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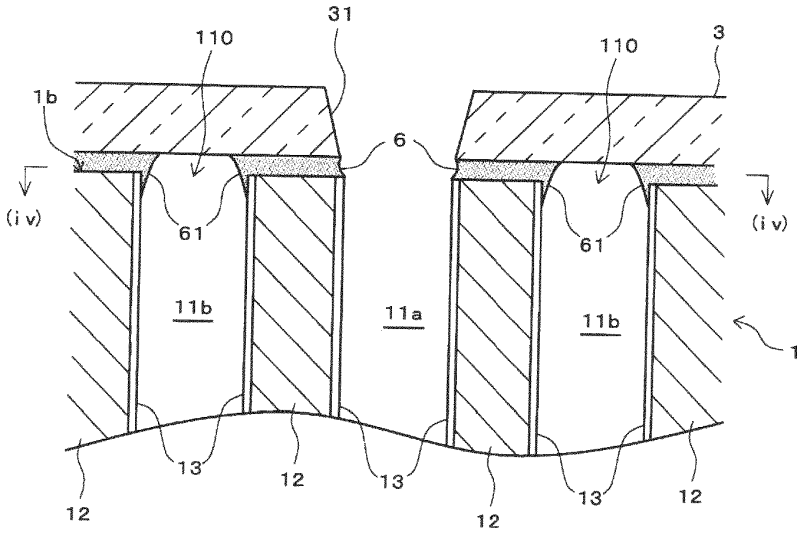
(54) Inkjet head and method for manufacturing inkjet head

(57) A state of adhesive fillets in an opening portion of a dummy channel is optimized, and an ink can be stably discharged without closing the dummy channel with the adhesive.

There is provided an inkjet head comprising: a head chip that has a channel column having channels and drive walls 12 alternately arranged therein and also has opening portions 110 of channels arranged in a front surface and a rear surface thereof; and a wiring substrate that is joined to the rear surface of the head chip so as to cover the channel column, the channel column having drive channels 11a and dummy channels 11b alternately arranged therein, the wiring substrate having ink supply through holes at positions associated with the opening portions 110 of the drive channels 11a, the wiring substrate being joined to the rear surface of the head chip through an adhesive 6 to close the square opening portion 110 of each dummy channel 11b, wherein adhesive fillets 61 made of the adhesive 6 in the opening portion 110 of each dummy channel 11b are independently present at four corners of the opening portion 110.

FIG .3



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Description

TECHNICAL FIELD

[0001] The present invention relates to an inkjet head and a method for manufacturing an inkjet head, and more particularly to an inkjet head that can stably inject an ink without closing a dummy channel with an adhesive and to a method for manufacturing the inkjet head.

BACKGROUND ART

[0002] As an inkjet head that discharges an ink in a channel and thereby records various kinds of images, there is a shearing mode type inkjet head. According to this inkjet head, a partition wall that divides many aligned channels is formed of a piezoelectric element to provide a drive wall, this drive wall is subjected to shearing deformation, and the ink in the channel is discharged from a nozzle by utilizing a pressure obtained due to a change in capacity of the channel.

[0003] As such an inkjet head, an inkjet head having a so-called harmonic type head chip is known. This head chip has a hexahedron shape, a channel opening portion is arranged in each of a front surface and a rear surface facing each other, and hence a straight type channel is provided. In such a straight type channel configuration, since each drive electrode configured to apply a voltage to the drive wall faces the inside of the channel and is not exposed to the outside, applying a voltage to each drive electrode is difficult. Therefore, in conventional examples, an electrode extraction wiring substrate is joined to a rear surface side of a head chip, and each drive electrode is thereby electrically drawn to the outside of the head chip by utilizing this wiring substrate, thereby exercising ingenuity for facilitating application of the voltage to each drive electrode.

[0004] For example, Patent Document I discloses that an end portion of a drive electrode in each channel is exposed on a rear surface of a harmonica type head chip having a plurality of channel columns to form an electrical contact in advance, a flexible wiring substrate is joined so as to cover this rear surface, and each drive electrode is thereby electrically drawn to the outside of the head chip by utilizing the surface of this wiring substrate. Each ink supply through hole is opened in the wiring substrate at a position corresponding to each channel so that an ink in a manifold joined to the rear surface side of the wiring substrate can be individually supplied into each channel through this through hole.

[0005] Patent Document 1: JP-A-2002-178509 (FIG. 18)

SUMMARY OF INVENTION

[0006] Meanwhile, besides an inkjet head in which all channels constituting one channel column are drive channels that discharge an ink, there is also an inkjet head in which drive channels that discharge an ink and dummy channels that do not discharge the ink (which are also referred to as air channels or air chambers) are alternately arranged.

[0007] In case of the inkjet head having the dummy channels, the ink does not have to flow into each dummy channel that does not discharge the ink. Rather, if the ink flows into each dummy channel, there occurs a problem that operations of drive walls provided on both sides are obstructed by the ink. Therefore, at the time of joining a wiring substrate so as to cover a rear surface of a head chip like the description in Patent Literature 1, an ink supply through hole is not formed at a position corresponding to an opening portion of each dummy channel, and the opening portion is closed by the wiring substrate. At this time, it is desirable to completely seal the opening portion of the dummy channel with use of an adhesive that is applied between this portion and the wiring substrate.

[0008] To completely seal the dummy channel opening portion with the adhesive, a sufficient amount of the adhesive must be applied between the head chip and the wiring substrate at the time of bonding these members, and a periphery of the opening portion of the dummy channel that is covered with the wiring substrate must be completely surrounded by the adhesive.

[0009] However, when the application amount of the adhesive is too small, the periphery of the dummy channel opening portion cannot be completely surrounded by the adhesive, positions having no adhesive are produced. If each position having no adhesive reaches an opening portion of each drive channel, the ink that is to be supplied to the drive channel flows into each dummy channel, operations of drive walls on both sides are affected, and stable discharge from an adjoining drive channel may be obstructed. On the other hand, when the application amount of the adhesive is too large, the excess adhesive enters each dummy channel by capillarity at the time of bonding.

[0010] FIG. 13 is an enlarged cross-sectional view showing a bonded portion of a head chip 100 and a wiring substrate 200 at this moment. A lower direction in the drawing is an ink discharge direction. Furthermore, FIG. 14 shows a state of each opening portion at that moment, and it is a cross-sectional view taken along a line (xiv)-(xiv) in FIG. 13.

[0011] As shown in these drawings, an adhesive 300 does not flow into a drive channel 101. That is because each through hole 201 having substantially the same opening area is formed in the wiring substrate 200 associated with the opening portion of the drive channel 101. However, the through hole is not formed at each position associated with an

opening portion of each dummy channel 102, and hence the adhesive 300 is apt to flow in so as to cover the opening portion of each dummy channel 102 along this wiring substrate 200. Therefore, the excess adhesive 300 enters each dummy channel 102 by the capillarity. The opening portion of each dummy channel 102 at this moment is substantially closed by the adhesive 300 that has flowed in, and the adhesive 300 that has flowed in deeply enters each dummy channel 102 along each drive wall 102 to form an adhesive fillet 301.

[0012] This adhesive fillet 301 is formed on the entire inner peripheral surface on the opening portion side of each dummy channel 102. Therefore, the adhesive fillet 301 that has expanded at the timing of curing acts to thrust an inner wall surface of each dummy channel 102 outward, and each drive wall 103 is prone to be damaged. Further, there arises a problem that the hardened adhesive fillet 301 obstructs an operation of each drive wall 103 itself.

[0013] Therefore, as a problem, it is difficult to stably manufacture an inkjet head that enables stable discharge by sealing the periphery of the opening portion of each dummy channel with the adhesive so as to complexly surround it.

[0014] It is to be noted that the drive channel is a channel to which an ink is supplied, and hence the periphery of its opening portion does not have to be necessarily completely sealed.

[0015] Furthermore, such a problem does not occur when a head chip is joined to a nozzle plate. That is because both the nozzle plate and a nozzle plate bonding surface provided on a front surface of the head chip are flat surfaces with no unevenness as different from an electrode, and hence the adhesive preferentially penetrates into a gap between the nozzle plate and the head chip by the capillarity in the gap even if an application amount of the adhesive is suppressed to the minimum level. Moreover, even if unevenness provided by a top coat present on the nozzle plate bonding surface or unevenness formed at the time of machining on the chip side is present, rigidity of the top coat is low, the nozzle plate is generally made of a resin material and thin, and hence the nozzle plate can be deformed in accordance with the unevenness, thereby filling the gap by application of a pressure after bonding.

