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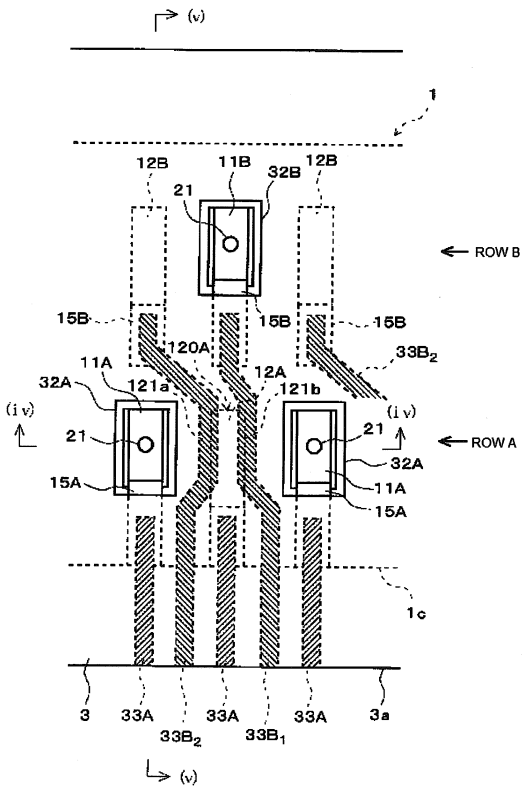
(54) INK-JET HEAD

(57) The purpose of the present invention is to provide an ink-jet head which enables the disposition of wiring electrodes at high density and can easily support an increased density of channels. An ink-jet head comprises a head chip (1) in which drive channels and dummy channels are alternately disposed, and a wiring substrate (3), and is characterized in that in the wiring substrate (3), through-holes for supplying ink are formed only at positions corresponding to openings of the drive channels, at least one wiring electrode passes between adjacent through-holes in at least one row of through-holes among a plurality of rows of through-holes corresponding to channel rows and extends to an end of the wiring substrate projecting sideways from the head chip, and at least one wiring electrode passing between the through-holes is not in contact with an opening of the dummy channel and overlaps with the opening of the dummy channel as seen from an ink discharge direction.

FIG. 3



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Description

TECHNICAL FIELD

[0001] The present invention relates to an ink-jet head, and more particularly to an ink-jet head that has a head chip in which drive channels and dummy channels are alternately arranged and can achieve high density of channels.

BACKGROUND

[0002] As a shear mode type ink-jet head that subjects a drive wall to shearing deformation by applying a drive signal of a predetermined voltage to a drive electrode formed on the drive wall that partitions channels and discharges an ink in each channel from a nozzle by using a pressure produced at this moment, there is known a so-called harmonica-shaped head chip having opening portions of channels arranged in a front face and a rear face, respectively.

[0003] In the harmonica-shaped head chip, since each drive electrode faces the inside of a channel and is not exposed to the outside, how each drive electrode is electrically connected with a drive circuit is a problem. In channel rows aligned in parallel in the head chip, a channel row placed on the outer side can be easily electrically connected with, e.g., an FPC at an end portion of this head chip by forming a connection electrode that is electrically conductive relative to the drive electrode from each channel to the end portion of the head chip with use of a rear face of the head chip. However, in case of applying a drive signal to each drive electrode of a channel row placed on the inner side from the end portion of the head chip, there is a problem that the connection electrode that is conducive with reach drive electrode must be formed to reach the end portion of the head chip across each channel row on the outer side.

[0004] In conventional examples, to solve such a problem, Patent Literature 1 discloses that four channel rows are arranged while shifting a channel pitch in increments of 1/4, drive electrodes in the respective channels are exposed around opening potions on a back side of a head chip to form respective electrical contacts, and a flexible substrate having a wiring electrode formed on one side thereof is attached to the back side of the head chip so as to cover the entire rear face while the wiring electrode forming surface is arranged to face the rear face of the head chip, whereby a drive signal can be applied from one lateral side of the head chip.

[0005] In this flexible substrate, a through-hole is formed at a position corresponding to each channel, and an ink can be supplied to each channel via this through-hole. A wiring electrode electrically connected with an electrical contact of each channel row placed on the inner side is formed between the through-holes adjacent to each other in the same channel row. In Patent Literature 1, up to three wiring electrodes run between the respective channels by shifting the pitch by 1/4 for each of the four channel rows. Since each wiring electrode runs between the through-holes adjacent to each other, each wiring electrode is arranged to be set in the range of a width (a thickness) of the drive wall as seen from a direction parallel to an ink discharge direction.

[0006] Meanwhile, as the shear mode type ink-jet head, there is an ink-jet head having an independently driven type head chip in which a channel row is configured by dividing respective channels in the channel row into drive channels that discharge an ink and dummy channels that do not discharge the ink and alternately arranging these channels. Alternately arranging the drive channels and the dummy channels enables discharging the ink from all the drive channels at the same time.

[0007] Patent Literature 2 discloses that each connection electrode that is conductive relative to a drive electrode in each channel is formed on a rear face of such an independently driven type harmonica-shaped head chip, and a flexible substrate having each wiring electrode formed on one side thereof is used in a narrow shape having the same width as a width of the wiring electrode on a rear face of the head chip, and the connection electrode of each channel row placed on the inner side in a plurality of aligned channel rows is drawn to an end portion of the head chip across each channel row on the outer side.

