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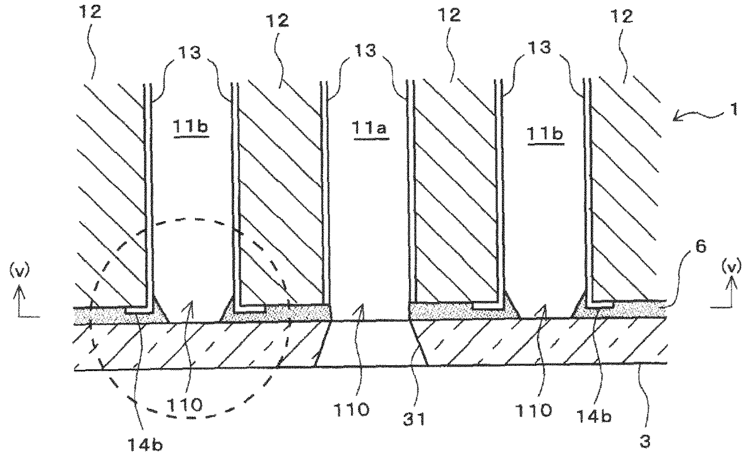
(54) **Inkjet head and method for manufacturing inkjet head**

(57) Aggregation of conductive particles in an adhesive is suppressed around channels between a head chip and a wiring substrate, and occurrence of a short circuit due to the aggregation of the conductive particles is avoided.

An inkjet head comprises: a head chip 1 that has a channel column in which drive channels from which an ink is discharged and dummy channels 11b from which the ink is not discharged are alternately arranged, and also has connection electrodes 14b, which achieve electrical conduction with drive electrodes 13 in the channels, formed on the rear surface thereof; and a wiring substrate 3 that is joined to the rear surface 1b of the head chip 1 to cover the channel column, has wiring electrodes which are electrically connected to the connection electrodes 14b, and has ink supply through holes at positions associated with opening portions of the drive channels, the connection electrode 14b of each dummy channel 11b is formed so as to surround the opening portion 110 of the dummy channel 11b, and a particle diameter of the conductive particles 61 is equal to or less than a gap a between a rear surface 1b of the head chip and a front surface of the wiring substrate 3 and larger than a gap c between the connection electrodes 14 on the rear surface 1b of the head chip and the front surface of the wiring substrate 3.

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 avoids occurrence of a short circuit due to flowage and aggregation of conductive particles in an adhesive that bonds a head chip to a wiring substrate and a method for manufacturing an inkjet head.

TECHNICAL FIELD

[0002] As an inkjet head that records various kinds of images by discharging an ink in a channel, 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] Meanwhile, such an operation of joining the head chip to the wiring substrate is conducted by bonding the head chip to the wiring substrate through an adhesive. To assuredly achieve electrical connection between electrodes of both the members, an adhesive containing conductive particles is generally used for the joining. When the adhesive is a thermosetting adhesive, it is heated to a predetermined curing temperature at the time of the joining.

[0006] When each electrode formed on a rear surface of the head chip overlaps each electrode on a front surface of the wiring substrate due to the joining of the head chip and the wiring substrate, a gap corresponding to the sum of both the electrodes is formed between these members. The adhesive is present in this gap, flows in the gap by capillarity when viscosity is low immediately after bonding, and spreads to substantially the entire region of the gap.

[0007] However, the adhesive may flow into an opening portion of each channel opened in the rear surface of the head chip by capillarity during this flowing process in some cases. The adhesive that has flowed into each channel may possibly not only close the channel but also possibly affect injection characteristics of the ink. Therefore, it is desirable to discharge the adhesive that has flowed into the channel to the outside of the channel before curing.

[0008] Therefore, the present inventor adopted a method for sandwiching both the head chip and the wiring substrate from both sides at the time of joining both the members, hermetically sealing the opening portion of each channel at this moment, and heating the whole to a predetermined temperature. According to this method, the channel is filled with a gas (air) by hermetically sealing the opening portion of the channel, the adhesive that has flowed into the channel is thrusted to the gap between the head chip and the wiring substrate by utilizing expanding force of the gas caused by heating, and the adhesive is cured in this state.

[0009] According to this method, the problem of closing of the channel caused by the adhesive can be solved by a simple method. Further, when the adhesive is a thermosetting resin, since heating means for curing can be used, the number of manufacturing steps or manufacturing facilities do not become complicated.

[0010] Patent Document 1: JP-A-2002-178509 (FIG. 18)

SUMMARY OF INVENTION

[0011] However, according to an experiment conducted by the present inventor, it was found out that, when the gas in the channel is thrusted out and the adhesive is cured, since some of conductive particles are aggregated between the head chip and the wiring substrate, conduction may be possibly achieved at a position where conduction should not be fundamentally achieved to cause a short circuit, thereby deteriorating a yield ratio. The aggregation of the conductive particles often occurs around each channel or especially between channels adjacent to each other, and the present inventor keenly examined a cause of this aggregation and consequently obtained the following knowledge.

[0012] When the head chip and the wiring substrate are bonded to each other through the adhesive, the adhesive between both the members spreads to the periphery by the capillarity even on a stage that sufficiently pressurization is yet to be performed. Furthermore, after the pressurization, flowage of the adhesive between both the members due to the capillarity is substantially terminated. Since the conductive particles are homogeneously dispersed in the adhesive, the conductive particles are homogeneously dispersed in this state, and partial aggregation does not occur. However, when heating is carried out in this state and the gas in the channel is expanded to thrust the adhesive from the channel, the thrusted adhesive flows in the narrow gap between the chip and wiring substrate, and hence the aggregation of the conducive particles is caused. This aggregation occurs because the conductive particles themselves are apt to be aggregated as their nature and the flowage of the adhesive in a restricted region promotes this nature.

[0013] Some of head chips have a channel column in which drive channels from which an ink is discharged and dummy channels from which the ink is not discharged are alternately arranged. Further, as a wiring substrate joined to such a head chip, there is one having an ink supply through hole only at each position associated with each drive channel. When such a head chip and the wiring substrate are joined, since the dummy channel is completely closed by the wiring substrate, the adhesive is prone to flow into the dummy channel along a surface of the wiring substrate, and the adhesive that has flowed in is thrusted out, whereby the aggregation is apt to occur around the dummy channel in particular.

[0014] The conductive particles aggregated around the channel in this manner may possibly cause a short circuit between electrodes of the channels adjacent to each other.

[0015] Moreover, the problem of the short circuit due to the aggregation of the conductive particles becomes prominent in case of a multi-column head having two or more channel columns as described below.

[0016] FIG. 14 and FIG. 15 show an inkjet head having two channel columns. FIG. 14 is an exploded perspective view, and FIG. 15 is a cross-sectional view of aligned three channels. In the drawings, reference numeral 100 denotes a head chip; 200, a nozzle plate; 300 a wiring substrate; 400, an adhesive; and A, an aggregated portion of conductive particles.

[0017] Here, as each channel column of the head chip 100, a channel column in which drive channels 101 and dummy channels 102 are alternately arranged is illustrated. In a nozzle plate 200, a nozzle 201 is formed in accordance with each drive channel 101. In a wiring substrate 300, an ink supply through hole 301 is formed only at a position associated with each drive channel 101, and a voltage application wiring electrode 302 for each drive channel 101 or each dummy channel 102 in one channel column is arranged between the through holes 301 associated with the other channel column.

[0018] As described above, in a case where high-density wiring is carried out so that each wiring electrode 302 associated with one channel column is arranged on a surface of the wiring substrate 300 between the channels 102 and 102 adjacent to each other in at least the other channel column, when the aggregated portion A of the conductive particles is formed around each dummy channel 102 by thrusting the adhesive 400 from the dummy channel 102, a possibility of a short circuit is disadvantageously high between each drive electrode 103 exposed to an opening portion of each dummy channel 102 and each wiring electrode 302.

[0019] Additionally, when the plurality of wiring electrodes are highly densely arranged between the channels due to an increase in the number of the channel columns, a short circuit between the wiring electrodes is further apt to occur due to the aggregation of the conductive particles.

[0020] Therefore, it is an object of the present invention to provide an inkjet head that can suppress aggregation of conductive particles in an adhesive around a channel between a head chip and a wiring substrate and can prevent a short circuit from occurring due to the aggregation of the conductive particles and also provide a method for manufacturing an inkjet head.

[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 containing conductive particles, thereby closing an opening portion of each dummy channel,
wherein the connection electrode of each dummy channel is formed so as to surround the opening portion of the dummy channel, and
a particle diameter of the conductive particles is equal to or less than a gap between a rear surface of the head chip and a front surface of the wiring substrate and larger than a gap between the connection electrodes on the rear surface of the head chip and the front surface of the wiring substrate.