[0016] As a result of keenly examining such a problem at the time of joining the head chip and the wiring substrate, the present inventor discovered that, to completely seal the periphery of the opening portion of each dummy channel with use of the adhesive applied between the head chip and the wiring substrate, the adhesive fillet made of the adhesive present around this opening portion does not completely close the opening portion, but it is important for the adhesive fillet to partially enter a peripheral edge of the opening portion.

[0017] That is, when the opening portion of each dummy channel is completely closed by the adhesive fillet, the adhesive has penetrated to the inside of the dummy channel, and the operation of each drive wall is obstructed. On the other hand, when the adhesive fillet is not present in the opening portion of each dummy channel at all, the adhesive surrounding the opening portion of each dummy channel is discontinuous, and portions where the adhesive is not partially present are apt to be produced. That is because a length between the opening portion of the dummy channel and the opening portion of the drive channel adjacent to this channel (a length corresponding to a thickness of the drive wall) is very small to provide a narrow shape and an amount of the adhesive present between these channels is very small. As a result, a possible that an ink supplied into the drive channel flows into the dummy channel increases.

[0018] Specifically, in the inkjet head, although the adhesive fillets are present at four corners in the square opening portion of the dummy channel, it was found out that discontinuity of the adhesive fillets at the four corners is important, thereby bringing the present invention to completion.

[0019] Therefore, it is an object of the present invention to provide an inkjet head that enables stable ink injection by optimizing a state of adhesive fillets in an opening portion of a dummy channel without closing the dummy channel with use of the adhesive.

[0020] Further, it is another object of the present invention to provide a method for manufacturing an inkjet head that enables stable ink injection by optimizing a state of adhesive fillets in an opening portion of a dummy channel without closing the dummy channel with use of the adhesive.

[0021] Other objects of the present invention will become obvious from the following description.

[0022] The above objects are achieved by each of the following inventions.

1. An inkjet head comprising:

a head chip that has channels and drive walls formed of piezoelectric elements alternately arranged thereon, has a channel column having drive electrodes formed on surfaces of the drive walls facing the inside of the channels, has opening portions of the channels arranged in a front surface and a rear surface thereof, and has connection electrodes, which achieve electrical conduction with the drive electrodes in the channels, formed on the rear surface thereof; and

a wiring substrate that is joined to the rear surface of the head chip so as to cover the channel column, has wiring electrodes, which are electrically connected to the connection electrodes, formed on a surface thereof joined to the head chip, and is configured to apply a voltage to the drive electrodes on the head chip through the wiring electrodes,

the channel column of the head chip having drive channels from which an ink is discharged and dummy channels

from which the ink is not discharged alternately arranged therein,
the wiring substrate having ink supply through holes at positions associated with opening portions of the drive channels and being joined to the rear surface of the head chip through an adhesive, thereby closing a square opening portion of each dummy channel,
wherein adhesive fillets made of the adhesive in the opening portion of each dummy channel are independently present at four corners of the opening portion of the dummy channel.

2. The inkjet head according to 1,

wherein the adhesive fillets are formed so as to extend to both a peripheral edge of the head chip on a rear surface side thereof and the wiring substrate.

3. A method for manufacturing an inkjet head, the inkjet head comprising:

a head chip that has channels and drive walls formed of piezoelectric elements alternately arranged thereon, has a channel column having drive electrodes formed on surfaces of the drive walls facing the inside of the channels, has opening portions of the channels arranged in a front surface and a rear surface thereof, and has connection electrodes, which achieve electrical conduction with the drive electrodes in the channels, formed on the rear surface thereof; and
a wiring substrate that is joined to the rear surface of the head chip so as to cover the channel column, has wiring electrodes, which are electrically connected to the connection electrodes, formed on a surface thereof joined to the head chip, and is configured to apply a voltage to the drive electrodes on the head chip through the wiring electrodes,
the channel column of the head chip having drive channels from which an ink is discharged and dummy channels from which the ink is not discharged alternately arranged therein,
the wiring substrate having ink supply through holes at positions associated with opening portions of the drive channels and being joined to the rear surface of the head chip through an adhesive, thereby closing a square opening portion of each dummy channel,
wherein the method comprises: bonding the head chip to the wiring substrate through the adhesive; performing heating in a state that the opening portions of the dummy channels on the opposite side of the bonding surface of the wiring substrate are hermetically closed; expanding a gas put in the dummy channels; and curing the adhesive that has entered dummy channels while being thrusted out from the opening portions of the dummy channels by the expansion of the gas so that adhesive fillets made of the adhesive remaining in the opening portions are independently present at four corners of each of the opening portions.

4. The method for manufacturing an inkjet head according to 3,

wherein the head chip is sandwiched between a seal material formed of an elastic member and the wiring substrate to hermetically seal the opening portions of the dummy channels on the opposite side of the joining surface of the wiring substrate, and heating is carried out in this state.

5. The method for manufacturing an inkjet head according to 4,

wherein, after the head chip is bonded to the wiring substrate, a nozzle plate is bonded to a surface of the head chip on the opposite side of the joining surface of the wiring substrate.

6. The method for manufacturing an inkjet head according to 3, 4, or 5,

wherein the adhesive is a thermosetting resin, the gas put in the dummy channels is expanded by using heat at the time of heating and curing the adhesive.

BRIEF DESCRIPTION OF DRAWINGS

[0023]

FIG. 1 is an exploded perspective view showing an example of an inkjet head according to the present invention;
FIG. 2 is a rear view of a head chip of the inkjet head shown in FIG. 1;
FIG. 3 is an enlarged cross-sectional view of a bonded portion of the head chip and a wiring substrate;

FIG. 4 is a cross-sectional view taken along a line (iv)-(iv) in FIG. 3;
FIG. 5 is an enlarged view of a joined portion of the head chip and the wiring substrate;
FIG. 6 is a view showing a joined surface of the wiring substrate with respect to the head chip;
FIG. 7 is a view for explaining a state where the head chip and the wiring substrate are held between pressure plates;
FIG. 8 is a view for explaining a condition of an adhesive at the time of heating in a state that members are held by the pressure plates;
FIG. 9 is a view for explaining another conformation of connection electrodes of the head chip;
FIG. 10 is a view for explaining another conformation of wiring electrodes of the wiring substrate;
FIG. 11 is a view for explaining still another conformation of the wiring electrodes of the wiring substrate;
FIG. 12 is a view for explaining a state of adhesive fillets in opening portions according to an embodiment;
FIG. 13 is an enlarged cross-sectional view showing a bonded portion of a head chip and wiring substrate according to a conventional technology; and
FIG. 14 is a cross-sectional view taken along a line (xiv)-(xiv) in FIG. 13.

DESCRIPTION OF EMBODIMENTS

[0024] An embodiment according to the present invention will now be described hereinafter with reference to the drawings.

(Inkjet Head)

[0025] FIG. 1 is an exploded perspective view showing an example of an inkjet head according to the present invention, FIG. 2 is a rear view of a head chip of the inkjet head shown in FIG. 1.

[0026] In the drawing, H denotes an inkjet head; 1, a head chip; 2, nozzle plate; 3, a wiring substrate; and 4, a manifold.

[0027] The head chip 1 is formed of a hexahedron having a front surface I a, a rear surface 1b, and four upper, lower, left, and right side surfaces sandwiched between the front surface 1a and the rear surface 1b. Many channels 11 as straight ink flow paths are formed to extend between the front surface 1a and the rear surface 1b provided at opposed positions in these surfaces. Each partition wall that divides the channels 11 adjacent to each other is a drive wall 12 formed of a piezoelectric element, and one channel column is constituted by alternately arranging many channels 11 and drive walls 12. Here, four channel columns 10A to 10D are provided, and they are aligned in a vertical direction in FIG. 1.

[0028] It is to be noted that, in the present invention, the "front surface" of the head chip 1 means a surface on a side where nozzles are arranged and an ink is discharged, and the "rear surface" means a surface provided on the opposite side.

[0029] The channels 11 in each of the channel columns 10A to 10D are formed of drive channels I 1a to which the ink is supplied and from which the ink is discharged and dummy channels 11b to which the ink is not supplied and from which the ink is not discharged, and the drive channels 11a and the dummy channels 11b are alternately arranged in each of the channel columns 10A to 10D.