[0008] The flexible substrate having each wiring electrode formed thereon is provided to close an opening portion of each dummy channel on the rear face at the time of getting across the channel row on the outer side. Since the surface of the flexible substrate opposite to the wiring electrode forming surface faces the rear face of the head chip, it is possible to prevent occurrence of a short circuit of each drive electrode exposed in or near an opening portion of the dummy channel or the connection electrode. Further, since the flexible substrate is provided to close the opening portion of each dummy channel on the back side, it is possible to easily cope with high density of the channels.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0009]

Patent Document 1: JP-A-2002-178509
Patent Document 2: JP-A-2008-143167

SAMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0010] Usually, in the harmonica-shaped head chip, an ink is supplied from the back side to each channel. Therefore, when each wiring electrode is exposed on the back side of the head chip like the description in Patent Literature 2, the wiring electrode directly comes into contact with the ink, and there occurs a problem of corrosion of each electrode.

[0011] To avoid direct contact of the electrode and the ink, forming a top coat on an electrode surface is generally known, but the ink to be adopted may possibly penetrate, and there is still a problem to be solved in terms of avoidance of corrosion of each electrode.

[0012] In case of arranging the wiring electrode to face the rear face of the head chip like the description in Patent Document 1, the wiring electrode can be prevented from directly coming into contact with the ink, but the wiring electrode that is wired across the channel rows runs on a drive wall between channels as seen from a direction parallel to an ink discharge direction, and hence a width of the drive wall becomes narrower as density of the channels increases, resulting in a problem that high density is hard to be realized.

[0013] That is, according to the technology disclosed in Patent Document 1, the wiring electrode must be narrowed as density of the channels increases and a space between channels (a width of the drive wall) through which the wiring electrode runs becomes narrower. However, when the wiring electrode is narrowed, electrical resistance increases, and there is a limit in narrowing.

[0014] Therefore, it is an object of the present invention to provide an ink-jet head that enables arranging wiring electrodes at high density and can easily cope with an increase in density of channels even if a substrate having the wiring electrodes is attached to a back side of an independently drive harmonica-shaped head chip having a plurality of channel rows in such a manner that the wiring electrodes are provided on the back side of the head chip.

[0015] Any other object of the present invention will become apparent in the following description.

MEANS FOR SOLVING PROBLEM

[0016] The above object is achieved by each of the following inventions.

[0017]

1. An ink-jet head comprising:

   a head chip in which a plurality of channel rows each having channels and drive walls formed of piezoelectric elements alternately arranged therein and also having drive electrodes formed on the drive walls each facing the inside of the channel are arranged, opening portions of the channels are arranged in each of a front face and a rear face, connection electrodes electrically conductive with respect to the drive electrodes in the channels are formed on the rear face, and each channel row is configured by alternately arranging drive channels from which an ink is discharged and dummy channels from which the ink is not discharged; and
   a wiring substrate that is attached to the rear face of the head chip so as to cover the plurality of channel rows and protrude toward a lateral side of the head chip,
   each of the connection electrodes being electrically drawn to an end portion of the wiring substrate by electrically connecting wiring electrodes formed on a surface of the wiring substrate attached to the head chip with the connection electrodes, the ink in the drive channels being discharged from nozzles by applying a voltage to the drive electrodes through the wiring electrodes and the connection electrodes,
   wherein, in the wiring substrate, each through-hole for ink supply is formed only at a position corresponding to the opening portion of each drive channel, at least one wiring electrode runs between the through-holes adjacent to each other in at least one through-hole row of a plurality of through-hole rows associated with the channel rows and extends to the end portion of the wiring substrate protruding toward the lateral side of the head chip, and at least one wiring electrode running between the through-holes is not in contact with the opening portion of the dummy channel and overlaps the opening portion of the dummy channel as seen from an ink discharge direction.

2. The ink-jet head according to 1,
wherein the wiring substrate is made of any one of glass, silicon, and ceramics.

3. The ink-jet head according to 1 or 2,
wherein the head chip has two channel rows which are a row A and a row B, and

a total of two wiring electrodes, which are one wiring electrode associated with the drive channel in the row B and one wiring electrode associated with the dummy channel in the row B adjacent to the drive channel in the wiring electrodes electrically connected to the connection electrodes in the channel row B, run between the through-holes in the one row A.

4. The ink-jet head according to 1 or 2,
wherein the head chip has three channel rows which are a row A, row B, and a row C,
a total of two wiring electrodes, which are one wiring electrode associated with the drive channel in the row C and one wiring electrode associated with the dummy channel in the row C adjacent to the drive channel in the wiring electrodes electrically connected to the connection electrodes in the channel row C, run between the through-holes in one row B, and
a total of four wiring electrodes, which are two wiring electrodes, i.e., one wiring electrode associated with the drive channel in the row B and one wiring electrode associated with the dummy channel in the row B adjacent to the drive channel in the row B in the wiring electrodes electrically connected to the connection electrodes in the channel row B and two wiring electrodes, i.e., one wiring electrode associated with the drive channel in the row C and one wiring electrode associated with the dummy channel in the row C adjacent to the drive channel in the row C, run between the through-holes in one row A.

EFFECT OF THE INVENTION

[0018] According to the present invention, it is possible to provide the ink-jet head that enables arranging wiring electrodes at high density and can easily cope with an increase in density of channels even if a substrate having the wiring electrodes is attached to a back side of an independently drive harmonica-shaped head chip having a plurality of channel rows in such a manner that the wiring electrodes are provided on the back side of the head chip.