2. 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 containing conductive particles, thereby closing an opening portion of each dummy channel,
wherein one end of each wiring electrode that achieves electrical conduction with the connection electrode of each dummy channel is formed with a portion that surrounds a region associated with the opening portion of the dummy channel, and
a particle diameter of the conductive particles is equal to or less than a gap between a rear surface of the head chip and a front surface of the wiring substrate and larger than a gap between the rear surface of the head chip and the front surfaces of the wiring electrodes of the wiring substrate.

3. The inkjet head according to 1 or 2,
wherein the opening portion of each dummy channel has a square shape, and adhesive fillets made of the adhesive are independently present at four corners of the opening portion of the dummy channel in the opening portion of the dummy channel.

4. The inkjet head according to 1, 2, or 3,
wherein the head chip has the two or more channel columns, and
on a surface of the wiring substrate associated with a space between channels adjacent to each other in at least one channel column, the wiring electrodes electrically connected with the connection electrodes in another channel columns are arranged.

5. 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 containing conductive

particles, thereby closing an opening portion of each dummy channel,
wherein the connection electrode of each dummy channel is formed so as to surround the opening portion of the dummy channel,
a particle diameter of the conductive particles is equal to or less than a gap between a rear surface of the head chip and a front surface of the wiring substrate and larger than a gap between the connection electrodes on the rear surface of the head chip and the front surface of the wiring substrate, and
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 joined surface of the wiring substrate are hermetically closed; expanding a gas hermetically 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.

6. 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 containing conductive particles, thereby closing an opening portion of each dummy channel,
wherein one end of each wiring electrode that achieve electrical conduction with the connection electrode of each dummy channel is formed with a portion that surrounds a region associated with the opening portion of the dummy channel,
a particle diameter of the conductive particles is equal to or less than a gap between a rear surface of the head chip and a front surface of the wiring substrate and larger than a gap between the rear surface of the head chip and the front surfaces of the wiring electrodes of the wiring substrate, and
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 joined surface of the wiring substrate are hermetically closed; expanding a gas hermetically 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.

7. The method for manufacturing an inkjet head according to 5 or 6,
wherein the opening portion of each dummy channel has a square shape, and adhesive fillets made of the adhesive in the opening portion of the dummy channel are independently present at four corners of the opening portion of the dummy channel by thrusting the adhesive that has entered the dummy channel by the expansion of the gas.

8. The method for manufacturing an inkjet head according to 5, 6, or 7,
wherein the heating is carried out in a state that the head chip is sandwiched between a seal material formed of an elastic member and the wiring substrate.

9. The method for manufacturing an inkjet head according to any one of 5 to 6,
wherein the adhesive is a thermosetting resin, and the gas is expanded by using heat at the time of heating and curing the adhesive.

[0023] According the present invention, it is possible to provide the an inkjet head that can suppress aggregation of conductive particles in an adhesive around a channel between a head chip and a wiring substrate and can prevent a short circuit from occurring due to the aggregation of the conductive particles and also provide the method for manufacturing an inkjet head.

BRIEF DESCRIPTION OF DRAWING

[0024]

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 an enlarged cross-sectional view showing a region surrounded by a broken line in FIG. 3;
FIG. 5 is a cross-sectional view taken along a line (v)-(v) in FIG. 3;
FIG. 6 is an enlarged view of a joined portion of the head chip and the wiring substrate;
FIG. 7 is a view for explaining another conformation of connection electrodes of the head chip;
FIG. 8 is a view for explaining another conformation of wiring electrodes of the wiring substrate;
FIG. 9 is an enlarged cross-sectional view of a region of one dummy channel in a joined region of the head chip and the wiring substrate having the wiring electrodes shown in FIG. 8;
FIG. 10 is a view for explaining still another conformation of a wiring electrode of the wiring substrate;
FIG. 11 is a view showing a joined surface of the wiring substrate relative to the head chip;
FIG. 12 is a view for explaining a state that the head chip and the wiring substrate are held by pressure plates;
FIG. 13 is a view for explaining a state of an adhesive at the time of heating in a held state using the pressure plates;
FIG. 14 is an exploded perspective view of an inkjet head having two channel columns for explaining conventional technology; and
FIG. 15 is a cross-sectional view showing aligned three channels in FIG. 14.

DESCRIPTION OF EMBODIMENTS

[0025] An embodiment according to the present invention will now be described hereinafter with reference to the drawings.

[0026] FIG. 1 is an exploded perspective view showing an example of an inkjet head according to the present invention, and FIG. 2 is a rear view of a head chip of the inkjet head shown in FIG. 1.

[0027] In the drawing, H denotes an inkjet head; 1, a head chip; 2, nozzle plate; 3, a wiring substrate; and 4, a manifold.

[0028] The head chip 1 is formed of a hexahedron having a front surface 1a, a rear surface 1b, and four upper, lower, left, and right side surfaces sandwiched between the front surface I a 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 I and drive walls 12. Here, four channel columns 10A to 10D are provided, and they are aligned in a vertical direction in FIG. 1.

[0029] 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.

[0030] This inkjet head H is an independent drive type inkjet head in which the channels 11 in each of the channel columns 10A to 10D are formed of drive channels 11a 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. The drive channels 11a and the dummy channels 11b are alternately arranged in each of the channel columns 10A to 10D.

[0031] This head chip 1 is a shearing mode type head chip, an opening portion of each drive channel 11a 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. Although the same opening portion has the dummy channel 11b, the opening portion of the dummy channel 11b is closed by a later-described nozzle plate 2 and a wiring substrate 3, and an ink does not enter or exit from this opening portion.

[0032] It is to be noted that, when each of these opening portions is simply referred to as an opening portion of the channel, it means the opening portion 110 that t is opened on the rear surface 1b side.

[0033] 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.

[0034] 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 1b of the head chip 1 by sputtering, vapor deposition, or electroless plating in accordance with each channel 11a or 11b.

[0035] A pattern of the connection electrodes 14 differs depending on the drive channels 11a and the dummy channels 11b. In this embodiment, a connection electrode 14a of a drive channel 11a is formed to be drawn out from one side of the opening portion 110 of the drive channel 11a, whereas a connection electrode 14b of a dummy channel 11b is formed to surround the periphery of the opening portion 110 of the dummy channel 11b.

[0036] Further, the connection electrodes 14a and 14b of the respective channels 11a and 11b in two channel columns 10A and 10B of the respective channel columns 10A to 10D are formed to extend toward a side edge e1 close to the channel column 10A from the opening portions 110 of the respective channels 11a and 11b, and the connection electrodes 14a and 14b of the respective channels 11a and 11b in the other two channel columns 10C and 10D are formed to extend toward a side edge e2 close to the channel column 10D from the opening portions 110 of the respective channels 11a and 11b. Each connection electrode 14a or 14b of each of the channel columns 10B and 10C ends before reaching each adjacent channel column 10A or 10D.

[0037] Here, the respective connection electrodes 14a and 14b are simultaneously formed with respect to the rear surface 1b of the head chip 1, and they have the same thickness.

[0038] 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. Therefore, the opening portion of each dummy channel 11b on the front surface 1a side is closed by the nozzle plate 2.

[0039] 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 1b of the head chip 1.

[0040] 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 101 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 on the rear surface 1b side is closed by the wiring substrate 3.

[0041] 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, by sputtering, vapor deposition, electroless plating, or the like in a one-on-one relationship with each of the connection electrodes 14a and 14b 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.

[0042] 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.

[0043] 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.

[0044] 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.

[0045] As a material of the wiring substrate 3, it is possible to adopt an appropriate such as glass, ceramics, silicon, plastic, and others. Among others, it is preferable to use the glass since it is appropriately 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 14a and 14b of the head chip 1 can be seen through from the back side of the wiring substrate 3, and the wiring electrodes 32 and the connection electrodes 14a and 14b can be easily positioned.

[0046] The head chip 1 and the wiring substrate 3 are joined through an adhesive. When the head chip 1 and the wiring substrate 3 are positioned and bonded to each other after application of the adhesive, the respective connection electrodes 14 of the head chip 1 are electrically connected to the respective wiring electrodes 32 of the wiring substrate 3 in a one-on-one relationship. The adhesive used here is a conductive adhesive, and conductive particles are dispersed in the adhesive.

[0047] At this time, the connection electrode 14b of each dummy channel 11b is formed to surround the opening portion 110, whereas the wiring electrode 32 just overlaps part of this connection electrode 14b, and hence a large part of the periphery of the connection electrode 14b does not overlap the wiring electrode 32 and faces the surface of the wiring substrate 3.

