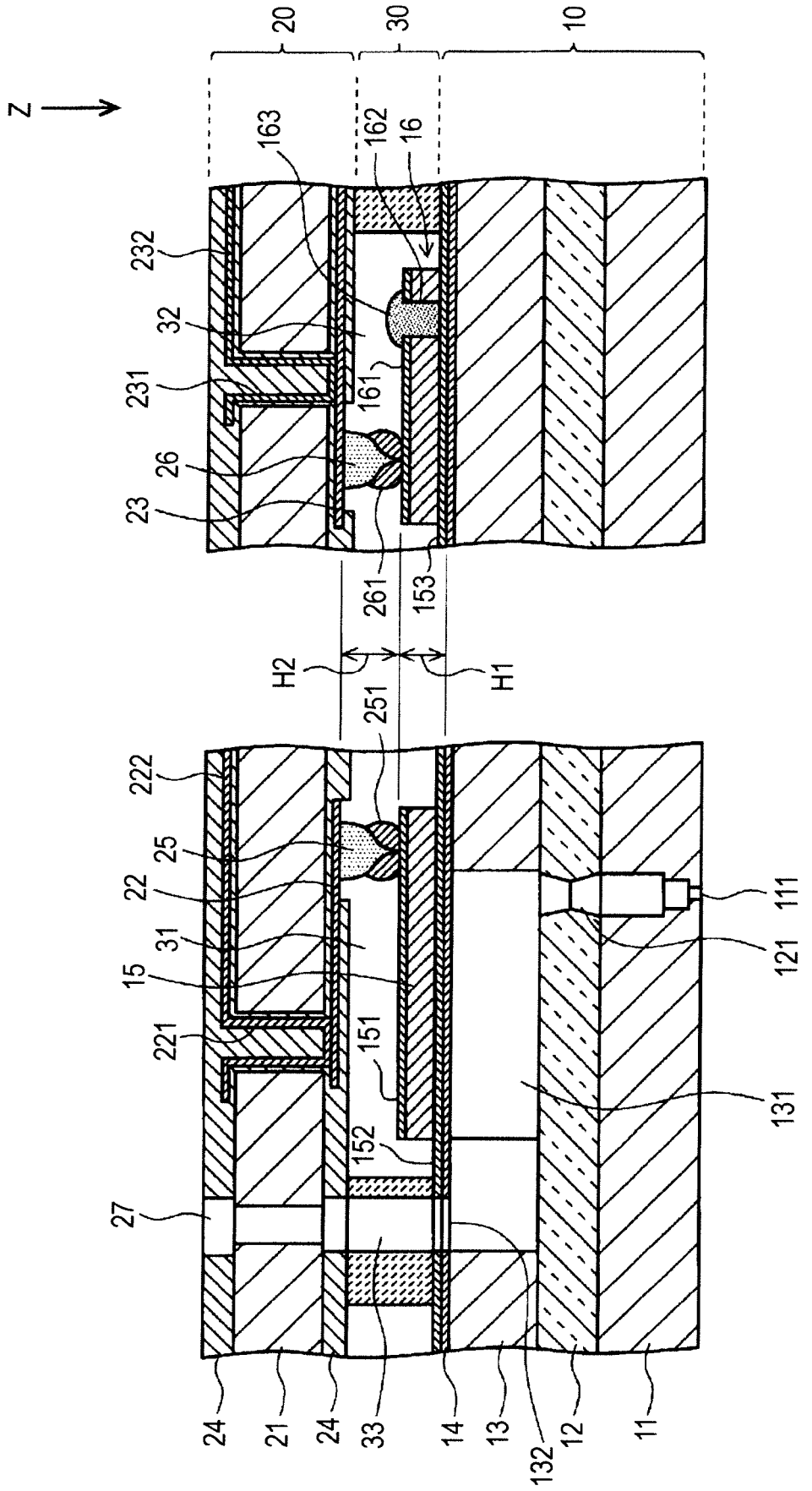
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FIG. 4