BRIEF DESCRIPTION OF DRAWINGS

[0019]

FIG. 1 is an exploded perspective view of an ink-jet head according to the present invention;
FIG. 2 is a partial back view of a head chip according to the present invention;
FIG. 3 is a partial back view showing a attaching state 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 a cross-sectional view taken along a line (v)-(v) in FIG. 3;
FIG. 6 is a partial back view showing a attaching state of the head chip including three channel rows and the wiring substrate;
FIG. 7 is a cross-sectional view taken along a line (vii)-(vii) in FIG. 6; and
FIG. 8 is a partial cross-sectional view of an ink-jet head showing a comparative example.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] A head chip according to the present invention has a plurality of channels, each of which has channels and drive walls formed of piezoelectric elements alternately arranged, in parallel. Opening portions of the respective channels are arranged to face each other on a front face and a rear face of the head chip. Each channel is formed into a straight shape whose cross-sectional shape does not vary from the opening portion in the rear face (an inlet port of the channel) to the opening portion on the front face (an outlet portion of the channel), and a drive electrode is formed on a surface of the drive wall facing the inside of each channel.

[0021] Such a head chip is a so-called shear mode type harmonica-shaped head chip formed of a hexahedron, and it causes shear deformation of the drive wall by applying a drive signal of a predetermined voltage to each drive electrode on both surfaces of the drive wall, and hence a pressure is changed for discharging an ink supplied into each channel, whereby ink drops are discharged from each nozzle arranged on the front side of the head chip.

[0022] According to the present invention, in such a hexahedral harmonica-shaped head chip, a surface on which each nozzle is arranged to discharge the ink is defined as a "front face", and a surface on the opposite side is defined as a "rear face". Further, a direction parallel to the front face or the rear face of the head chip which is also a direction to get away from the head chip is defined as a "lateral side".

[0023] The channel row in the present invention is an independently driven type head chip in which drive channels and dummy channels are alternately arranged. Connection electrodes that are conductive relative to the respective drive electrodes in the drive channels and the dummy channels are individually formed on the rear face of the head chip, and they are aligned on the rear face of the head chip at the same chip as the corresponding drive channels or dummy channels.

[0024] The drive channel is a channel through which the ink is discharged from a nozzle in accordance with image data at the time of recording an image, and the dummy channel is a channel through which the ink is not always discharged. Since each dummy channel does not have to discharge the ink, and hence it is not generally charged with the ink, or a nozzle associated with each dummy channel is not formed on a nozzle plate.

[0025] A wiring substrate attached to the rear face of the head chip through an adhesive is an intermediate wiring member that couples the head chip with a drive circuit. Preferably, it connects the head chip with an electrical wiring member from the drive circuit and facilities electrical connection with the electrical wiring member. This wiring substrate electrically draws each drive electrode to the lateral side orthogonal to the channel rows of the head chip through each corresponding connection electrode.

[0026] The wiring substrate according to the present invention is attached to the back side of the head chip to cover all the channel rows opened in the rear face and have an end portion protruding toward the lateral side orthogonal to the channel rows in the head chip.

[0027] This wiring substrate has through-holes, which enable supplying the ink into the drive channels, only at positions associated with the drive channels of the head chip. Therefore, the opening portions of the dummy channels on the back side are closed by this wiring substrate.

[0028] It is to be noted that the opening portion means a portion that is opened on a level with the rear face of the head chip.

[0029] On a surface of the wiring substrate that is attached to the head chip (which will be referred to as a front side hereinafter), wiring electrodes that are electrically connected to the respective connection electrodes aligned on the rear face of the head chip are formed. In a state that this wiring substrate is attached to the rear face of the head chip, one end of each wiring electrode is electrically connected with a corresponding connection electrode, and the other end of the same extends to the end portion of the wiring substrate protruding toward the lateral side of the head chip.

[0030] At least one wiring electrode runs between the through-holes adjacent each other in at least one through-hole row of the plurality of through-holes in the wiring substrate associated with the channel rows in the head chip. This wiring electrode running between the through-holes is a wiring electrode that is electrically connected to the connection electrode in another channel row.

[0031] At least one wiring electrode running between the through-holes is not in contact with the opening portion of the dummy channel and overlaps the opening portion of the dummy channel as seen from an ink discharge direction in a state that the wiring substrate is attached to the rear face of the head chip through an adhesive. That is, the wiring electrode running between the through-holes is not in contact with the rear face of the head chip except that it is in contact with the connection electrode to which the wiring electrode should be electrically conductive.

[0032] As a result, even if the wiring substrate is attached to the entire rear face of the head chip in such a manner that the wiring electrode is provided on the back side of the head chip, since the wiring electrode does not come into contact with the rear face of the head chip except the connection electrode of the corresponding channel, crosstalk and a short-circuit can be prevented from occurring. Furthermore, since at least one wiring electrode running between the through-holes runs above the opening portion of the dummy channel, an entire space between the adjoining through-holes including the upper side of the opening portion of the dummy channel can be used even though a space between the channels is small, and hence high-density wiring is possible without considerably reducing a width of each wiring electrode, thus coping with high density of the channels.

[0033] In such an ink-jet head, an electrical wiring member having a wiring line that is electrically connected with the wiring electrode is attached to the end portion of the wiring substrate protruding toward the lateral side of the head chip. The electrical wiring member is connected with the drive circuit, and a voltage from the drive circuit is applied to the drive electrode through the wiring electrode and the connection electrode of the wiring substrate. As a result, the ink in the drive channel can be discharged from the nozzle. As the electrical wiring member, a flexible printed circuit (which will be referred to as an FPC hereinafter) is preferably used.

[0034] It is preferable for a substrate material of the wiring substrate in the present invention to be any one of glass, silicon, and ceramics. When such a material is used, rigidity is higher than that of a resin material having the same thickness, the wiring substrate can be thereby thinned, and channel resistance of each through-hole can be suppressed.

[0035] An embodiment according to the present invention will now be described hereinafter with reference to the drawings.

[0036] FIG. 1 is an exploded perspective view of an ink-jet head, and FIG. 2 is a partial back view of the head chip.