[0048] FIG. 3 is a partial cross-sectional view of a joined region of the head chip 1 and the wiring substrate 3 after the adhesive is cured, FIG. 4 is an enlarged view of a part surrounded by a broken line in FIG. 3, and FIG. 5 is a cross-sectional view taken along a line (v)-(v) in FIG. 3. An upper direction in each of FIG. 3 and FIG. 4 is an ink discharge direction.

[0049] As shown in FIG. 3 and FIG. 4, in a state that the head chip 1 is joined to the wiring substrate 3, a gap G is slightly formed between both the members. This gap G is formed between the rear surface 1b of the head chip 1 and the front surface of the wiring substrate 3 when each connection electrode 14a or 14b formed on the rear surface 1b of the head chip 1 overlaps one end of each wiring electrode 32 (which is not shown in FIG. 3 and FIG. 4) formed on the wiring substrate 3. Therefore, a dimension a of the gap G corresponds to a dimension obtained by adding a thickness of each connection electrode 14a or 14b to a thickness of each wiring electrode 32.

[0050] A sufficient amount of the adhesive 6 is present in this gap G. After the head chip 1 is bonded to the wiring substrate 3 and before pressurization is effected, the adhesive 6 flows in this gap G by capillarity, partially reaches the opening portion 10 of each dummy channel 11b along the surface of the wiring substrate 3, and also flows into the dummy channel 11b. As a result, adhesive fillets 6a made of the adhesive 6 are formed in the opening portion 110 of each dummy channel 11b. The adhesive fillets 6a formed at a peripheral edge of the opening portion 110 of this dummy channel 11b are independently present at four corners of this opening portion 110 without closing the opening portion 110 of the dummy channel 11b.

[0051] Here, the independent presence of each adhesive fillet 6a means that, when the opening portion 110 of the dummy channel 11b is observed from the rear surface 1b of the head chip 1 as shown in FIG. 5, the adhesive fillets 6a are present at the four corners of the square opening portion 110, respectively, but the adhesive fillets 6a at the four corners are not connected to each other on the peripheral edge of the opening portion 110. Therefore, at the peripheral edge of this opening portion 110, a region S where the adhesive fillet is not formed is present between the adhesive fillets 6a adjacent to each other.

[0052] If the adhesive fillets 6a are independently present at the four corners of the opening portion 110 in this manner, although each adhesive fillet 6a partially enters each dummy channel 11b, an amount of this adhesive fillet is small, hence the adhesive fillet 6a only slightly enters from the opening portion 110 of each dummy channel 11b as shown in FIG. 4, and it does not deeply enter. Therefore, each cured adhesive fillet 6a does not greatly affect an operation of each drive wall 12, and stable discharge is not obstructed. Additionally, since the adhesive fillets 6a are just independently present at the four corners, the adhesive fillets 6a expanded at the time of curing does not thrust out the drive walls 12, and the drive walls 12 are not damaged.

[0053] Further, in a state where the adhesive fillets 6a are formed at the four corners of the opening portion 110 of each dummy channel 11b 1 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. 5, the periphery of the opening portion 110 of each dummy channel 11b is surrounded and completely sealed by using the sufficient amount of adhesive 6. Therefore, the ink supplied to each adjacent drive channel 11a does not flow into the dummy channel 11b 1 to obstruct an operation of each drive wall 12.

[0054] Such adhesive fillets 6a 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 and the adhesive 6 does not flow to the opening portions 110 of the drive channels 11a along the surface of the wiring substrate 3, the adhesive 6 does not flow to the inner side of each through hole 31, and the adhesive fillets 6a are not formed.

[0055] The adhesive 6 contains conductive particles 61. As the conductive particles 61, besides metal particles af Au or Ni, there are conductive particles obtained by plating surfaces of synthetic resin particles with a metal film of Au or Ni, and either type can be used in the present invention.

[0056] In this embodiment, a particle diameter b of the conductive particle 61 is equal to or less than the gap between the rear surface 1b of the head chip 1 and the front surface of the wiring substrate 3, i.e., equal to or less than a dimension a of the gap G and larger than a gap between each connection electrode 14a or 14b on the rear surface 1b of the head chip 1 and the front surface of the wiring substrate 3, i.e., a dimension c in FIG. 4 ($a \geq b > c$). This dimension c corresponds to a thickness of each wiring electrode 32.

[0057] It is to be noted that the particle diameter is an average particle diameter, and it is defined by an equivalent diameter of equal volume sphere.

[0058] Since the connection electrode 14b of each dummy channel 11b is formed so as to surround the opening portion 110, the adhesive 6 may flow between a region of each connection electrode 14b, which does not overlap the wiring electrode 32, and the front surface of the wiring substrate 3 (a portion of the dimension c), but the conductive particles

61 cannot pass through this portion of the dimension c. Therefore, the conducive particles 61 in the adhesive 6 present in the gap G after bonding the head chip 1 to the wiring substrate 3 are divided into the conductive particles present on the inner side (in the opening portion 110) and the conductive particles present on the outer side (between the rear surface 1b of the head chip 1 and the front surface of the wiring substrate 3) in the region of the connection electrode 14b of this dummy channel 11b with the connection electrode 14b at the boundary, and these conductive particles cannot be moved in and out between these sides.

[0059] On a stage after the head chip 1 is bonded to the wiring substrate 3 and before pressurization is carried out, the dimension c is larger than the particle diameter b of the conductive particles 61, and the adhesive 6 in the gap G flows into each dummy channel 11b together with the conductive particles 61 by the capillarity when the adhesive 6 is in a low-viscosity state before pressurization and curing. However, thereafter, when the head chip 1 is bonded to the wiring substrate 3, the dimension c becomes smaller than the particle diameter b of the conductive particles 61, and the adhesive 6 that has flowed into the dummy channel may flow around the opening portion 110 of the dummy channel 1b beyond the connection electrode 14b, but the conductive particles 61 contained in the adhesive 6 do not flow toward the periphery of the opening portion 110 of the dummy channel 11b beyond the connection electrode 14b. Therefore, the conductive particles 61 on the inner side of each connection electrode 14b are not mixed with the conductive particles 61 on the outer side of the same, and aggregation of the conductive particles 61 caused due to mixing of these particles can be avoided.

[0060] In case of the head chip 1 having two or more channel columns, since the wiring electrodes 32 electrically connected with the connection electrodes in one channel column B are arranged on the surface of the wiring substrate 3 in accordance with spaces between adjacent channels 11 in the other adjacent channel column 10A, when the conductive particles 61 are aggregated around the opening portion 110 of each dummy channel 11b, a short circuit is apt to occur between the electrodes. However, since the aggregation of the conductive particles 61 can be avoided, the highly reliable inkjet head that prevents a short circuit from occurring can be provided as a multi-column inkjet head.

[0061] To enable the dimension a of the gap G, the particle diameter b of the conductive particles 61, and the dimension c of the gap between the connection electrodes 14a and 14b and the wiring substrate 3 to meet the above relationship, appropriately selecting or adjusting at least one of the particle diameter c of the conductive particles 61 and the thickness of each wiring electrode 32 can suffice.

[0062] In addition, as to the inkjet head H, as shown in FIG. 6, it is preferable to form adhesive fillets 6b in a region extending to both a peripheral edge 1c on the rear surface 1b side of the head chip 1 and the wiring substrate 3 with use of the adhesive 6 applied between head chip 1 and the wiring substrate 3. The presence of the adhesive fillets 6b enables improving bonding strength of the head chip 1 and the wiring substrate 3.

[0063] Although the connection electrode 14b of each dummy channel 11b alone is formed to surround the opening portion 110 of the dummy channel 11b in the above conformation, there is no limitation in forming each connection electrode 14a of the drive channel 11a to surround the opening portion 110 of the drive channel 11a.

[0064] FIG. 7 shows another conformation of a pattern of the connection electrodes formed on the rear surface 1b of the head chip 1.

[0065] In this conformation, all the connection electrodes 14 have the same pattern with respect to both the drive channels 11a and the dummy channels 11b. That is, all the connection electrodes 14 have the same pattern, and they are formed to be drawn out from one side of each opening portion 110 the respective channels 11a and 1b.

[0066] On the other hand, FIG. 8 shows another conformation of the pattern of the wiring electrodes 32 of the wiring substrate 3 joined to the head chip I shown in FIG. 7. Here, only a part corresponding to the two channel columns on one end portion 3b side of the wiring substrate 3 is shown, but the two channel columns on the other end portion 3a side are likewise formed.