[0030] This head chip 1 is a shearing mode type head chip, an opening portion of each channel 11a or 11b on the front surface 1a side is an outlet of the ink, and an opening portion 110 of the same on the rear surface 1b side is an inlet of the ink. When each of these opening portions is simply referred to as an opening portion of the channel, it means an opening portion 110 that serves as the inlet of the ink that is opened on the rear surface 1b side.

[0031] Each channel 11a or 11b in each of the channel columns 10A to 10D is formed by grinding each straight groove having a predetermined depth from a surface of a piezoelectric element substrate by using a dicing blade and covering an upper surface of this groove with a cover substrate. Therefore, the opening portion 110 of each channel 1a or 11b opened in the rear surface 1b has a square shape.

[0032] A voltage application drive electrode 13 (see FIG. 3) configured to deform and drive each drive wall 12 is closely formed on a surface of each drive wall 12 facing the inside of each channel 11a or 11b by sputtering, vapor deposition, electroless plating, or the like. Further, each connection electrode 14 that is electrically conductive with the drive electrode 13 through the opening portion 110 of each channel 11a or 1b is individually formed in the rear surface I b of the head chip 1 by sputtering, vapor deposition, or electroless plating in accordance with each channel 11a or 11b.

[0033] In the respective connection electrodes 14, the connection electrode 14 of each channel 11a or 11b in each of the two channel columns 10A and 10B is formed from the opening portion 110 of each channel 11a or 11b toward a side edge e1 close to the channel column 10A, and the connection electrode 14 of each channel 11a or 11b of each of the other two channel columns 10C and 10D is formed from the opening portion 110 of each channel 11a or 11b toward a side edge e2 close to the channel column 10D. Each connection electrode 14 of each of the channel columns 10B and 10C ends before reaching each adjacent channel column 10A or 10D.

[0034] A nozzle plate 2 is bonded to the front surface 1a of the head chip 1. Each nozzle 21 is pierced in the nozzle

plate 2 only at a position associated with each drive channel 11a.

[0035] A wiring substrate 3 is bonded to the rear surface 1b of the head chip 1. The wiring substrate 3 has a larger area than an area of the rear surface 1b of the head chip 1, and both end portions 3a and 3b arranged in a direction orthogonal to a channel column direction largely stick out toward the lateral side (the vertical direction in the drawing) so as to protrude from the head chip 1 in a state that the wiring substrate 3 is bonded to the rear surface I b of the head chip 1.

[0036] In the wiring substrate 3, each through hole 31 through which the ink stored in a manifold 4 joined to the rear surface side of the wiring substrate 3 is supplied to each drive channel 11a is individually opened only at a position associated with each drive channel 11a of the head chip 1. Each through hole 31 has a square shape like the opening portion 110 of the drive channel 11a, and the front surface side facing the head chip 1 has substantially the same opening area as the opening portion 110. On the other hand, the through hole is not formed at a region associated with each dummy channel 11b in the wiring substrate 3. Therefore, the opening portion 110 of the dummy channel 11b is closed by the wiring substrate 3.

[0037] Each wiring electrode 32 is formed on a front surface of the wiring substrate 3, which serves as a joining surface relative to the head chip 1, in a one-on-one relationship with each connection electrode 14 aligned on the rear surface 1b of the head chip 1. In a state that the head chip 1 is bonded to the wiring substrate 3, one end of each wiring electrode 32 reaches a position near the opening portion 110 of each corresponding drive channel 11a or dummy channel 1b and the other end of the same extends toward each end portion 3a or 3b of the wiring substrate 3 sticking out to the lateral side of the head chip 1.

[0038] The other end of each wiring electrode 32 is distributed to the end portion 3a or 3b in accordance with each pair of channel columns. That is, the other end of each wiring electrode 32 associated with each of the channel columns 10A and 10B extends toward the upper end portion 3a in the drawing, and the other end of each wiring electrode 32 associated with each of the channel columns 10C and 10D extends toward the lower end portion 3b in the drawing.

[0039] Each wiring electrode 32 associated with each of the two inner channel columns 10B and 10C is arranged to reach each end portion 3a or 3b through a space between the respective wiring electrodes 32 associated with the respective outer channel columns 10A and 10D. In more detail, the two wiring electrodes 32 associated with the inner channel columns 10B and 10C run between the adjoining through holes 31 and 31 associated with the outer channel columns 10A and 10D and extend to the end portions 3a and 3b of the wiring substrate 3. As a result, the wiring electrodes 32 can be highly densely arranged.

[0040] External wiring members 5 and 5 (see FIG. 1) made of FPC or the like are joined to the end portions 3a and 3b of the wiring substrate 3, respectively, thereby electrically connecting to a non-illustrated drive circuit. As a result, a drive signal (a drive voltage) from the drive circuit is applied to the drive electrodes 13 in the respective channels 11a and 11b through the external wiring members 5 and 5, the wring electrodes 32 of the wiring substrate 3, and the connection electrodes 14 of the head chip 1.

[0041] As a material of the wiring substrate 3, it is possible to adopt an appropriate insulating material such as glass, ceramics, silicon, plastic, and others. Among others, it is preferable to use the glass since it is rigid, inexpensive, and easy to process. The wiring substrate 3 made of glass can be highly precisely formed by performing blasting relative to the through holes 31. Further, when a transparent glass plate is used, the wiring electrodes 32 or the connection electrodes 14 of the head chip I can be seen through from the back side of the wiring substrate 3, and the wiring electrodes 32 and the connection electrodes 14 can be easily positioned.

[0042] The head chip 1 can be joined to the wiring substrate 3 by applying an adhesive to the wiring substrate 3 and then positioning and bonding the head chip 1. As the adhesive, a thermosetting conductive adhesive is generally used. After applying the adhesive, when the head chip 1 and the wiring substrate 3 are positioned and bonded, the respective connection electrodes 14 of the head chip 1 and the respective wiring electrodes 32 of the wiring substrate 3 are electrically connected on one-on-one level. Furthermore, the unhardened adhesive applied at this moment flows between the head chip 1 and the wiring substrate 3 by capillarity, and part of this adhesive enters each dummy channel 11b, whereby the adhesive fillet is formed in the opening portion 110 of each dummy channel 11b.

[0043] FIG. 3 and FIG. 4 are views for explaining a condition of this adhesive fillet, and FIG. 3 is an enlarged cross-sectional view showing a bonded portion of the head chip 1 and the wiring substrate 3. A lower direction in the drawing is an ink discharge direction. Moreover, FIG. 4 is a cross-sectional view taken along a line (iv)-(iv) in FIG. 3 showing a condition of each opening portion 110 at this moment.

[0044] As shown in these drawings, although the adhesive 6 that is present between the head chip 1 and the wiring substrate 3 when these members are bonded to each other flows on the surface of the wiring substrate 3 by the capillarity in a low-viscosity state before curing and also partially enters each dummy channel 11b, each adhesive fillet 61 formed at the peripheral edge of the opening portion 110 of each dummy channel 11b at this moment is independently present at each of four corners of the opening portion 110 without closing the opening portion 110 of each dummy channel 11b.

[0045] Here, the independent presence of each adhesive fillet 61 means that, when the opening portion 110 is observed from the rear surface 1b of the head chip I as shown in FIG. 4, the adhesive fillets 61 are present at the four corners of the square opening portion 110, respectively, but the adhesive fillets 61 at the four corners are not connected to each

other on the peripheral edge of the opening portion. Therefore, a region S where the adhesive fillet is not formed is present between the adhesive fillets 61 adjacent to each other.

[0046] If the adhesive fillets 61 are independently present at the four corners of the opening portion 110 in this manner, although each adhesive fillet 61 partially enters each dummy channel 11b, an amount of this adhesive fillet is small, hence the adhesive fillet 61 only slightly enters from the opening portion 110 of each dummy channel 11b as shown in FIG. 3, and it does not deeply enters as different from the example shown in FIG. 10. Therefore, each cured adhesive fillet 61 does not greatly affect an operation of each drive wall 12, and stable discharge is not obstructed. Additionally, since the adhesive fillets 61 are just independently present at the four corners, the adhesive fillets 61 expanded at the time of curing does not thrust out the drive walls 12, and the drive walls 12 are not damaged.