[0037] In the drawings, reference numeral 1 denotes a shear mode type harmonica-shaped head chip; 2, a nozzle plate; 3, a wiring substrate; and 4, a FPC

[0038] This head chip 1 has two channel rows, i.e., a row A and a row B. Here, a lower channel row in FIG. 2 is determined as the row A, and the upper channel row in the same is determined as the row B. In each channel row, drive channels 11A or 11B and dummy channels 12A or 12B are alternately arranged. Each drive wall 13A or 13B formed of a piezoelectric element is provided between each drive channel 11A or 11B and each dummy channel 12A or 12B adjacent thereto. Each drive channel 11A or 11B and each dummy channel 12A or 12B are opened in a front face 1a

and a rear face 1b of the head chip 1, respectively, and drive electrodes 14 are hermetically formed on inner surfaces of the respective openings by, e.g., vapor deposition or sputtering.

[0039] It is to be noted that, in the head chip 1, the drive channels 11A and the dummy channels 12A in the channel row which is the row A and the drive channels 11B and the dummy channels 12B in the channel row which is the row B are arranged to be shifted every pitch. That is, as seen along a direction that is parallel to the rear face 1b of the head chip 1 and orthogonal to the channel rows, the drive channels 11 A in the row A and the dummy channels 12B in the row B are placed on the same straight line, and the dummy channels 12A in the row A and the drive channels 11B in the row B are placed on the same straight line.

[0040] On the rear face 1b of the head chip 1, connection electrodes 15A and 15B that achieve electrical conduction with the respective drive electrodes 14 of the drive channels 11A and 11B and the dummy channels 12A and 12B are formed by, e.g., vapor deposition or sputtering. One end of each connection electrode 15A or 15B achieves electrical conduction with the drive electrodes 14 in each corresponding drive channel 11A or 11B or each corresponding dummy channel 12A or 12B. The other end of each connection electrode 15A associated with the drive channel 11A and the dummy channel 12A in the row A is formed to reach one end edge 1c (a lower end edge in FIG. 2) of the head chip 1 from the inside of each channel 11A or 12A, but the other end of each connection electrode 15B associated with the drive channel 11B and the dummy channel 12B in the row B is extended from the inside of each channel 11B or 12B toward the row A and formed to reach the front side of the channel row which is the row A. Therefore, both the connection electrodes 15A and 15B are extended from the respective channels 11A, 11B, 12A, and 12B in the same direction (a direction of an end edge 1c).

[0041] A nozzle plate 2 is attached to the front face 1a of the head chip 1 through an adhesive. In the nozzle plate 2, nozzles 21 are opened only at positions associated with the respective drive channels 11A and 11B.

[0042] A wiring substrate 3 is a tabular substrate larger than an outer shape of the rear face 1b of the head chip 1. It is desirable for the wiring substrate 3 to be inflexible when it is attached to the rear face 1b of the head chip 1, and glass, silicon, or ceramics is preferably used. In this embodiment, a glass substrate was used.

[0043] In a attaching region that is attached to the rear face 1b of the head chip 1 (a region indicated by an alternate long and short dash line in FIG. 1), through-holes 32A and 32B through which an ink is supplied from a non-illustrated common ink chamber into the respective drive channels 11A and 11B are individually opened only at positions associated with the drive channels 11A and 11B opened in the rear face 1b of the head chip 1. An opening space of each through-hole 32A or 32B is formed to be equal to or slightly larger than an opening space of each drive channel 11A or 11B.

[0044] It is preferable for the wiring substrate 3 to have a thickness of 0.3 mm to 0.8 mm in terms of assuring appropriate rigidity while suppressing channel resistance of each through-hole 32A or 32B.

[0045] Moreover, each wiring electrode 33A or 33B, which is electrically connected to each connection electrode 15A or 15B aligned on the rear face 1b of the head chip 1 on one-on-one level, is formed on the surface of the wiring substrate 3 by, e.g., plating, vapor deposition, or sputtering so as to extend in a direction crossing the channel rows in the head chip 1 on the surface of the wiring substrate 3.

[0046] One end of each wiring electrode 33A corresponding to the connection electrode 15A drawn from each channel 11A or 12A in the row A is placed in the vicinity associated with each channel 11A or 12A in the row A in a attaching region 31, and the other end of the same is extended from the attaching region 31 toward the lateral side orthogonal to the channel rows of the head chip 1 and protrudes from the attaching region 31 to reach the end portion 3a of the wiring substrate 3.

[0047] On the other hand, one end of each wiring electrode 33B corresponding to the connection electrode 15B drawn from each channel 11B or 12B in the row B is placed in the vicinity associated with each channel 11B or 12B in the row B in the attaching region 31, the other end of the same extends in the same direction as each wiring electrode 33A, runs between the through-holes 32A adjacent to each other in the row A, and protrudes from the attaching region 31 to reach the end portion 3 a of the wiring substrate 3, and each wiring electrode 33B and each wiring electrode 33A are alternately aligned.

[0048] The wiring substrate 3 is positioned in such a manner that the respective wiring electrodes 33A and 33B are electrically connected with the respective corresponding connection electrodes 15A and 15B of the head chip 1, and it is attached to the rear face 1b of the head chip 1 through an adhesive. As the adhesive, an anisotropic conductive adhesive containing conductive particles may be used, but using an adhesive that does not contain conductive particles is preferable in terms of enhancement of certainty of short-circuit prevention.

[0049] Particulars of each wiring electrode 33B running between the through-holes 32A and 32A in the row A will now be further described hereinafter with reference to FIG. 3 to FIG. 5.

[0050] FIG. 3 is a partial rear view showing a state that the wiring substrate 3 is attached to the rear face 1b of the head chip 1 from the back side of the wiring substrate 3, FIG. 4 is a cross-sectional view taken along a line (iv)-(iv) in FIG. 3, and FIG. 5 is a cross-sectional view taken along a line (v)-(v) in FIG. 3.