[0067] In this conformation, a covering portion 32a formed of a metal film having an area slightly larger than an opening area of the opening portion 110 is integrally formed at one end of each wiring electrode 32 electrically connected to the connection electrode 14 of each dummy channel 11b in the wiring electrodes 32 formed on the wiring substrate 3 so that the opening portion 110 of each dummy channel 11b can be covered. Therefore, the region of each covering portion 32a is arranged to cover the opening portion 110 of the corresponding dummy channel 11b and overlap each connection electrode 14 when this wiring substrate 3 is joined to the head chip 1.

[0068] Since this covering portion 32a has an area larger than the opening area of the opening portion 110 of each dummy channel 11b, an outer peripheral portion of the covering portion 32a is arranged to surround a region on the surface of the wiring substrate 3 associated with the opening portion 110 of each dummy channel 11b.

[0069] FIG. 9 is an enlarged cross-sectional view of a region of one dummy channel 11b in the joined region of this head chip 1 and the wiring substrate 3. The upper direction in the drawing is an ink discharge direction.

[0070] In this case, likewise, when the head chip 1 is bonded to the wiring substrate 3, part of the adhesive 6 flows into each dummy channel 11b along the wiring substrate 3, thereby forming the adhesive fillets 6a. The adhesive fillets 6a are independently formed at four corners of the opening portion 110 like FIG. 5.

[0071] The gap G formed between the head chip 1 and the wiring substrate 3 is formed between the back surface 1b of the head chip 1 and the front surface of the wiring substrate 3 when each connection electrode 14 formed on the rear surface 1b of the head chip 1 overlaps the covering portion 32a of each wiring electrode 32 formed on the wiring substrate 3. A dimension a of this gap G corresponds to a dimension obtained by adding the thickness of each connection electrode 14 to a thickness of the covering portion 32a of each wiring electrode 32.

[0072] Furthermore, in this case, the particle diameter b of the conductive particles 61 is equal to or less than the gap between the rear surface 1b of the head chip 1 and the front surface of the wiring substrate 3, i.e., equal to or less than the dimension a of the gap G and larger than the gap between the rear surface 1b of the head chip 1 and the front surface of each wiring electrode 32 (the covering portion 32a) of the wiring substrate 3, i.e., a dimension d in FIG. 9 ($a \geq b > c$). This dimension d corresponds to the thickness of each connection electrode 14.

[0073] Since the covering portion 32a of each wiring electrode 32 is formed so as to surround the region on the front surface of the wiring substrate 3 associated with the opening portion 110 of each dummy channel 11b, the adhesive 6 may flow between a region of each covering portion 32, which does not overlap the connection electrode 14, and the rear surface 1b of the head chip 1 (a portion of the dimension d), but the conductive particles 61 cannot pass through this portion of the dimension d. Therefore, in the opening portion 110 of this dummy channel 11b, the conducive particles 61 in the adhesive 6 present in the gap G after bonding the head chip 1 to the wiring substrate 3 are divided into the conductive particles present on the inner side (in the opening portion 110) and the conductive particles present on the outer side (between the rear surface 1b of the head chip 1 and the front surface of the wiring substrate 3) of each covering portion 32a arranged to surround the opening portion 110 with the outer peripheral portion of the covering portion 32a at the boundary, and these conductive particles cannot be moved in and out between these sides.

[0074] On a stage after the head chip 1 is bonded to the wiring substrate 3 and before pressurization is carried out, the dimension d is larger than the particle diameter b of the conductive particles 61, and the adhesive 6 in the gap G flows into each dummy channel 11b together with the conductive particles 61 by the capillarity when the adhesive 6 is in a low-viscosity state before pressurization and curing. However, thereafter, when the head chip 1 and the wiring substrate 3 are pressured and bonded, the dimension d becomes smaller than the particle diameter b of the conductive particles 61, and the adhesive 6 that has flowed into the dummy channel 11 may flow around the opening portion 110 of the dummy channel 11b beyond the outer periphery of the covering portion 32a, but the conductive particles 61 contained in the adhesive 6 do not flow toward the periphery of the opening portion 110 of the dummy channel 11b beyond the outer periphery of the covering portion 32a. Therefore, the conductive particles 61 on the inner side of each covering portion 32a are not mixed with the conductive particles 61 on the outer side of the same, and aggregation of the conductive particles 61 caused due to mixing of these particles can be avoided.

[0075] To enable the dimension a of the gap G, the particle diameter b of the conductive particles 61, and the dimension d of the gap between the rear surface 1b of the head chip 1 and the surface of the covering portion 32a of the wiring substrate 3 to meet the above relationship, appropriately selecting or adjusting at least one of the particle diameter b of the conductive particles 61 and the thickness of each connection electrode 14 can suffice.

[0076] As the wiring electrode 32 having the portion surrounding the region associated with the opening portion 110 of each dummy channel 11b on the wiring substrate 3 as described above, besides the conformation shown in FIG. 8, a square frame-like surrounding portion 32b may be formed at one end of the wiring electrode 32 as shown in FIG. 10.

[0077] In this surrounding portion 32b, a region x which has substantially the same size as the opening area of the opening portion 110 and has no metal film formed therein is formed in a region associated with the opening portion 110 of the dummy channel 11b. Therefore, the surrounding portion 32b is formed into a square shape so that the periphery of the opening portion 110 can be surrounded on the surface of the wiring substrate 3. Such a wiring electrode 32 can obtain the same effect as that described above.

[0078] The respective configurations of the connection electrode 14b, the covering portion 31a and the surrounding portion 32b of the wiring electrode 32 that surround the opening portion 110 of the dummy channel 11b described above may be appropriately combined. That is, although not shown, for example, the connection electrode 14b of each dummy channel 11b in any one of a plurality of channel columns may be formed to surround the opening portion 110 as shown in FIG. 2, the connection electrode 14b in another channel column may be formed to be drawn from one side of the opening portion 110 as shown in FIG. 7, and the covering portion 31a shown in FIG. 8 or the surrounding portion 32b shown in FIG. 10 may be formed at one end of the wiring electrode 32 associated with this connection electrode 14b.

[0079] An example of a method for manufacturing the inkjet head H will now be described with reference to FIG. 11 to FIG. 13. It is to be noted that the description will be given as to the conformation where the connection electrode 14b of each dummy channel 11b is formed so as to surround the opening portion 110 of the dummy channel 11b, but manufacture can be carried out in completely the same manner even in the conformation shown in FIG. 7 to FIG. 10.

[0080] FIG. 11 shows the front surface of the wiring substrate 3 (the joining surface relative to the head chip 1). First, as shown in the drawing, the adhesive 6 containing the conducive particles 61 is applied to the wiring substrate 3 having the through holes 31 and the respective wiring electrodes 32 formed thereon so as to form strip-like shapes on portions where the respective connection electrodes 14a and 14b of the head chip I overlap the wiring electrodes 32 and then the head chip 1 is positioned and bonded. As a result, the adhesive 6 applied in the strip-like shapes flows between the head chip I and the wiring substrate 3 by the capillarity. In this process, part of the adhesive 6 also flows into each dummy channel 11b together with the conductive particles 61 as indicated by each broken line in FIG. 13.

[0081] 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.

[0082] FIG. 12 is a cross-sectional view showing a method that is preferred at the time of forming this sealed state. Reference signs 7a and 7b denote a pair of upper and lower pressure plates, and the head chip I and the wiring substrate 3 bonded to each other are disposed between the pressure plates 7a and 7b. Then, the head chip I and the wiring substrate 3 are sandwiched between both the pressure plates 7a and 7b, whereby a predetermined pressure is applied.

[0083] Of both the pressure plates 7a and 7b, the pressure plate 7a arranged on the front surface 1a side of the head chip I 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 I a of the head chip 1. As the elastic material, rubber can be generally used, and silicon rubber is preferable in particular.

[0084] The reason why this seal material is provided is as follows. In general, since the head chip 1 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.

[0085] 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 I 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.

[0086] 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.

[0087] 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.

[0088] When the gas in each dummy channel 11b is expanded by heating the head chip 1, the adhesive 6 containing the conductive particles 61 that has entered the dummy channel 11b is thrusted by the expansion of the gas to the periphery of the opening portion 110 from the opening portion 110 of each dummy channel 11b through the gap between each connection electrode 14b formed on the rear surface 1b of the head chip 1 and the front surface of the wiring substrate 3 (the portion of the dimension b in FIG. 4). At this time, since the conductive particles 61 in the adhesive 6 in the dummy channel 11b stay in the opening portion 110 of the dummy channel 11b since they cannot pass through this gap.