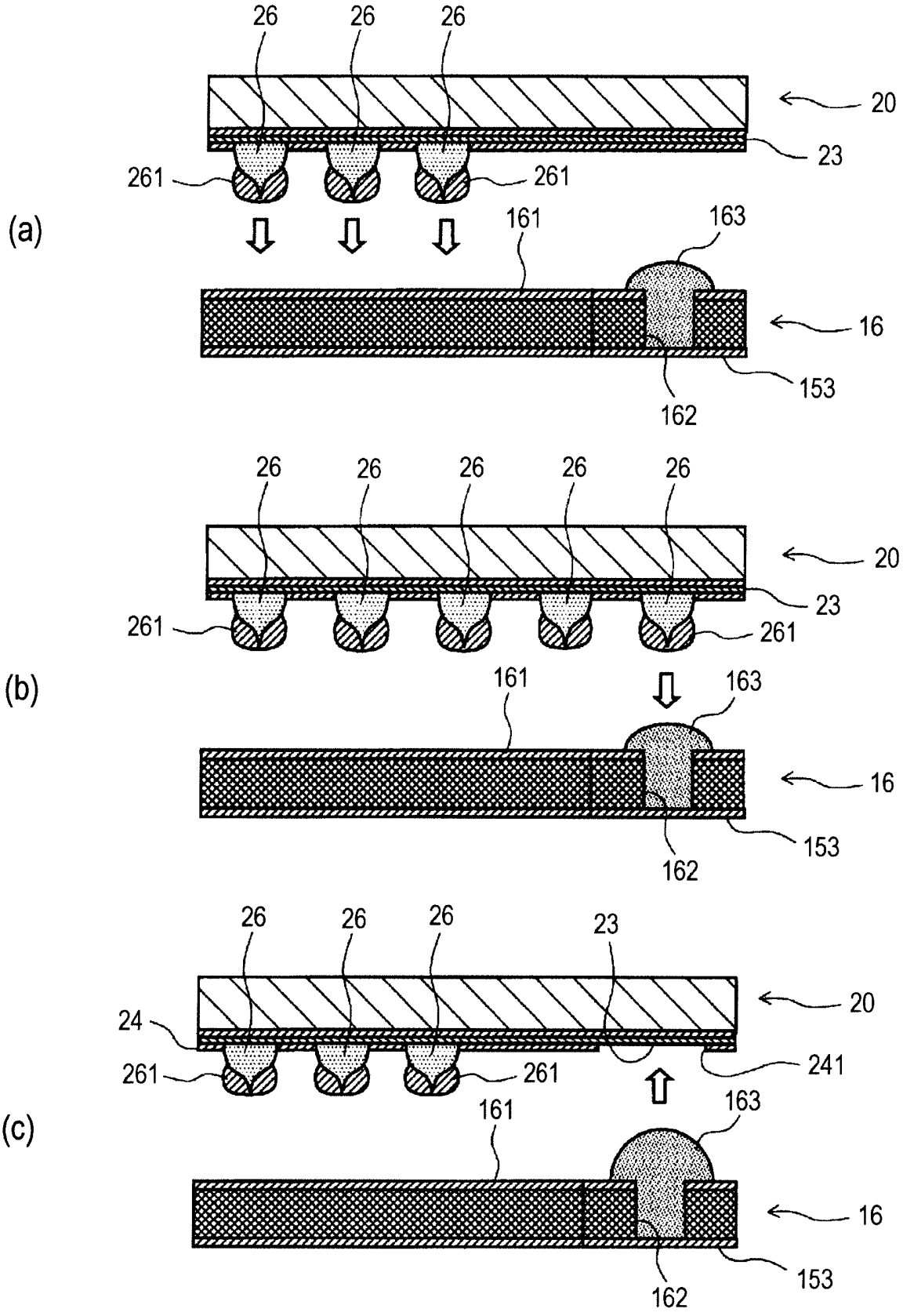
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FIG. 5