[0051] The wiring electrodes that are conductive relative to the respective connection electrodes 15B in the row B are constituted of wiring electrodes $33B_1$ electrically connected with the connection electrodes 15B in the drive channels 11

B in the row B and wiring electrodes $33B_2$ electrically connected with the connection electrodes 15B in the dummy channels 12B in the row B. These wiring electrodes $33B_1$ and $33B_2$ runs between the through-holes 32A and 32A adjacent to each other in the row A and extend to the end portion 3a of the wiring substrate 3. A total of two wiring electrodes, i.e., one wiring electrode $33B_1$ electrically connected with the connection electrode 15B of one drive channel 11B and one wiring electrode $33B_2$ electrically connected to the connection electrode 15B of one dummy channel 12B, which are adjacent to each other in the row B, are arranged between the through-holes 32A and 32A in the row A on the surface of the wiring substrate 3.

[0052] The wiring electrode $33B_2$ having one end electrically connected with the connection electrode 15B of the dummy channel 12B in the row B bends on the surface of the wiring substrate 3 from a region connected to the connection electrode 15B toward the space between the through-holes 32A and 32A in the row A on the other end side, runs over an opening portion 120A of the dummy channel 12A in the row A placed between the through-holes 32A and 32A so as to partially cover an edge portion 121 a of the opening portion 120A, further bends on the surface of the wiring substrate 3 toward the space between the connection electrodes 15A and 15A adjacent to each other in the row A so as not to come into contact with the connection electrode 15A of the dummy channel 12A, and extends to the end portion 3 a to be aligned with the wiring electrodes 33A and 33A electrically connected with the connection electrodes 15A and 15A.

[0053] Further, the wiring electrode $33B_1$ having one end electrically connected with the connection electrode 15B of the drive channel 11 B in the row B runs over the opening portion 120A of the dummy channel 12A in the row A so as to partially cover an edge portion 121b facing the edge portion 121a covered with the wiring electrode $33B_2$ on the opening portion 120A of the dummy channel 12A in the row A placed between the through-holes 32A and 32A in the row A from a region connected with the connection electrode 15B on the other side, bends on the surface of the wiring substrate 3 toward the space between the connection electrodes 15A and 15A adjacent to each other in the row A toward the opposite side of the wiring electrode $33B_2$ so as not to come into contact with the connection electrode 15A of the dummy channel 12A, and extends to the end portion 3a to be aligned with the wiring electrodes 33A and 33A electrically connected with the connection electrodes 15A and 15A.

[0054] It is to be noted that the edge portions 121a and 121b of the opening portion 120A of the dummy channel 12A mean side edge portions of the drive electrode 14 on the opening side formed on the respective drive walls 13 facing each other in four side edges forming the peripheral edge of the opening portion 120A of the dummy channel 12A.

[0055] As described above, in the ink-jet head according to the present invention, when each of the wiring electrodes $33B_1$ and $33B_2$ corresponding to the channel rows in the row B adjacent to the channels rows in the row A runs between the through-holes 32A and 32A in the row A so as to get across the channel row in the row A placed on the outermost side of the head chip 1, it partially protrudes toward not only the inside of the space above each drive wall 13A in the row A on the rear face 1b of the head chip 1 but also the inside of the opening portion 120A of the dummy channel 12A from this space by a length corresponding to a protruding amount c as shown in FIG. 4. Further, the respective wiring electrodes $33B_1$ and $33B_2$ are arranged so as to partially overlap the edge portions 121a and 121b of the opening portion 120A of the dummy channel 12A as seen in an ink discharge direction (a direction extending from the upper side toward the lower side in FIG. 4).

[0056] Since both the wiring electrodes $33B_1$ and $33B_2$ are hermetically formed on the surface of the wiring substrate 3, they are not in contact with the opening portion 120A of the dummy channel 12A, i.e., the rear face 1b of the head chip 1. As shown in FIG. 4 and FIG. 5, since a gap S corresponding to a thickness of each connection electrode 15A or 15B + a thickness of each wiring electrode 33A or 33B is formed between the head chip 1 and the wiring substrate 3, the surface of each wiring electrode $33B_1$ or $33B_2$ is apart from the rear face 1b of the head chip 1 by a length corresponding to the thickness of each connection electrode 15A or 15B in a region except the region connected to the connection electrode 15B. The surface of each wiring electrode $33B_1$ or $33B_2$ is insulated from the rear face 1b of the head chip 1 by filling the space between these surfaces with an adhesive 50. Therefore, even if each wiring electrode $33B_1$ or $33B_2$ is arranged so as to overlap the opening portion 120A, it does not come into contact with the drive electrode 14 exposed in the opening portion 120A, and crosstalk or a short-circuit does not occur.

[0057] Furthermore, a wiring space for each wiring electrode $33B_1$ or $33B_2$ is not restricted to the space corresponding to the thickness of the drive wall 13A, and a wide area extending between the through-holes 32A and 32A can be used, and hence each wiring electrode $33B_1$ or $33B_2$ can be widely formed. Therefore, an increase in electrical resistance of each wiring electrode $33B_1$ or $33B_2$ can be suppressed.

[0058] It is to be noted that each wiring line $33B_1$ or $33B_2$ running above the opening portion 120A of the dummy channel 12A in the row A is wired to overlap the opening portion 120A of the dummy channel 12A, bends so as to avoid the region of the connection electrode 15A in such a manner that it does not come into contact with the connection electrode 15A of the dummy channel 12A, and is aligned with the wiring electrode 33A at the end portion 3a of the wiring substrate 33.