[0089] Furthermore, when the adhesive 6 is cured in this state, the adhesive fillets 6a made of the adhesive 6 remaining in the opening portion 110 of each dummy channel 11b are allowed to be independently present at the four corners of the opening portion 110 as shown in FIG. 4 and FIG. 5.

[0090] As a result, partial aggregation of the conductive particles 61 in the adhesive 6 around the opening portion 110 of each dummy channel 11b can be suppressed, the conductive particles 61 in the adhesive 6 that have flowed into the opening portion 110 remain in the opening portion 110, and hence reliability of electrical connection between each connection electrode 14b and the wiring electrode 32 can be also improved. Moreover, the state shown in FIG. 5 that the periphery of the opening portion 110 of each dummy channel 11b is surrounded and sealed with the adhesive 6 can be easily created.

[0091] Additionally, according to this method, 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 simultaneously formed to get across both the peripheral edge I c on the rear surface 1b side of the head chip 1 and the wiring substrate 3 as shown in FIG. 6. As a result, the inkjet head H in which a joined state of the head chip 1 and the wiring substrate 3 is firmly maintained can be easily obtained.

[0092] 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. 4 and FIG. 5, a degree of expansion of the gas hermetically put in each dummy channel 11b is important. If the expansion of the gas is insufficient, it is difficult to independently provide the adhesive fillets 6a 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 6a 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.

[0093] The heating temperature at the time of expanding the gas must be a temperature that does not increase viscosity of the adhesive 6 too much and enables maintaining a flowing state. The specific temperature 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.

[0094] 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, a manifold 4 is joined to the rear surface side of the wiring substrate 3, and 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.

[0095] 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.

[0096] 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.

[0097] Moreover, after the nozzle plate 2 is joined to the head chip 1, the wiring substrate 3 may be joined. In this case, the seal material 8 may not be used. However, in case of joining the wiring substrate 3 and then forming an insulating top coat on an electrode surface, to enable performing an operation for forming the insulating top coat before joining the nozzle plate 2, it is preferable to avoid joining the nozzle plate 2 to the head chip 1 at the stage of joining the head chip 1 to the wiring substrate 3.

EXAMPLE

[0098] An effect of the present invention will now be illustrated based on an example.

(Examples 1 to 3)

[0099] 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.

[0100] 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

[0101] As to the connection electrodes of the head chip, like FIG. 2, the connection electrode of each dummy channel alone was formed to surround the opening portion of the dummy channel.

[0102] All the connection electrodes were configured to have a thickness of 2.5 μm.

[0103] 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.

[0104] The wiring electrodes were all configured to have a thickness of 1.5 μm (the dimension c in FIG. 4).

[0105] This head chip and the wiring substrate were bonded through a thermosetting adhesive containing conductive particles (353ND manufactured by EPOTEK, a final curing temperature: 100°C). The adhesive was applied to the wiring substrate side in stripe shapes like FIG. 11.

[0106] In each example, a particle diameter b of the conductive particles contained in this adhesive was configured to differ as shown in Table 1. It is to be noted that the particle diameter is an average particle diameter, and a particle size distribution was $\pm$0.05 μm.

[0107] The head chip and the wiring substrate were sandwiched together with a seal material between a pair of pressure plates made of metal plates (SUS), subjected to predetermined pressurization, heated, and cured as shown in FIG. 12. Part of the adhesive that has flowed into each dummy channel by heating was thrusted out from the dummy channel, and an inkjet head having independent adhesive fillets present at four corners of an opening portion of each dummy channel was completed. A length between a rear surface of the head chip and a front surface of the wiring substrate (the dimension a in FIG. 4) was 4 μm.

[0108] Likewise, 20 inkjet heads were created per example, and the average number of positions where short circuits occurred due to aggregation of the conductive particles per head chip was confirmed by confirming presence/absence of a short circuit in an electrical manner and then further confirming each position where the short circuit occurred with use of a microscope. Since the wiring substrate is a transparent glass substrate, observing from the wiring substrate side enables confirming how aggregation occurred. Table I shows this result.

(Comparative Examples 1 to 3)

[0109] 20 inkjet heads were fabricated per comparative example like Examples I to 3 except that patterns of drive channels and connection electrodes of dummy channels are all the same pattern that is drawn from one side of each opening portion like FIG. 7, and the average number of positions where short circuits occurred due to aggregation of the conductive particles per head chip was likewise confirmed with respect 20×2048 channels. Table 1 shows this result.

[Table 1]

	Length between head chip rear surface and wiring substrate front surface (dimension a)	Conductive particle diameter (b)	Thickness of wiring electrode (dimension c)	Average number of positions where short circuit occurred per head chip
Example 1	4μm	3μm	1.5μm	0
Example 2	4μm	2.5μm	1.5μm	0
Example 3	4μm	2μm	1.5μm	0
Comparative Example 1	4μm	3μm	1.5μm	6
Comparative Example 2	4μm	2.5μm	1.5μm	5
Comparative Example 3	4μm	2μm	1.5μm	3

[0110] Since all comparative examples do not have a pattern that each connection electrode surrounds the opening portion of each dummy channel and the dimension c (1.5μm in Comparative Example) between the connection electrode surface and the wiring substrate surface is widened to the dimension a (4pm in Comparative Example) between head chip rear surface and wiring substrate front surface, the periphery of the opening portion has a part where the dimension a is larger than the particle diameter b of the conductive particles. Therefore, it was observed that the adhesive in each dummy channel was thrusted out to the periphery by heating, the conductive particles were also thrusted out at this moment, and a short circuit thereby occurred due to aggregation of the conductive particles in each completed inkjet head.

[0111] On the other hand, all embodiments are constituted of a pattern that each connection electrode surrounds the periphery of the opening portion of each dummy channel, and hence the dimension c between the connection electrode surface and the wiring substrate surface is smaller than the particle diameter d of the conductive particles around the opening portion. Therefore, when the adhesive in each dummy channel was thrusted to the periphery by heating, the conductive particles did not flow to the outer side of each connection electrode, and occurrence of a short circuit due to aggregation of the conductive particles was not observed in each completed inkjet head.

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 containing conductive particles, thereby closing an opening portion of each dummy channel,
wherein the connection electrode of each dummy channel is formed so as to surround the opening portion of the dummy channel, and
a particle diameter of the conductive particles is equal to or less than a gap between a rear surface of the head chip and a front surface of the wiring substrate and larger than a gap between the connection electrodes on the rear surface of the head chip and the front surface of the wiring substrate.

2. 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 containing conductive particles, thereby closing an opening portion of each dummy channel,
wherein one end of each wiring electrode that achieves electrical conduction with the connection electrode of each dummy channel is formed with a portion that surrounds a region associated with the opening portion of the dummy channel, and
a particle diameter of the conductive particles is equal to or less than a gap between a rear surface of the head chip and a front surface of the wiring substrate and larger than a gap between the rear surface of the head chip and the front surfaces of the wiring electrodes of the wiring substrate.

3. The inkjet head according to claim 1 or 2,
wherein the opening portion of each dummy channel has a square shape, and adhesive fillets made of the adhesive are independently present at four corners of the opening portion of the dummy channel in the opening portion of the dummy channel.

4. The inkjet head according to claim 1, 2, or 3,
wherein the head chip has the two or more channel columns, and
on a surface of the wiring substrate associated with a space between channels adjacent to each other in at least one channel column, the wiring electrodes electrically connected with the connection electrodes in another channel columns are arranged.

5. 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 containing conductive particles, thereby closing an opening portion of each dummy channel,

wherein the connection electrode of each dummy channel is formed so as to surround the opening portion of the dummy channel,

a particle diameter of the conductive particles is equal to or less than a gap between a rear surface of the head chip and a front surface of the wiring substrate and larger than a gap between the connection electrodes on the rear surface of the head chip and the front surface of the wiring substrate, and

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 joined surface of the wiring substrate are hermetically closed; expanding a gas hermetically 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.

6. 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 containing conductive particles, thereby closing an opening portion of each dummy channel,

wherein one end of each wiring electrode that achieve electrical conduction with the connection electrode of each dummy channel is formed with a portion that surrounds a region associated with the opening portion of the dummy channel,

a particle diameter of the conductive particles is equal to or less than a gap between a rear surface of the head chip and a front surface of the wiring substrate and larger than a gap between the rear surface of the head chip and the front surfaces of the wiring electrodes of the wiring substrate, and

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 joined surface of the wiring substrate are hermetically closed; expanding a gas hermetically 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.

7. The method for manufacturing an inkjet head according to claim 5 or 6,
wherein the opening portion of each dummy channel has a square shape, and adhesive fillets made of the adhesive in the opening portion of the dummy channel are independently present at four corners of the opening portion of the dummy channel by thrusting the adhesive that has entered the dummy channel by the expansion of the gas.