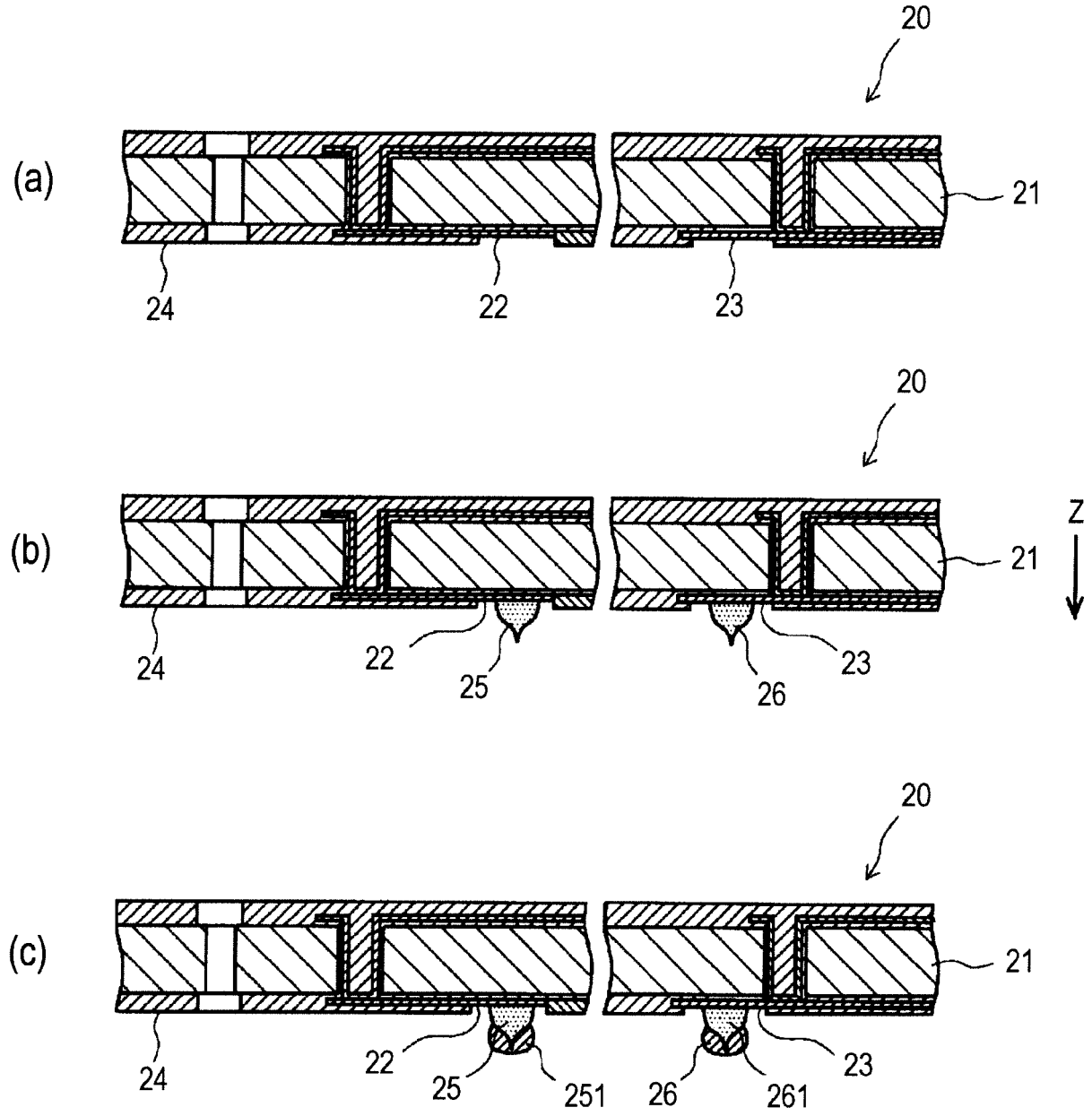

FIG. 6

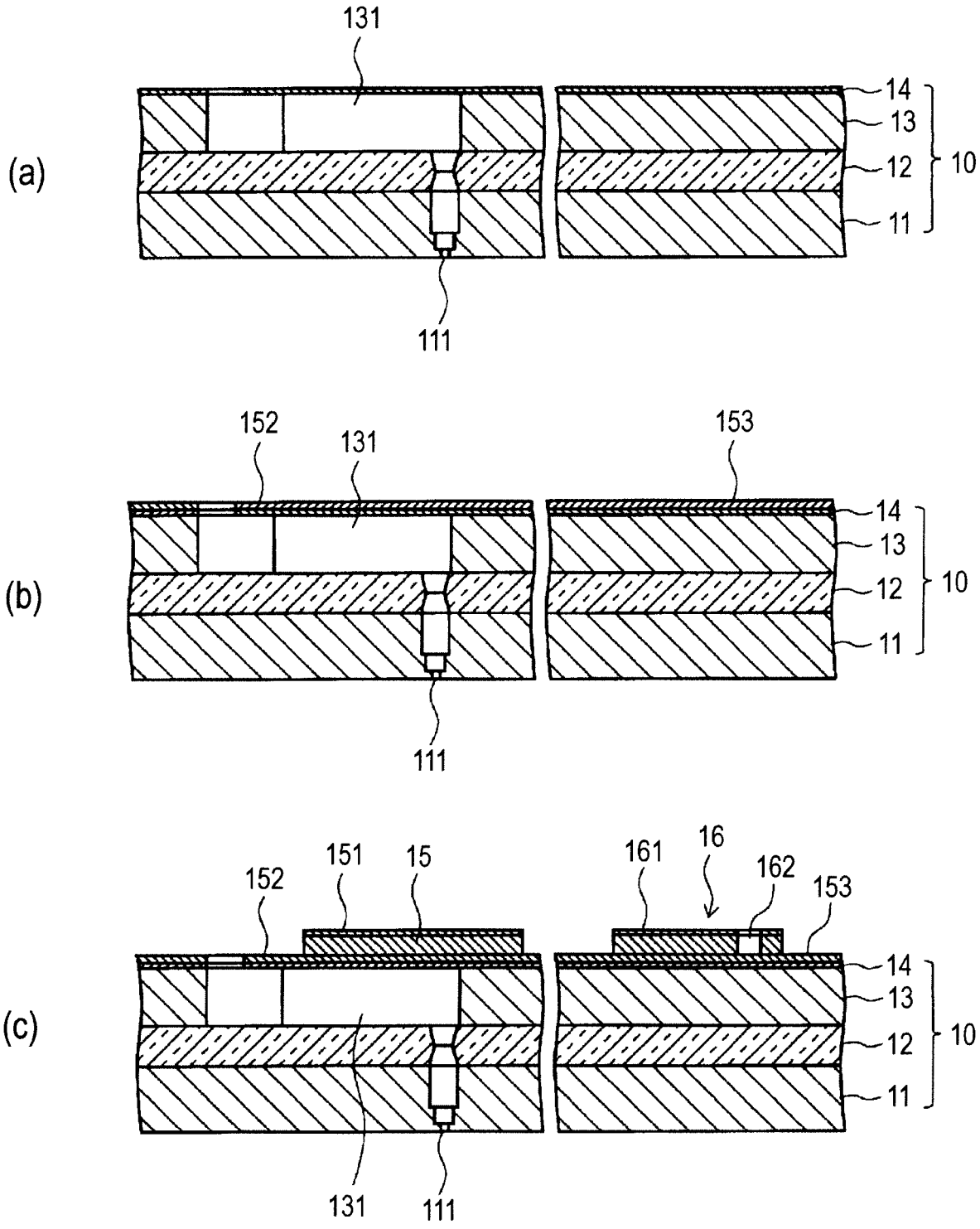
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FIG. 7