[0059] Although the structure including the two channel rows, i.e., the row A and the row B provided in the head chip 1 has been exemplified in the foregoing embodiment, the number of channel rows may be three or more.

[0060] A description will now be given as to an ink-jet head using a head chip 1' including three channel rows, i.e., a

row A, a row B, and a row C with reference to FIG. 6 and FIG. 7.

[0061] FIG. 6 is a partial back view showing a state that a wiring substrate 3' is attached to a rear face 1b of the head chip 1' from a back side of the wiring substrate 3', and FIG. 7 is a cross-sectional view taken along a line (vii)-(vii) in FIG. 6. It is to be noted that, in this head chip 1', respective channel rows, i.e., a row A and a row B have the same configuration as that of the head chip 1 including the above-explained two channel rows, and hence a description thereof will be omitted. Furthermore, parts denoted by the same reference signs as those in FIG. 3 and FIG. 4 are parts having the same configuration, and hence a detailed description thereof will be omitted.

[0062] In a channel row which is a channel C, alignment is provided in such a manner that an alignment pitch of drive channels 11C and dummy channels 12C becomes the same as an alignment pitch of drive channels 11A and dummy channels 12A as channels in the row A.

[0063] In this embodiment, two wiring electrodes 33C run between through-holes 32B and 32B adjacent to each other in the row B of the wiring substrate 3', i.e., a wiring electrode $33C_1$ electrically connected to a connection electrode 15C of the drive channel 11C in the row C and a wiring electrode $33C_2$ electrically connected to a connection electrode 15C of a dummy channel 12C in the row C run so as to overlap opening portions 120B of the dummy channels 12B in the row B, and they have the same configuration as the wiring electrodes $33B_1$ and $33B_2$ running between the through-holes 32A and 32A in the row A in the embodiment of the two channel rows explained above. In this case, A is read as B and B is read as C in reference signs.

[0064] On the other hand, a total of four wiring electrodes, i.e., wiring electrodes $33B_1$ and $33B_2$ electrically connected with the respective connection electrodes 15B in the row B and the wiring electrodes $33C_1$ and $33C_2$ electrically connected to the respective connection electrodes 15C in the row C are arranged between through-holes 32A and 31A in the row A.

[0065] At this time, as shown in FIG. 7, as seen in an ink discharge direction, the wiring electrodes $33B_1$ and $33C_1$ placed on the inner side are arranged in the opening portion 120A so as to overlap the opening portion 120A of the dummy channel 12A in the row A, and each of the wiring electrodes $33B_2$ and $33C_2$ placed on the outer side is arranged in the range of a thickness of a drive wall 13A. The respective wiring electrodes $33B_1$, $33B_2$, $33C_1$, and $33C_2$ are not in contact with the rear face 1b of the head chip 1, and an adhesive 50 fills a space between these electrodes and the rear face 1b.

[0066] As described above, according to the present invention, when the entire space between the through-holes 32A and 32A is used, the total of four wiring electrodes $33B_1$, $33B_2$, $33C_1$, and $33C_2$ can be arranged, thereby coping with an increase in density.

[0067] It is to be noted that the head chip 1 having the two channel rows shown in FIG. 1 to FIG. 5 can be formed as a head chip having four channel rows in which the two head chips 1 are aligned by configuring drawing directions of the wiring electrodes 33A and 33B on the surface of the wiring substrate 3 to be provided on both end sides to sandwich each head chip. Moreover, in case of the head chip 1' having the three channel rows shown in FIG. 6 and FIG. 7, a head chip having six channel rows can be likewise configured.

EXAMPLES

[0068] In a head chip including two channel rows, channel density that enables wiring was verified in regard to a case where wiring electrodes on a surface of a wiring substrate are formed as shown in FIG. 3 to FIG. 5 (the present invention) and a case where two wiring electrodes between through-holes adjacent to each other are formed on drive walls so that they do not overlap an opening portion of each dummy channel as shown in FIG. 8 (a comparative example).

[0069] When the channel density is 180 dpi (dot per inch), a drive wall thickness of 59 μm, a channel width of 82 μm, and a through-hole width of 102 μm are provided as shown in Table 1.

[0070] Here, considering a machining accuracy or a attaching position accuracy of the head chip and the wiring substrate, in case of the comparative example, 20 μm or more must be assured as a length a1 between the wiring electrode and an adjacent through-hole and a length a2 between the wiring electrode and an opening portion of a dummy channel. In this case, a width of each wiring electrode is 9 μm at a maximum. Wiring that provides a width of 20 μm or less has high manufacturing difficulty level and, even if manufacture is possible, a wiring thickness must be reduced in proportion to the wiring width, and hence it can be expected that an increase in electrical resistance adversely affects ink discharge due to, e.g., a rise in drive voltage.

[0071] Therefore, in case of this comparative example, to realize a practicable wiring width, channel density of up to approximately 120 dpi is a limit as shown in Table 1.

[Table 1]

DENSITY	NUMBER OF ROWS	THICKNESS OF DRIVE WALL	WIDTH OF CHANNEL	WIDTH OF THROUGH-HOLE	a1	a2	MAXIMUM WIDTH OF WIRING LINE	PRACTICAL APPLICATION
180dpi	2	59	82	102	20	20	9	×
120dpi	2	89.5	122	142	20	20	39.5	○

[0072] On the other hand, in case of the present invention, as shown in Table 2, even if channel density of 180 dpi is provided, a width of each wiring electrode can be set up to 46 μm, and 1/3 of the length b in FIG. 4 can be a width that allows each wiring electrode to run.

[0073] In case of the two channel rows, it can be understood that, even if 300 dpi is provided, a wiring width of 22 μm can be assured and higher density than that in the comparative example can be achieved.