8. The method for manufacturing an inkjet head according to claim 5, 6, or 7,
wherein the heating is carried out in a state that the head chip is sandwiched between a seal material formed of an elastic member and the wiring substrate.

9. The method for manufacturing an inkjet head according to any one of claims 5 to 8,
wherein the adhesive is a thermosetting resin, and the gas is expanded by using heat at the time of heating and curing the adhesive.

FIG. 1

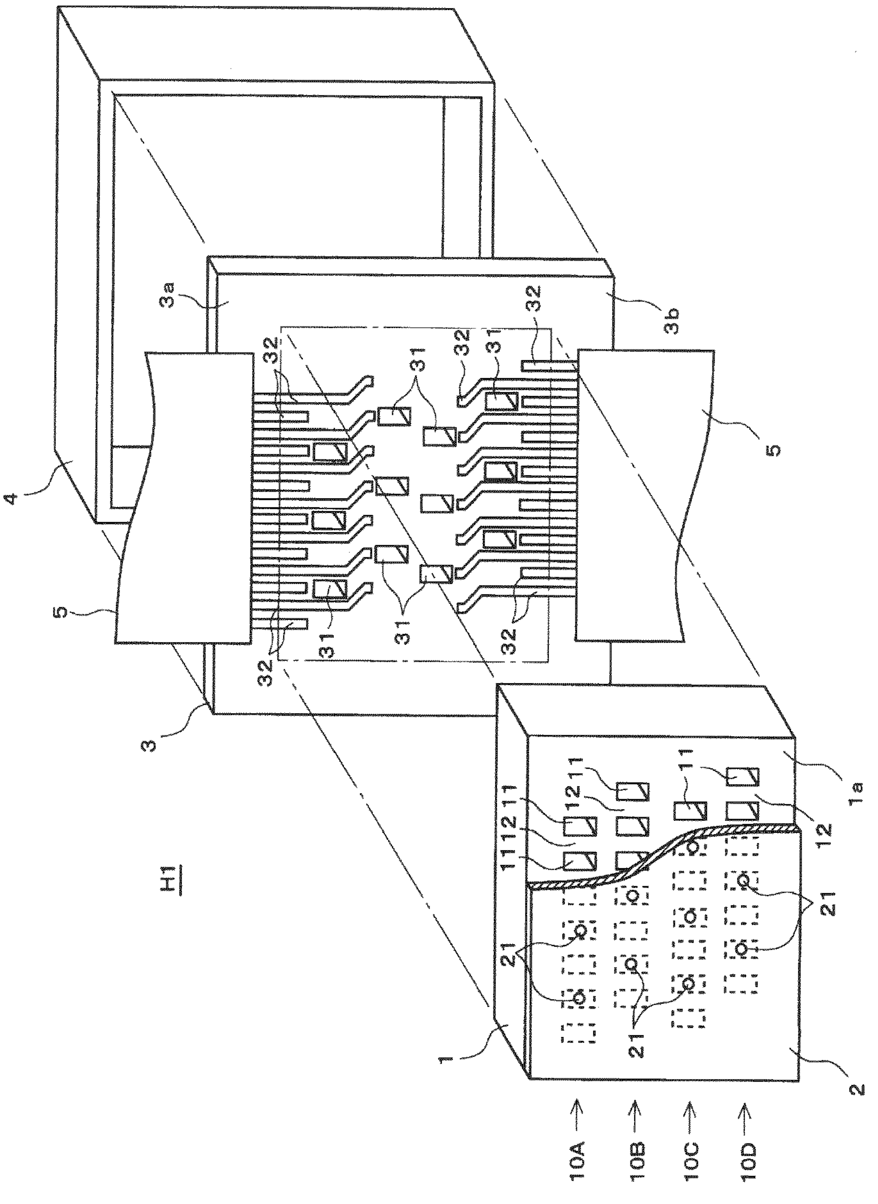
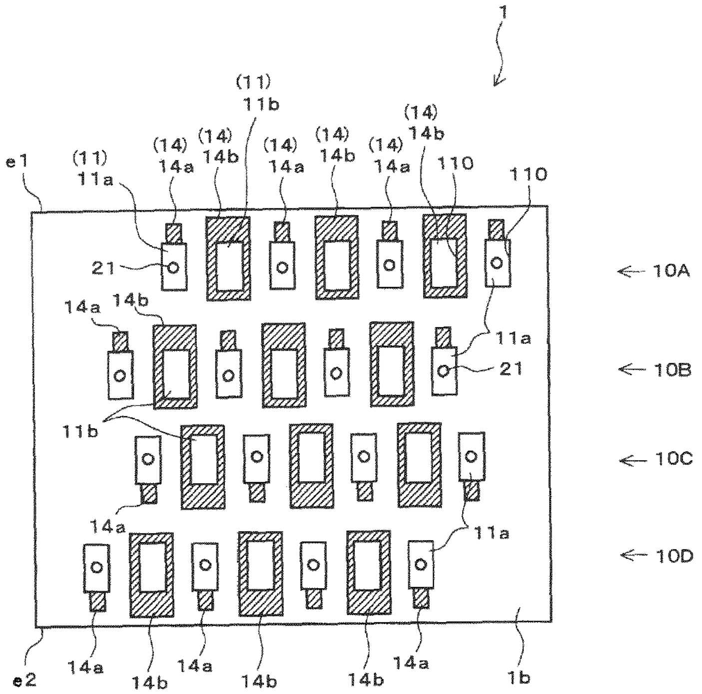


FIG. 2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(14)
14b
(14)
14a
(14)
14b
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14a
(14)
14b
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e1
(11)
11a
110
110
21
10A
14a
14b
11a
21
10B
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11a
10D
e2
14a
14b
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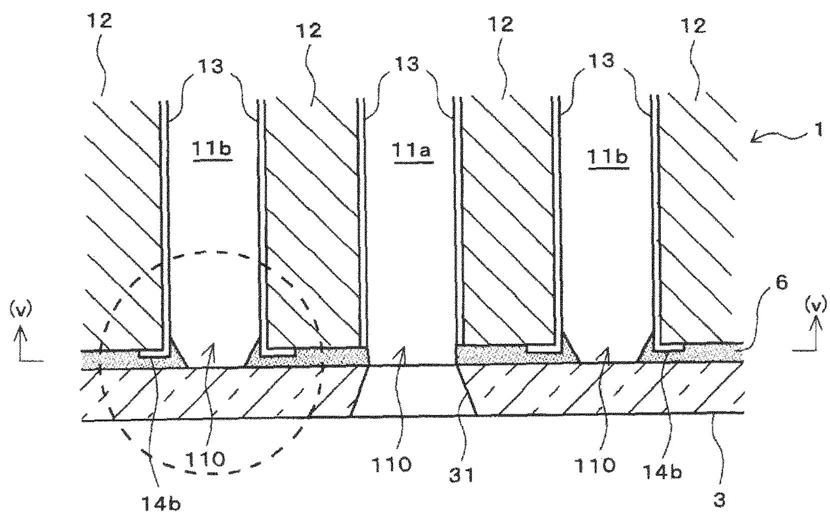
FIG. 3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(v)
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31
110
14b
14b
3