[0047] Further, in a state where the adhesive fillets 61 are formed at the four corners of the opening portion 110 of each dummy channel 11b in this manner, the adhesive 6 that is sufficient to surround the opening portion 110 is present around the opening portion 110 of each dummy channel 11b on the rear surface 1b of the head chip 1. Therefore, as shown in FIG. 4, the periphery of the opening portion 110 of each dummy channel 11b is surrounded and completely sealed by using the sufficient adhesive 6. Therefore, the ink supplied to each adjacent drive channel 11a does not flow into the dummy channel 11b.

[0048] Such adhesive fillets 61 are likewise formed in the opening portions 110 of all the dummy channels 11b formed in the head chip 1. Since the through holes 31 are formed in the wiring substrate 3, the adhesive 6 does not flow into the drive channels 11a by the capillarity beyond the through holes 31, and the adhesive fillets 61 are not formed.

[0049] In the inkjet head according to the present invention, as shown in FIG. 5, it is preferable to likewise form an adhesive fillet 62 in a region extending to both the peripheral edge 1c on the rear surface 1b side of the head chip I and the wiring substrate 3 by using the adhesive 6 applied between the head chip 1 and the wiring substrate 3. Presence of this adhesive fillet 62 enables improving bonding strength of the head chip 1 and the wiring substrate 3.

(Method for Manufacturing Inkjet Head)

[0050] A preferred method for manufacturing the inkjet head H will now be described with reference to FIG. 6 to FIG. 8.

[0051] FIG. 6 shows a joining surface of the wiring substrate 3 relative to the head chip 1. First, as shown in the drawing, the adhesive 6 is applied to the wiring substrate 3 having the through holes 31 and the respective wiring electrodes 32 formed thereon so as to form stripe shapes over portions where the respective connection electrodes 14 of the head chip 1 and the wiring electrodes 32 overlap, and then the head chip 1 is positioned and bonded.

[0052] Subsequently, the opening portions of the dummy channels 11b opened in the front surface 1a of the head chip 1 placed on the opposite side of the joining surface relative to the wiring substrate 3 are sealed.

[0053] FIG. 7 is a cross-sectional view showing a method that is preferred at the time of forming this sealed state. The head chip 1 and the wiring substrate 3 bonded to each other are disposed between a pair of upper and lower pressure plates 7a and 7b, and they are sandwiched between both the pressure plates 7a and 7b, whereby a predetermined pressure is applied. As a result, the adhesive 6 applied in the stripe shapes flows between the head chip 1 and the wiring substrate 3 by the capillarity. At this time, the adhesive 6 that has reached the opening portion 110 of each dummy channel 11b partially enters the dummy channel 11b from the opening portion 110 as shown in FIG. 8.

[0054] Of both the pressure plates 7a and 7b, the pressure plate 7a arranged on the front surface 1a side of the head chip 1 has a sheet-shaped seal material 8 which is made of an elastic material provided on a surface thereof, and this seal material 8 abuts on the front surface 1a of the head chip 1. As the elastic material, rubber can be generally used, and silicon rubber is preferable in particular.

[0055] The reason why this seal material 8 is provided is as follows. In general, since the head chip I is fabricated by fully cutting ceramics by using a dicing blade or the like, marks formed by cutting may remain as fine irregularities on full-cut surfaces (the front surface 1a and the rear surface 1b) in some cases. In this state, when the tabular pressure plate 7a alone is used, the dummy channels 11b are hard to be sealed. Although this problem is improved by polishing the full-cut surfaces, when the seal material 8 made of the elastic material is interposed like this embodiment, the opening portions in the front surface 1a of the head chip 1 can be effectively sealed without purposely performing the polishing operation even though the irregularities are formed on the front surface 1a of the head chip 1.

[0056] The opening portions 110 of the dummy channels 11b on the wiring substrate 3 side are sealed with the adhesive 6 that has flowed to the periphery thereof. Therefore, the seal material 8 does not necessarily have to be provided to the pressure plate 7b on the wiring substrate 3 side. The dummy channels 1b of the head chip 1 are sealed between the seal material 8 on the pressure plate 7a and the wiring substrate 3, and they have a gas (air) hermetically put therein.

[0057] Then, when the head chip 1 and the wiring substrate 3 are heated in this state, the gas hermetically put in the dummy channels 11b is expanded.

[0058] In regard to this heating, when the adhesive 6 is a thermosetting adhesive, heat at the time of thermal curing can be used. When the adhesive 6 is not the thermosetting type, the head chip 1 and the wiring substrate 3 may be heated by appropriate heating means such as an oven while being sandwiched between the pressure plates 7a and 7b.

Here, a description will be given as to a situation where the adhesive 6 is the thermosetting type and the heating is carried out by using heat at the time of thermal curing.

[0059] When the gas in each dummy channel 11b is expanded by heating the head chip 1, the adhesive 6 that has entered the dummy channel 11b is thrusted to the space between the rear surface 1b of the head chip 1 and the wiring substrate 3 from the opening portion 110 of the dummy channel 11b by this expansion of the gas. Further, when the adhesive 6 is cured in this state, the adhesive fillets 61 made of the adhesive 6 remaining in the opening portion 110 of the dummy channel 11b are independently present at the four corners of the opening portion 110 as shown in FIG. 3 and FIG. 4. As a result, the state shown in each of FIG. 3 and FIG. 4 in which the periphery of the opening portion 110 of the dummy channel 11b is surrounded and sealed with the adhesive 6 can be easily created.

[0060] Further, even if a sufficient amount of the adhesive 6, which is applied first, is applied, each dummy channel 11b can be prevented from being closed with the adhesive 6. Therefore, the sufficient adhesive fillets 62 can be formed to get across both the peripheral edge on the rear surface 1b side of the head chip I and the wiring substrate 3 as shown in FIG. 5. As a result, the inkjet head H in which a joined state of the head chip I and the wiring substrate 3 is firmly maintained can be easily obtained.

[0061] To independently provide the adhesive fillets 6 at the four corners of the opening portion 110 of each dummy channel 11b as shown in FIG. 3 and FIG. 4, a degree of expansion of the gas hermetically put in each dummy channel I 1b is important. If the expansion of the gas is insufficient, it is difficult to independently provide the adhesive fillets 61 at the four corners of the opening portion 110. If the gas is excessively expanded, the adhesive 6 is thrusted out too much, portions where the adhesive 6 is partially discontinuous are apt to be produced around the opening portion 110 of each dummy channel 11b. Therefore, the gas in each dummy channel 11b must be appropriately expanded so that the adhesive fillets 61 can independently present at the four corners of the opening portion 110. This degree of expansion of the gas can be realized by appropriately controlling a temperature or a heating time at the time of heating in accordance with a size (a volume) of each dummy channel 11b.

[0062] The heating temperature or the heating time at the time of expanding the gas must be a temperature and a time that do not increase viscosity of the adhesive 6 too much, enable maintaining a flowing state, and do not allow flowage after flowing to some extent since the air in each dummy channel 11b must be appropriately expanded before reaching an adhesive curing temperature. The specific temperature or time is appropriately adjusted in accordance with a type of the adopted adhesive 6 (a curing temperature, viscosity), a volume of each dummy channel 11b, a size or thermal conductivity of the head chip 1, and others.

[0063] After joining the head chip 1 and the wiring substrate 3 in this manner, the nozzle plate 2 is joined to the front surface 1a of the head chip 1, the manifold 4 is joined to the rear surface side of the wiring substrate 3, and the external wiring members 5 and 5 are joined to both the end portions 3a and 3b of the wiring substrate 3, respectively, thereby bringing the inkjet head H to completion.

[0064] It is to be noted that, in case of forming a top coat such as a parylene film to cover the surface of each drive electrode 13, the top coat can be formed after joining the head chip 1 and the wiring substrate 3 as described above and before joining the nozzle plate 2. If the top coat does not have to be formed, the head chip I and the wiring substrate 3 after joining the nozzle plate 2 may be joined. In this case, since the opening portion of each dummy channel 11b on the front surface side 1a of the head chip 1 is hermetically closed with the nozzle plate 2, the seal material 8 does not necessarily have to be provided.

(Another Conformation of Inkjet Head)

[0065] Although each connection electrode 14 formed on the head chip 1 of the above-described inkjet head H is drawn only from one side the opening portion 110, FIG. 9 shows a conformation where the connection electrode 14 of each dummy channel 11b is formed to surround the opening portion 110.

[0066] In general, since a metal surface has excellent adhesive wettability, when the connection electrode 14 of the dummy channel 11b is formed to surround the opening portion 110 in this manner, flowage of the adhesive can be controlled so that the adhesive can easily surround the opening portion 110. Therefore, the opening portion 110 of each dummy channel 11b can be more assuredly sealed.