[0074] Additionally, in case of the present invention, even if three channel rows are provided, 1/7 of the length b enables each wiring electrode to run, and channel density of 180 dpi can be realized.

[Table 2]

DENSITY	NUMBER OF ROWS	THICKNESS OF DRIVE WALL	WIDTH OF CHANNEL	WIDTH OF THROUGH-HOLE	a	b*	MAXIMUM WIDTH OF WIRING LINE	PRACTICAL APPLICATION
180dpi	2	59	82	102	20	140	46	○
180dpi	3	59	82	102	20	140	20	○
300dpi	2	42	43	63	20	67	22	○
*Since the width of each through-hole is larger than the width of each channel, b=drive wall × 2+width of each channel-20-a×2.								

EXPLANATIONS OF LETTERS OR NUMERALS

[0075]

1, 1': head chip

- 1a: front face
- 1b: rear face
- 1c: end edge
- 11 A, 11B, 11C: drive channel
- 12A, 12B, 12C: dummy channel
- 120A, 120B: opening portion
- 121a, 121b: edge portion
- 13A, 13B: drive wall
- 14: drive electrode
- 15A, 15B: connection electrode

2: nozzle plate

- 21: nozzle

3, 3': wiring substrate

- 3a: end portion
- 31: attaching region
- 32A, 32B, 32C: through-hole

33A, 33B, $33B_1$, $33B_2$, $33C_1$, $33C_2$: wiring electrode

4: FPC
50: adhesive

Claims

1. An ink-jet head comprising:

a head chip in which a plurality of channel rows each having channels and drive walls formed of piezoelectric elements alternately arranged therein and also having drive electrodes formed on the drive walls each facing the inside of the channel are arranged, opening portions of the channels are arranged in each of a front face and a rear face, connection electrodes electrically conductive with respect to the drive electrodes in the channels are formed on the rear face, and each channel row is configured by alternately arranging drive channels from which an ink is discharged and dummy channels from which the ink is not discharged; and
a wiring substrate that is attached to the rear face of the head chip so as to cover the plurality of channel rows and protrude toward a lateral side of the head chip,
each of the connection electrodes being electrically drawn to an end portion of the wiring substrate by electrically connecting wiring electrodes formed on a surface of the wiring substrate attached to the head chip with the connection electrodes, the ink in the drive channels being discharged from nozzles by applying a voltage to the drive electrodes through the wiring electrodes and the connection electrodes,
wherein, in the wiring substrate, each through-hole for ink supply is formed only at a position corresponding to the opening portion of each drive channel, at least one wiring electrode runs between the through-holes adjacent to each other in at least one through-hole row of a plurality of through-hole rows associated with the channel rows and extends to the end portion of the wiring substrate protruding toward the lateral side of the head chip, and at least one wiring electrode running between the through-holes is not in contact with the opening portion of the dummy channel and overlaps the opening portion of the dummy channel as seen from an ink discharge direction.

2. The ink-jet head according to claim 1,
wherein the wiring substrate is made of any one of glass, silicon, and ceramics.

3. The ink-jet head according to claim 1 or 2,
wherein the head chip has two channel rows which are a row A and a row B, and
a total of two wiring electrodes, which are one wiring electrode associated with the drive channel in the row B and one wiring electrode associated with the dummy channel in the row B adjacent to the drive channel in the wiring electrodes electrically connected to the connection electrodes in the channel row B, run between the through-holes in the one row A.

4. The ink-jet head according to claim 1 or 2,
wherein the head chip has three channel rows which are a row A, row B, and a row C,
a total of two wiring electrodes, which are one wiring electrode associated with the drive channel in the row C and one wiring electrode associated with the dummy channel in the row C adjacent to the drive channel in the wiring electrodes electrically connected to the connection electrodes in the channel row C, run between the through-holes in one row B, and
a total of four wiring electrodes, which are two wiring electrodes, i.e., one wiring electrode associated with the drive channel in the row B and one wiring electrode associated with the dummy channel in the row B adjacent to the drive channel in the row B in the wiring electrodes electrically connected to the connection electrodes in the channel row B and two wiring electrodes, i.e., one wiring electrode associated with the drive channel in the row C and one wiring electrode associated with the dummy channel in the row C adjacent to the drive channel in the row C, run between the through-holes in one row A.