FIG. 4

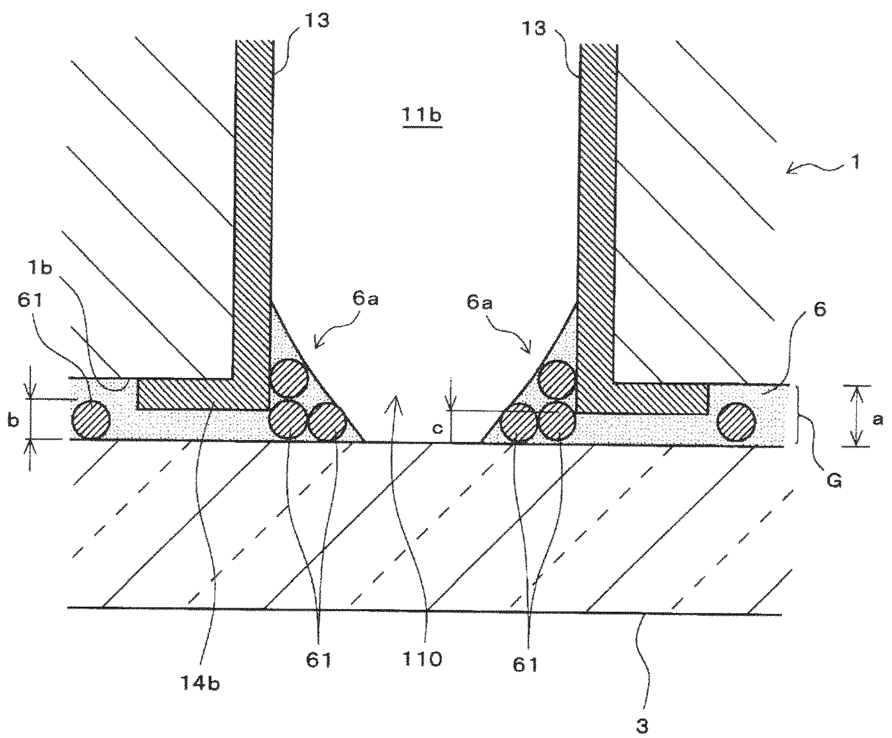
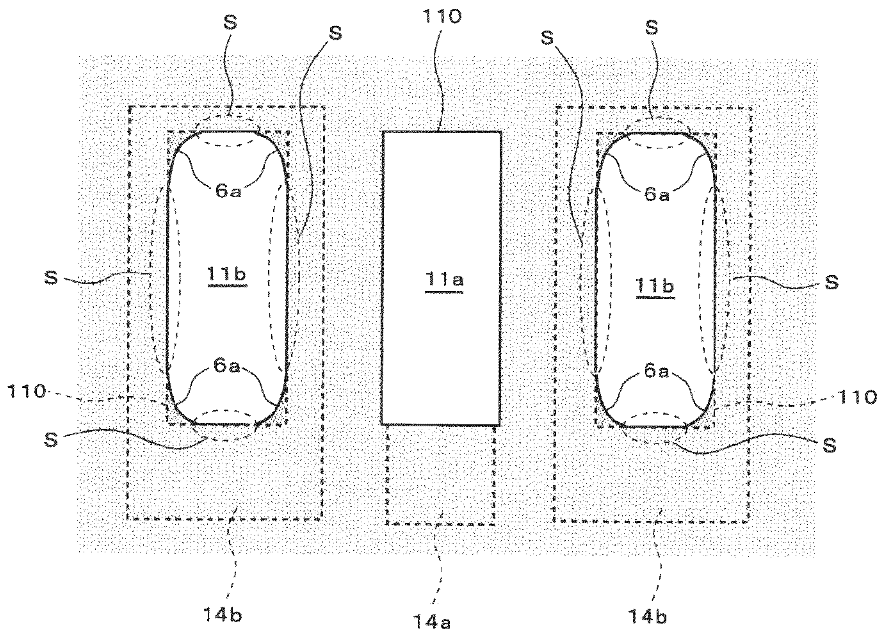


FIG. 5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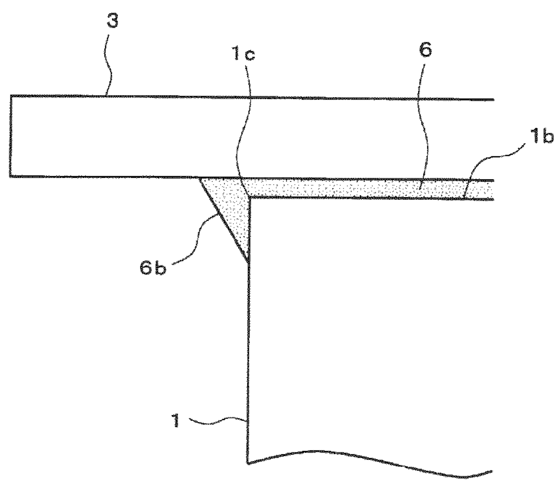
14a
14b

FIG. 6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6
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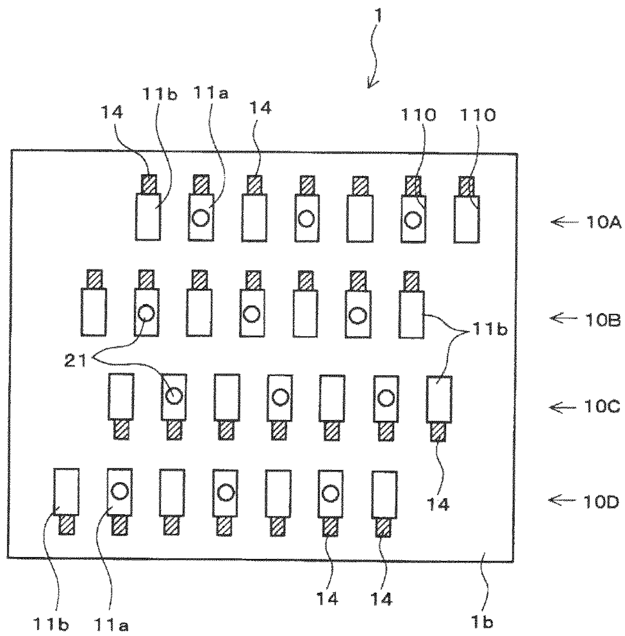
FIG. 7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10D
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14
1b

FIG. 8

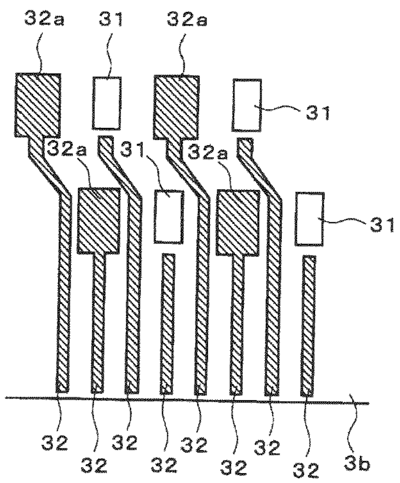
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FIG. 9

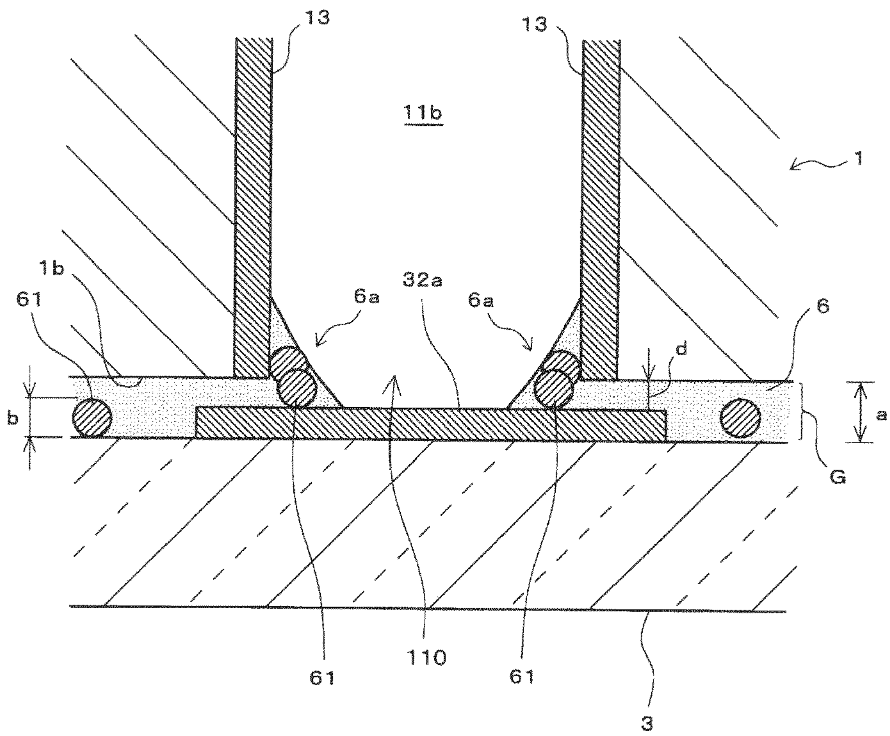


FIG. 10

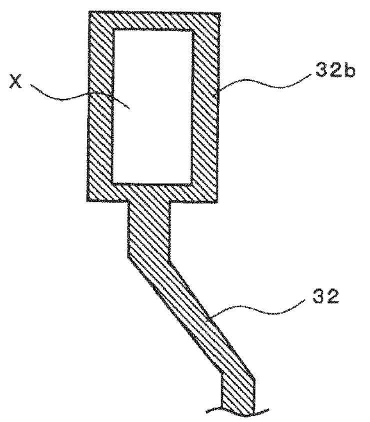
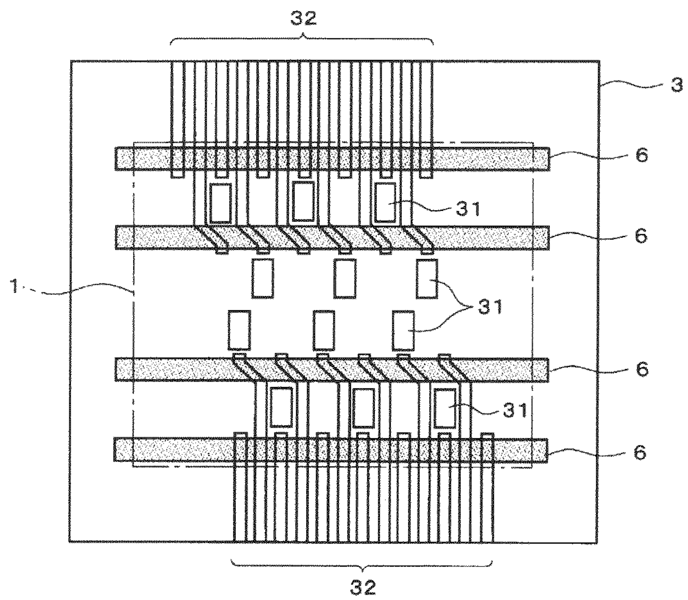