[0067] It is to be noted that there is no restriction in applying the connection electrode 14 surrounding the opening portion 110 in this manner to the drive channel 11a.

[0068] FIG. 10 shows another conformation of a pattern of the wiring electrodes 32 of the wiring substrate 3. Here, only a portion corresponding to the two channel columns on one end portion 3b side of the wiring substrate 3 is shown.

[0069] In this conformation, of the wiring electrodes 32 formed on the wiring substrate 3, each wiring electrode 32 electrically connected to the connection electrode 14 of each dummy channel 11b has a covering portion 32a, which is formed of a metal film having a slightly larger area than the opening portion 110, integrally formed at one end thereof so that the opening portion 110 of the dummy channel 11b can be covered. Therefore, when this wiring substrate 3 is joined to the head chip 1, a region of this covering portion 32a is arranged so as to cover the opening portion 110 of the

corresponding dummy channel 11b. As a result, like the above example, flowage of the adhesive can be controlled so that the adhesive can easily surround the opening portion 110. Therefore, the opening portion 110 of each dummy channel 11b can be more assuredly sealed.

[0070] As means for allowing the adhesive to easily surround the opening portion 110, besides the conformation shown in FIG. 10, a surrounding portion 32b having a square frame shape may be formed at one end of the wiring electrode 32 as shown in FIG. 11. In the surrounding portion 32b, a region a which has substantially the same size as the opening portion 110 and has no metal film formed therein is formed in a region associated with the opening portion 100 of each dummy channel 11b. Therefore, the surrounding portion 32b is formed into a square shape so as to surround the periphery of the opening portion 110. As a result, like the above example, the adhesive can easily surround the opening portion 110, but the metal film is not formed in the area a associated with the opening portion 110, and hence the adhesive does not excessively enter the opening portion 110.

[0071] Although the head chip 1 includes the four channel columns 10A to 10D in the inkjet head H in the above description, the number of the channel columns of the head chip 1 does not matter in the present invention. Only one column may be provided, or a plurality of columns, e.g., two, three, or five or more columns may be provided.

(Another Conformation of Method for Manufacturing Inkjet Head)

[0072] As the method for manufacturing an inkjet head, the most preferred conformation that can easily form a state that the adhesive fillets 61 are independently present at the four corners of the opening portion 110 of each dummy channel 11b has been illustrated. As another manufacturing method, there is, e.g., a method for forming the adhesive 6 at necessary positions on both or one of the rear surface 1b of the head chip I and the front surface of the wiring substrate 3 so as to form a predetermined pattern while appropriately controlling an application amount based on a transfer method.

[0073] Furthermore, in the method for manufacturing an inkjet head, in place of the conformation that the seal material 8 is provided on the pressure plate 7a, the pressure plate 7a itself may be made of an elastic material. As a result, the seal material 8 is no longer required.

EXAMPLE

[0074] An effect of the present invention will now be illustrated based on an example.

[0075] As the head chip, a shearing mode type head chip was fabricated by using PZT as a drive wall material. The head chip was cut out by performing full-cutting with respect to both end surfaces (a front surface and a rear surface). End surfaces of the cutout head chip were not polished in particular. Connection electrodes were formed on the rear surface of the head chip like FIG. 2.

[0076] Specification of the head chip is as follows.
The number of channel columns: 4
The number of channels in one column: 512
A size of a dummy channel: depth 360 μm$\times$width 82 μm$\times$L length 3.0 mm

[0077] In a wiring substrate, through holes were formed in a glass substrate only at positions associated with drive channels of the head chip by blasting, and wiring electrodes associated with connection electrodes of the head chip were formed like the wiring substrate shown in FIG. 1.

[0078] This head chip and the wiring substrate were bonded through a thermosetting adhesive (353ND manufactured by EPOTEK, a final curing temperature: 100°C). The adhesive was applied to the wiring substrate side in stripe shapes like FIG. 6.

[0079] A total of four samples, each of which is likewise obtained by fabricating and bonding the head chip and the wiring substrate, were prepared, and each sample was sandwiched between a pair of pressure plates made of metal plates (SUS) and heated and cured under conditions shown in Table 1. In regard to each sample, a state of adhesive fillets in an opening portion of each dummy channel, presence/absence of leakage of an ink into each dummy channel, and an injection test were evaluated, and a result is shown in Table 1.

[0080] It is to be noted that a seal material was interposed between the pressure plate and the head chip in each of Samples 3 and 4 alone. Further, in regard to each of Samples I and 3, a temperature of 60°C which is relatively low as an initial curing temperature was set, then heating was carried out, and curing was effected by increasing the temperature to 100°C which is a final curing temperature. Each of Samples 2 and 3 was cured by increasing a temperature to 100°C, which is the final curing temperature, from the beginning.

[0081] A fillet state was evaluated by observing a rear surface side of the head chip with use of a microscope through the wiring substrate made of transparent glass. As shown in FIG. 12, the fillet state was evaluated as (a) a substantially closed state obtained by forming the adhesive fillet on the entire inner side of the opening, (b) a state of the present invention where the adhesive fillets are independently present at four corners of the opening portion, and (c) a state that

the adhesive fillet is not present in the opening portion at all.

[0082] A leak examination was performed by immersing an integrated matter obtained by joining a nozzle plate, the head chip, and the wiring substrate in an ink in a low-pressure state of 0.1 kPa for 20 minutes, then pulling up this integrated matter, and confirming whether the ink had entered each dummy channel under an atmospheric pressure. Presence/absence of infiltration of the ink was confirmed by a visual examination using a microscope. A circle mark represents that the ink did not enter all the dummy channels, and a cross mark represents that the ink entered even one dummy channel.

[0083] The injection test was evaluated by completing each inkjet head, then actually discharging the ink from each drive channel, and measuring a drop speed. When a fixed amount or more of the adhesive enters each dummy channel, the cured adhesive obstructs an operation of drive walls provide on both sides thereof, and a speed of drops discharged from each drive channel is lowered. A circle mark represents that a reduction in drop speed is less than 10 with respect to an average speed of speeds of drops discharged from all the drive channels, and a cross mark represents that even one drive channel shows a decrease of 10% or more and a speed of drops from this drive channel is lowered because the adhesive or the ink entered each dummy channel.

[Table 1]

Sample	Seal Material	Adhesive Initial Curing Temperature	Fillet State	Leak Inspection	Injection Test
1	None	60°C	(a)	○	×
2	None	100°C	(a)	○	×
3	Silicon Rubber	60°C	(b)	○	○
4	Silicon Rubber	100°C	(c)	×	×

[0084] As a result, in Sample 3, as a fillet state, the fillets are independently present at the four corners of the opening portion, and both the leak examination and the injection text had good results.

[0085] In Sample 1, the fillet was not able to be independently present at the four corners of the opening portion, and the injection test had a poor result. It can be considered that the poor result was obtained because end faces of the head chip were not polished at all, fine irregular shapes remained on the surfaces, thus a gas expanded in each dummy channel leaked from a space between the head chip and the pressure plate, and the adhesive that had entered the dummy channel was insufficiently thrusted out.

[0086] Moreover, Sample 2 has no seal material like Sample 1, but the adhesive that had entered each dummy channel was insufficiently thrusted out even though a heating temperature was simply increased, and the fillet state and the injection test had the same results as Sample 1.

[0087] In Sample 4, leakage of the ink occurred, the ink entered each dummy channel, and hence the injection test had a poor result. It can be considered that the result was poor because each dummy channel had an excellent hermetically closed state due to presence of the seal material at the time of sandwiching using the pressure plates, but the adhesive in each dummy channel was thrusted out too much by the expanded gas since a heating temperature was too high, the adhesive around the opening portion of each dummy channel was partially discontinuous, and the opening portion was not completely surrounded.