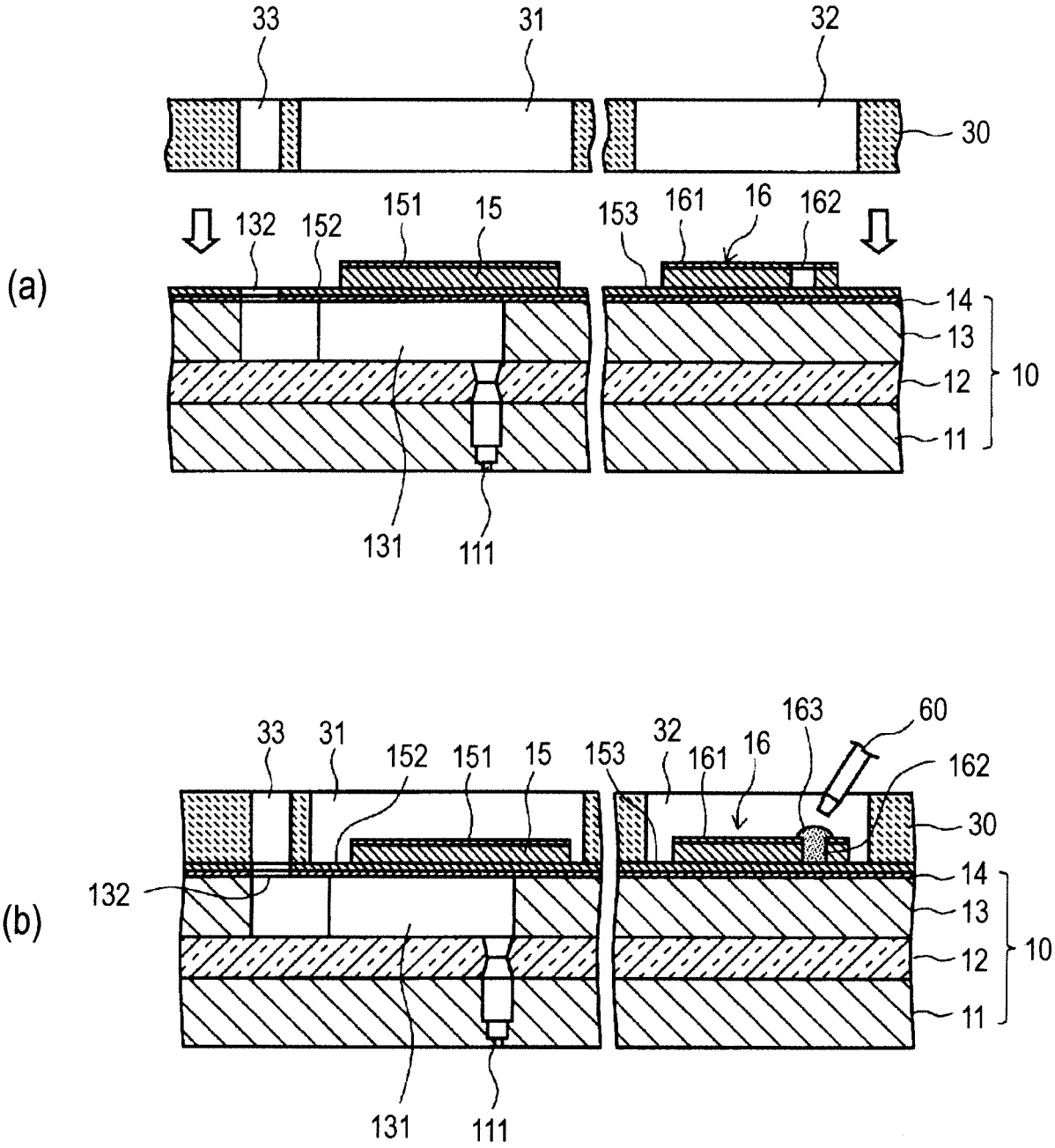
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FIG. 8