FIG. 11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31
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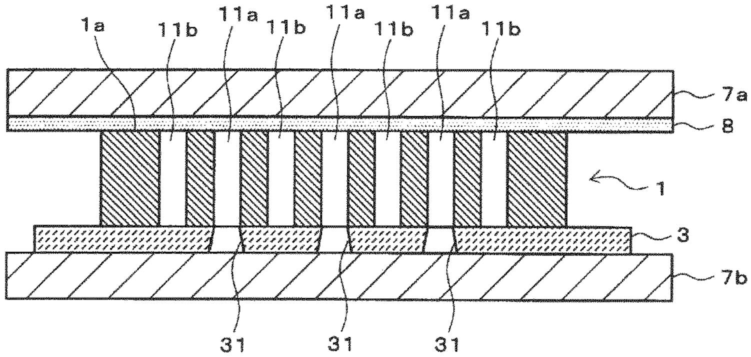
32

FIG. 12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11a
11b
11a
11b
7a
8
1
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7b
31
31
31

FIG. 13

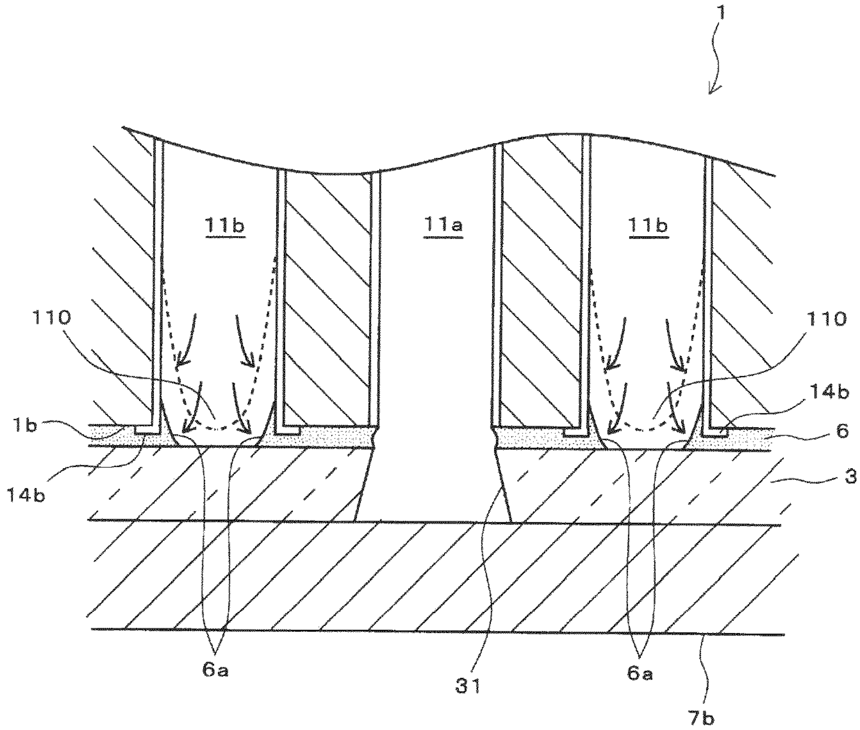
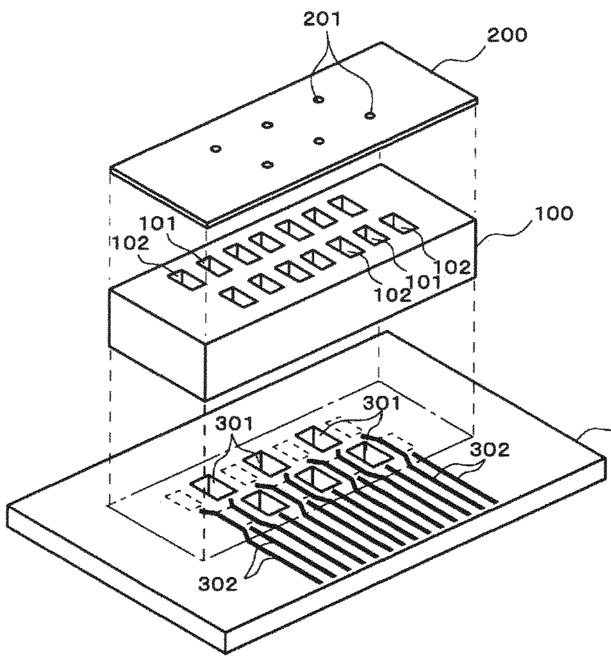


FIG. 14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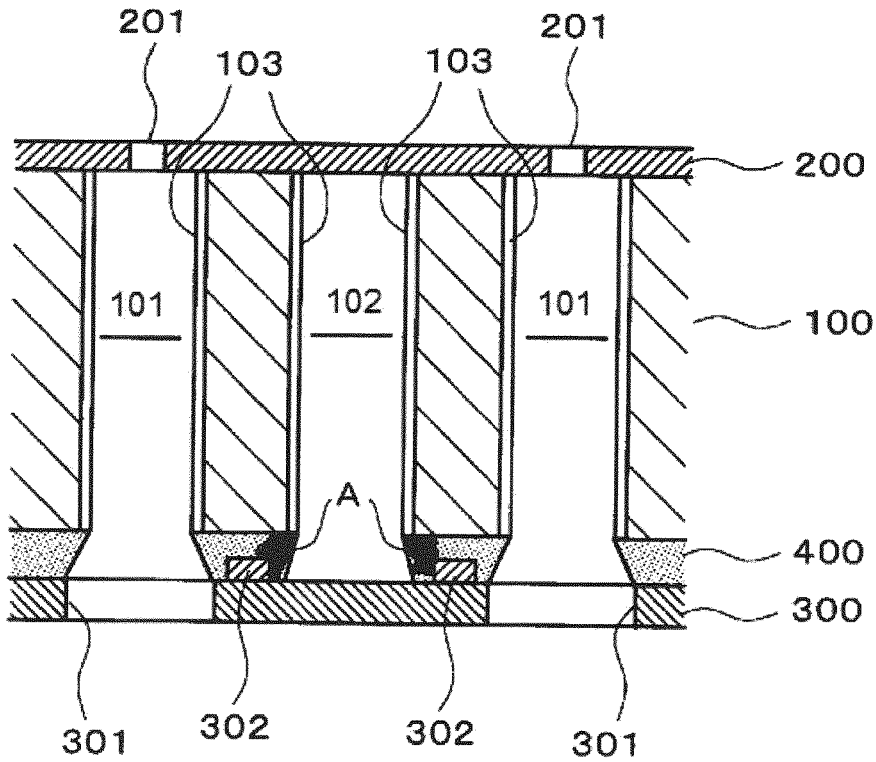
302

FIG. 15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EUROPEAN SEARCH REPORT

Application Number
EP 13 19 7893

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 5 680 163 A (SUGAHARA HIROTO [JP]) 21 October 1997 (1997-10-21) * column 8, line 7 - column 9, line 42 * * figures 9-11 *	1,2,5,6	INV. B41J2/14 B41J2/16
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A	JP 2007 076062 A (KONICA MINOLTA IJ TECHNOLOGIES) 29 March 2007 (2007-03-29) * abstract; figures *	1,2,5,6	
A	US 2006/055742 A1 (YOKOUCHI TSUTOMU [JP]) 16 March 2006 (2006-03-16) * paragraph [0147] - paragraph [0164] * * figure 9 *	1,2,5,6	
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	12 March 2014	Didenot, Benjamin

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