Claims

1. An inkjet head comprising:

a head chip that has channels and drive walls formed of piezoelectric elements alternately arranged thereon, has a channel column having drive electrodes formed on surfaces of the drive walls facing the inside of the channels, has opening portions of the channels arranged in a front surface and a rear surface thereof, and has connection electrodes, which achieve electrical conduction with the drive electrodes in the channels, formed on the rear surface thereof; and

a wiring substrate that is joined to the rear surface of the head chip so as to cover the channel column, has wiring electrodes, which are electrically connected to the connection electrodes, formed on a surface thereof joined to the head chip, and is configured to apply a voltage to the drive electrodes on the head chip through the wiring electrodes,

the channel column of the head chip having drive channels from which an ink is discharged and dummy channels from which the ink is not discharged alternately arranged therein,

the wiring substrate having ink supply through holes at positions associated with opening portions of the drive channels and being joined to the rear surface of the head chip through an adhesive, thereby closing a square opening portion of each dummy channel,
wherein adhesive fillets made of the adhesive in the opening portion of each dummy channel are independently present at four corners of the opening portion of the dummy channel.

2. The inkjet head according to claim 1,
wherein the adhesive fillets are formed so as to extend to both a peripheral edge of the head chip on a rear surface side thereof and the wiring substrate.

3. A method for manufacturing an inkjet head, the inkjet head comprising:

a head chip that has channels and drive walls formed of piezoelectric elements alternately arranged thereon, has a channel column having drive electrodes formed on surfaces of the drive walls facing the inside of the channels, has opening portions of the channels arranged in a front surface and a rear surface thereof, and has connection electrodes, which achieve electrical conduction with the drive electrodes in the channels, formed on the rear surface thereof; and
a wiring substrate that is joined to the rear surface of the head chip so as to cover the channel column, has wiring electrodes, which are electrically connected to the connection electrodes, formed on a surface thereof joined to the head chip, and is configured to apply a voltage to the drive electrodes on the head chip through the wiring electrodes,
the channel column of the head chip having drive channels from which an ink is discharged and dummy channels from which the ink is not discharged alternately arranged therein,
the wiring substrate having ink supply through holes at positions associated with opening portions of the drive channels and being joined to the rear surface of the head chip through an adhesive, thereby closing a square opening portion of each dummy channel,
wherein the method comprises: bonding the head chip to the wiring substrate through the adhesive; performing heating in a state that the opening portions of the dummy channels on the opposite side of the bonding surface of the wiring substrate are hermetically closed; expanding a gas put in the dummy channels; and curing the adhesive that has entered dummy channels while being thrusted out from the opening portions of the dummy channels by the expansion of the gas so that adhesive fillets made of the adhesive remaining in the opening portions are independently present at four corners of each of the opening portions.

4. The method for manufacturing an inkjet head according to claim 3,
wherein the head chip is sandwiched between a seal material formed of an elastic member and the wiring substrate to hermetically seal the opening portions of the dummy channels on the opposite side of the joining surface of the wiring substrate, and heating is carried out in this state.

5. The method for manufacturing an inkjet head according to claim 4,
wherein, after the head chip is bonded to the wiring substrate, a nozzle plate is bonded to a surface of the head chip on the opposite side of the joining surface of the wiring substrate.

6. The method for manufacturing an inkjet head according to claim 3, 4, or 5,
wherein the adhesive is a thermosetting resin, the gas put in the dummy channels is expanded by using heat at the time of heating and curing the adhesive.