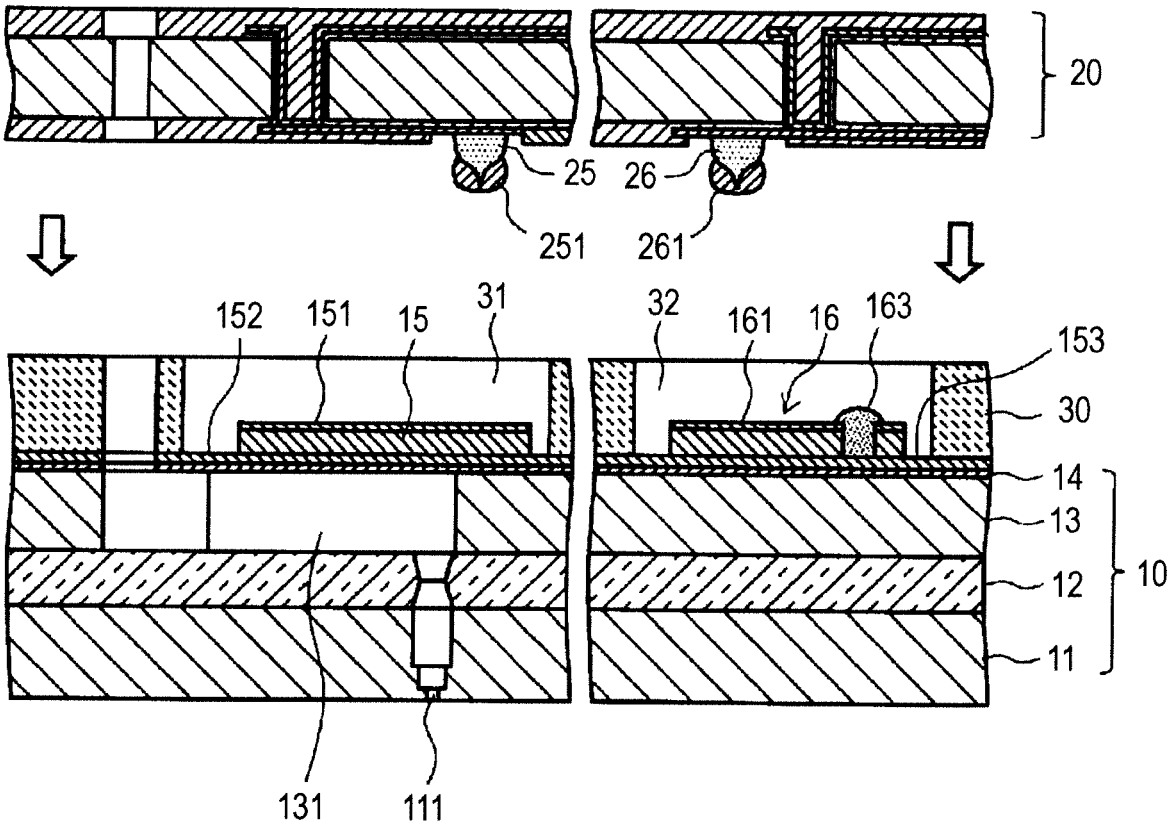
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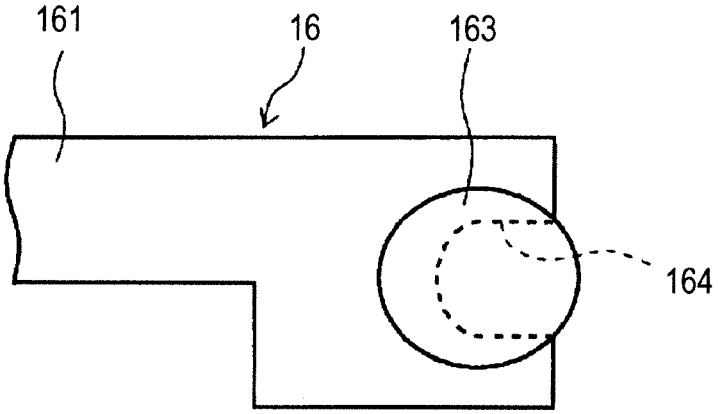
FIG. 9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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/060020

A. CLASSIFICATION OF SUBJECT MATTER
B41J2/14(2006.01)i, *B41J2/16*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B41J2/14, B41J2/16

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015
Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	WO 2012/176875 A1 (Konica Minolta Holdings, Inc.), 27 December 2012 (27.12.2012), paragraphs [0040] to [0055], [0066] to [0067]; fig. 2, 6 (Family: none)	1,4-5,8-9, 11-14 2-3,6-7,10
Y A	JP 2004-304025 A (Kyocera Corp.), 28 October 2004 (28.10.2004), paragraphs [0028] to [0036], [0043] to [0047]; fig. 4 (Family: none)	1,4-5,8-9, 11-14 2-3,6-7,10
A	JP 2003-072068 A (Fuji Xerox Co., Ltd.), 12 March 2003 (12.03.2003), paragraphs [0081] to [0083] & US 2003/0063171 A1	2

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

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
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Date of the actual completion of the international search	Date of mailing of the international search report
02 June 2015 (02.06.15)	09 June 2015 (09.06.15)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2013-035193 A (Konica Minolta Holdings, Inc.), 21 February 2013 (21.02.2013), entire text; all drawings (Family: none)	1-14

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REFERENCES CITED IN THE DESCRIPTION

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