FIG .1

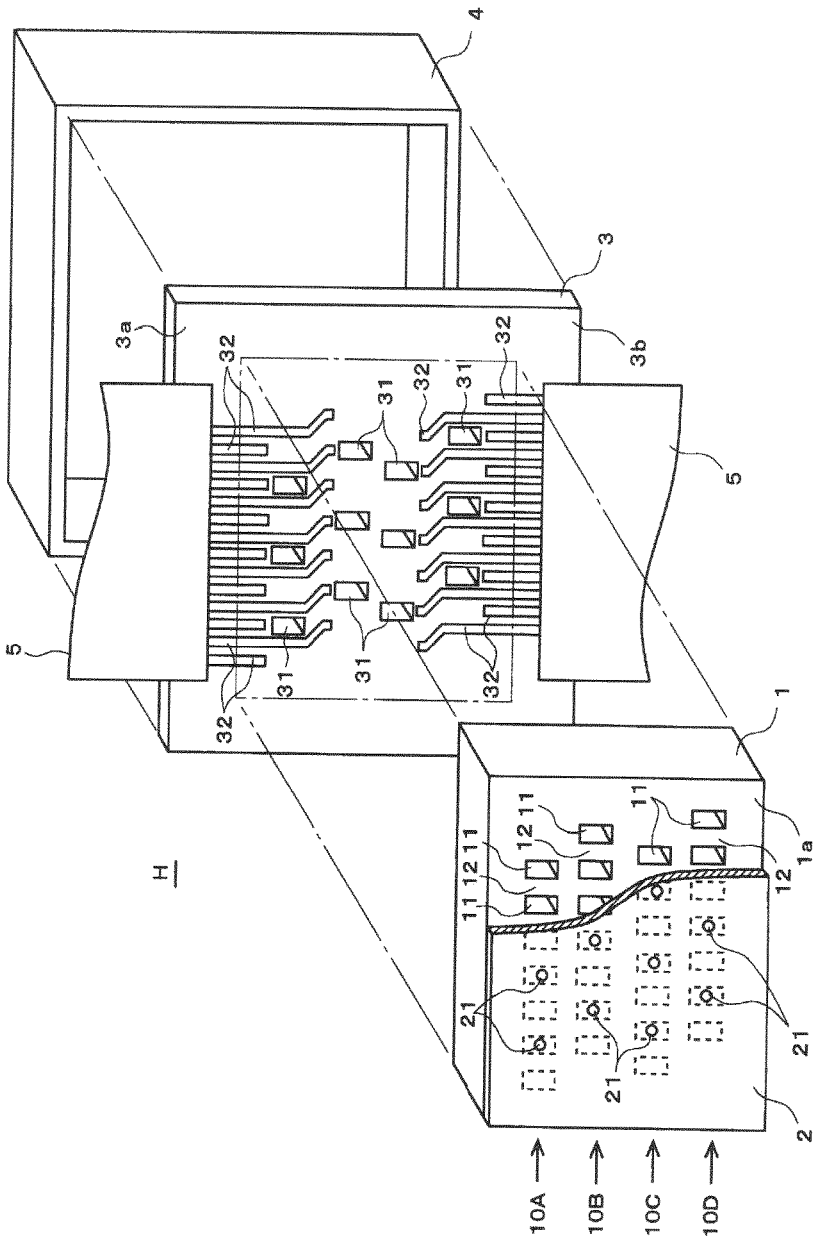


FIG .2

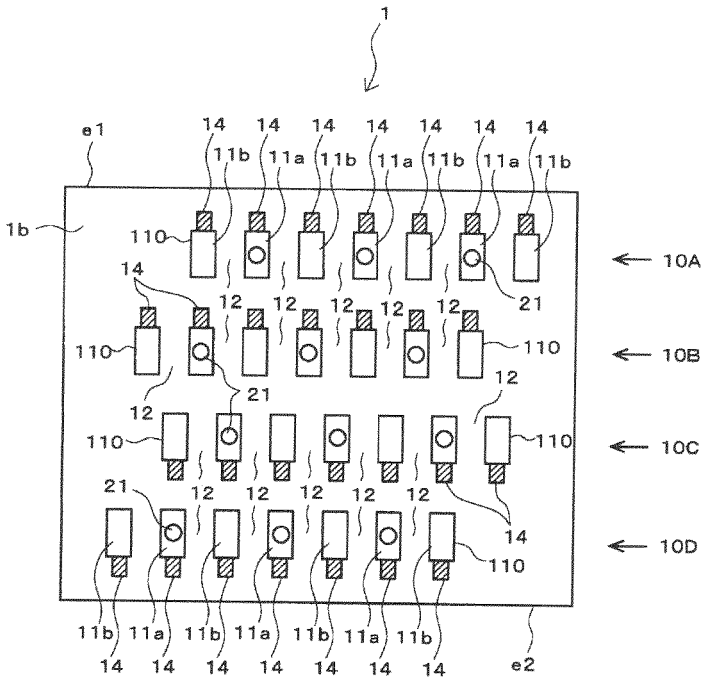

1
e1
14
11b
11a
1b
110
10A
21
12
10B
10C
10D
e2

FIG .3

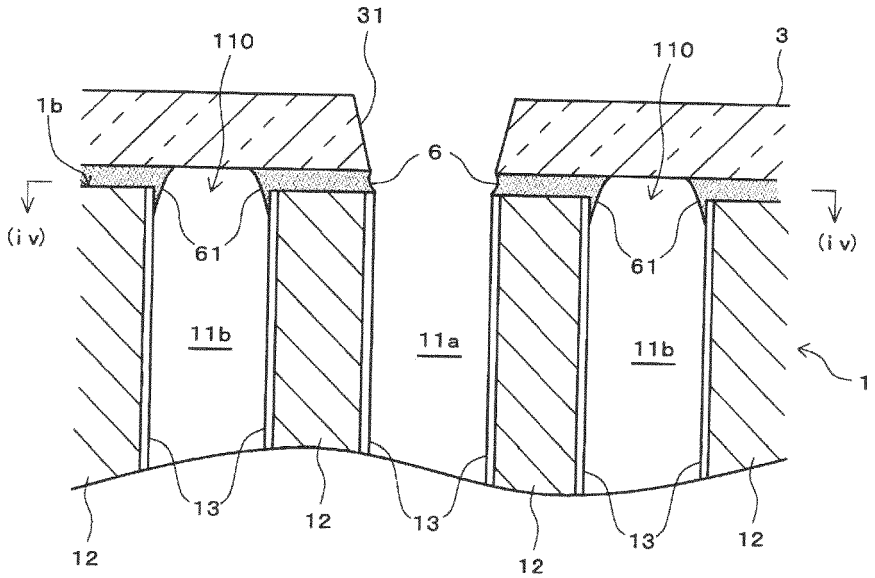

31
110
3
1b
6
(iv)
61
11b
11a
1
13
12

FIG .4

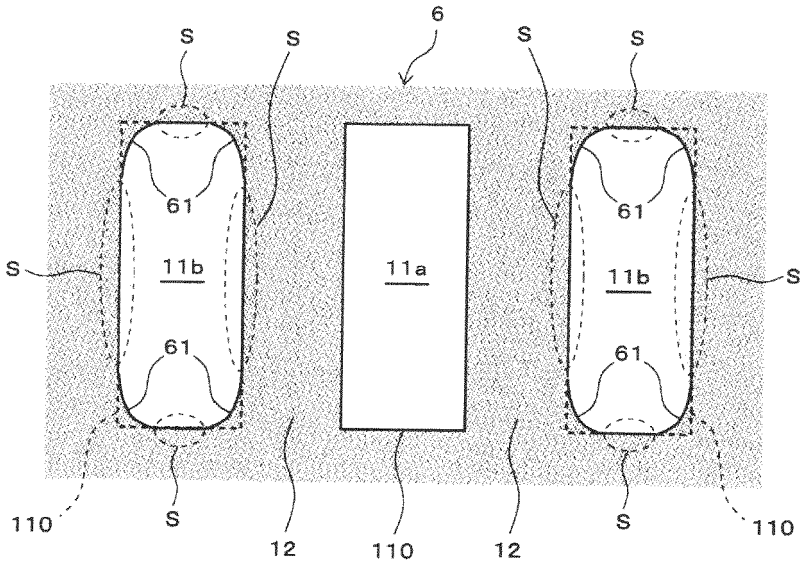


FIG .5

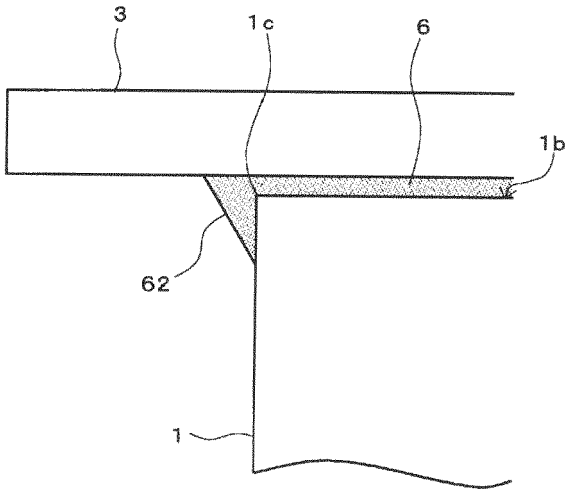
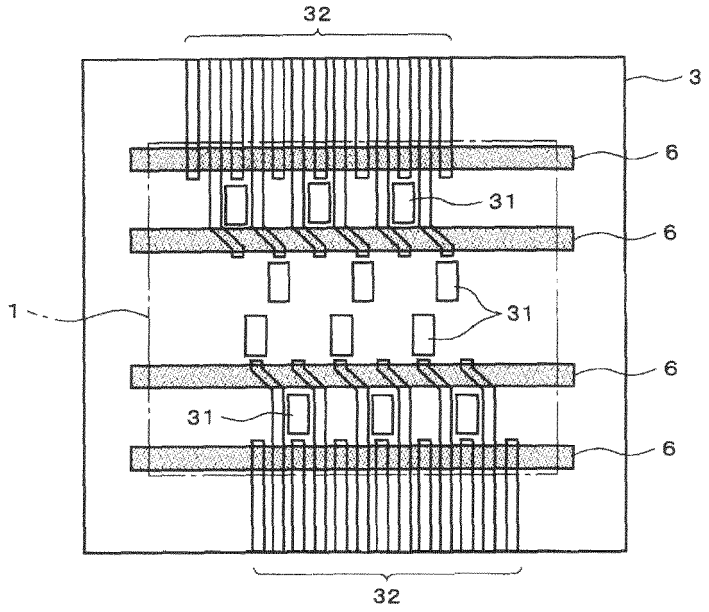


FIG .6


32
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31
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31
6
32

FIG .7

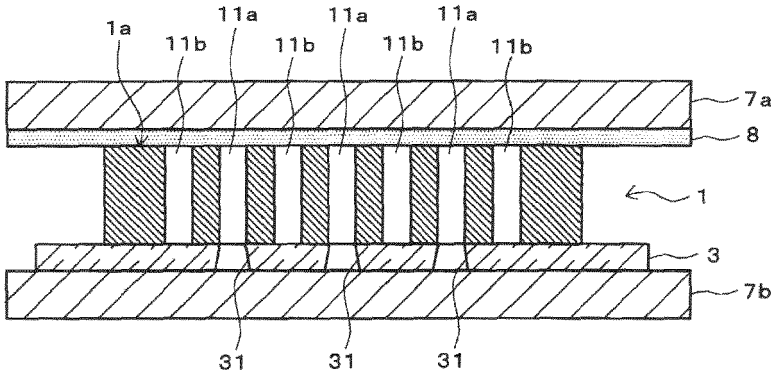
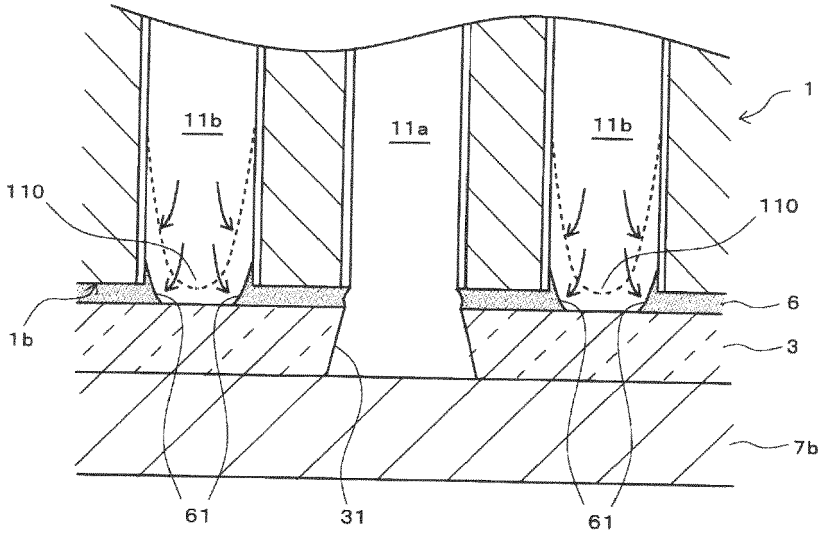

1a
11b
11a
11b
11a
11b
11a
11b
7a
8
1
3
7b
31
31
31

FIG .8


11b
11a
11b
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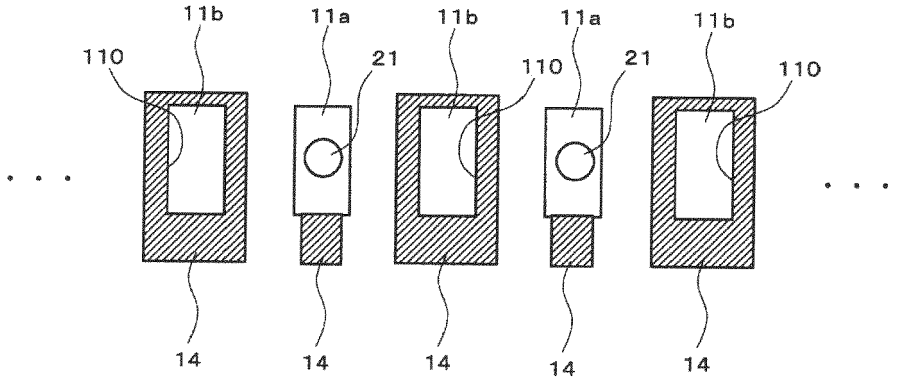
110
110
6
1b
3
7b
61
31
61

FIG .9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11b
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14
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14
14
14

FIG .10

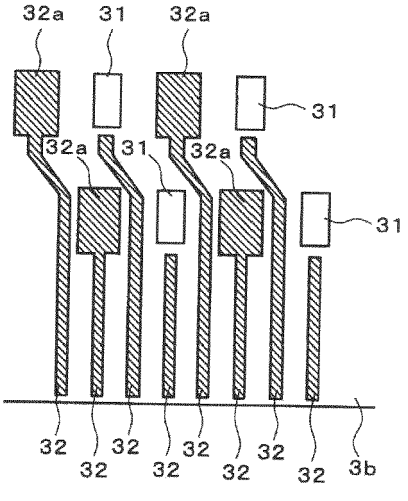


FIG .11

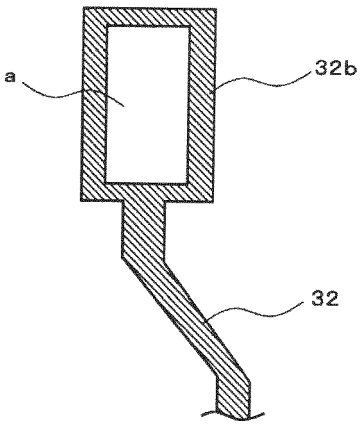


FIG .12

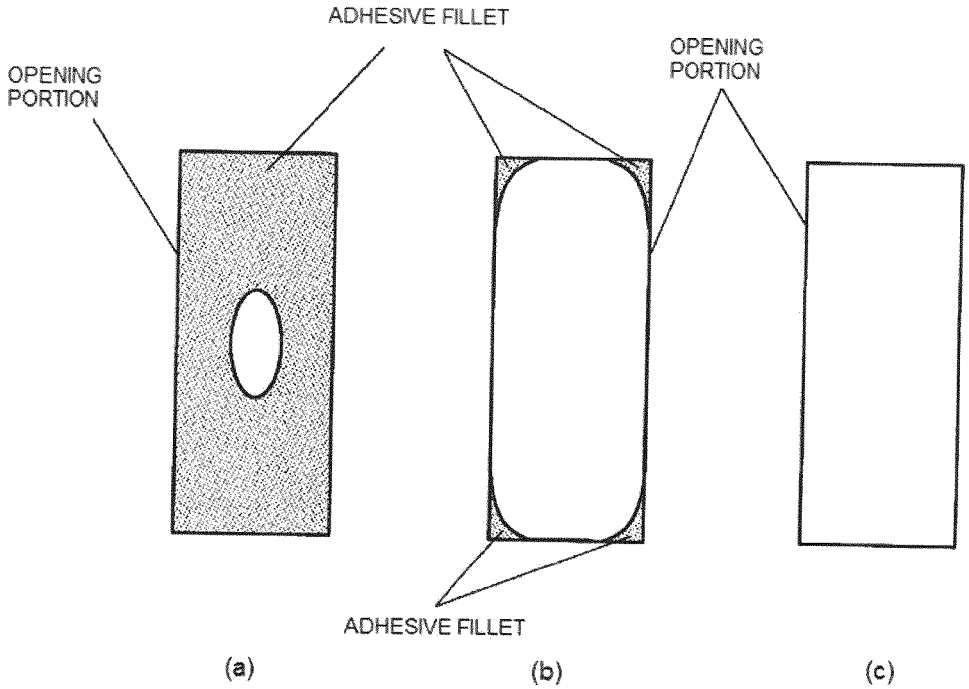

ADHESIVE FILLET
OPENING PORTION
OPENING PORTION
ADHESIVE FILLET
(a)
(b)
(c)

FIG .13

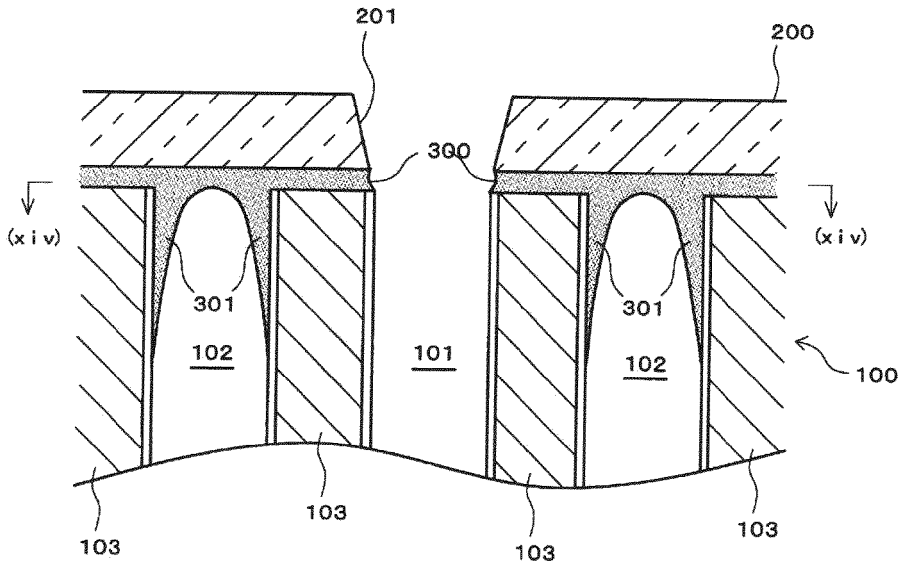
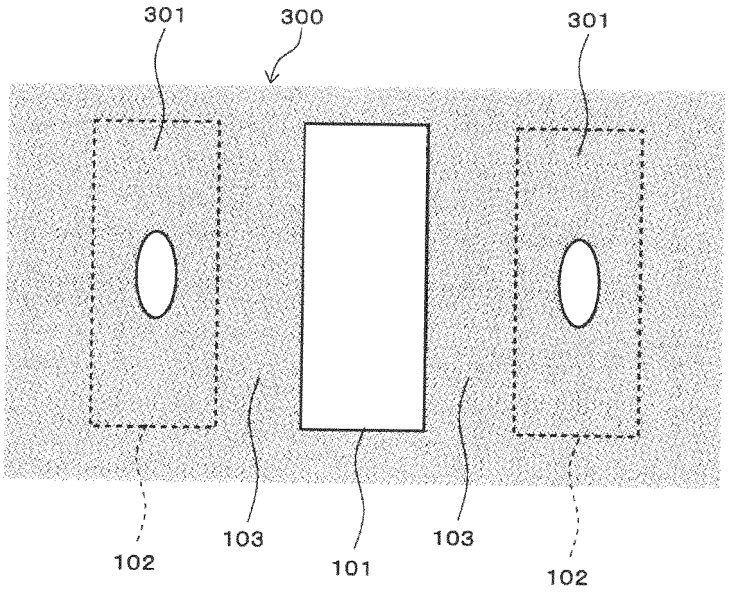

201
200
300
(xiv)
(xiv)
301
301
102
101
102
100
103
103
103
103

FIG .14



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EUROPEAN SEARCH REPORT

Application Number
EP 13 19 7887

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	JP 2012 016848 A (KONICA MINOLTA IJ TECHNOLOGIES) 26 January 2012 (2012-01-26) * paragraph [0032] - paragraph [0034]; figures 1,4 * * paragraph [0050] - paragraph [0052] * -----	1-6	INV. B41J2/14 B41J2/16
A	EP 1 923 219 A2 (KONICA MINOLTA IJ TECHNOLOGIES [JP]) 21 May 2008 (2008-05-21) * the whole document * -----	1-6	

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	17 March 2014	Didenot, Benjamin

CATEGORY OF CITED DOCUMENTS

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17-03-2014

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		JP 2012016848 A	26-01-2012
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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