FIG. 1

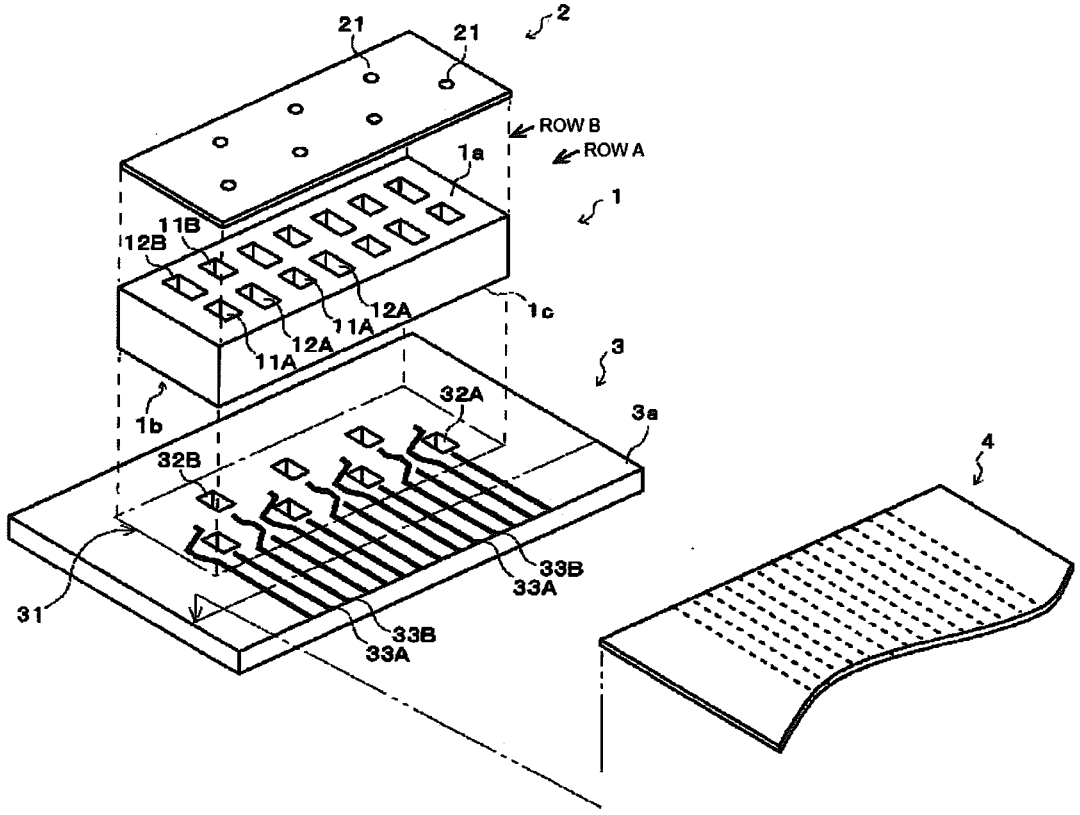

21
21
2
ROW B
ROW A
1a
1
11B
12B
12A
11A
12A
11A
1c
3
1b
32A
3a
32B
33B
33A
31
33B
33A
4

FIG. 2

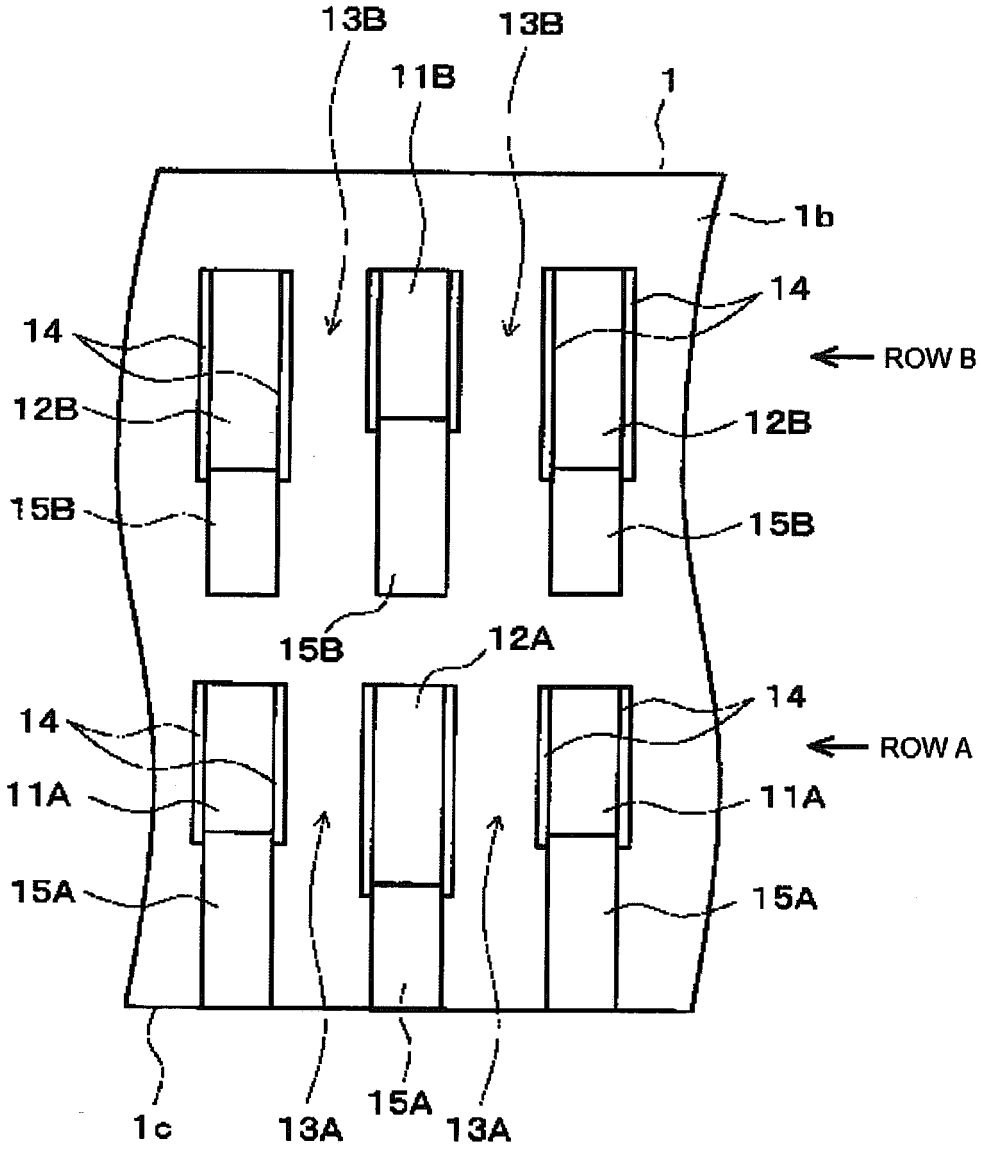

13B
13B
11B
1
1b
14
14
ROW B
12B
12B
15B
15B
15B
12A
14
14
ROW A
11A
11A
15A
15A
1c
13A
15A
13A

FIG. 3

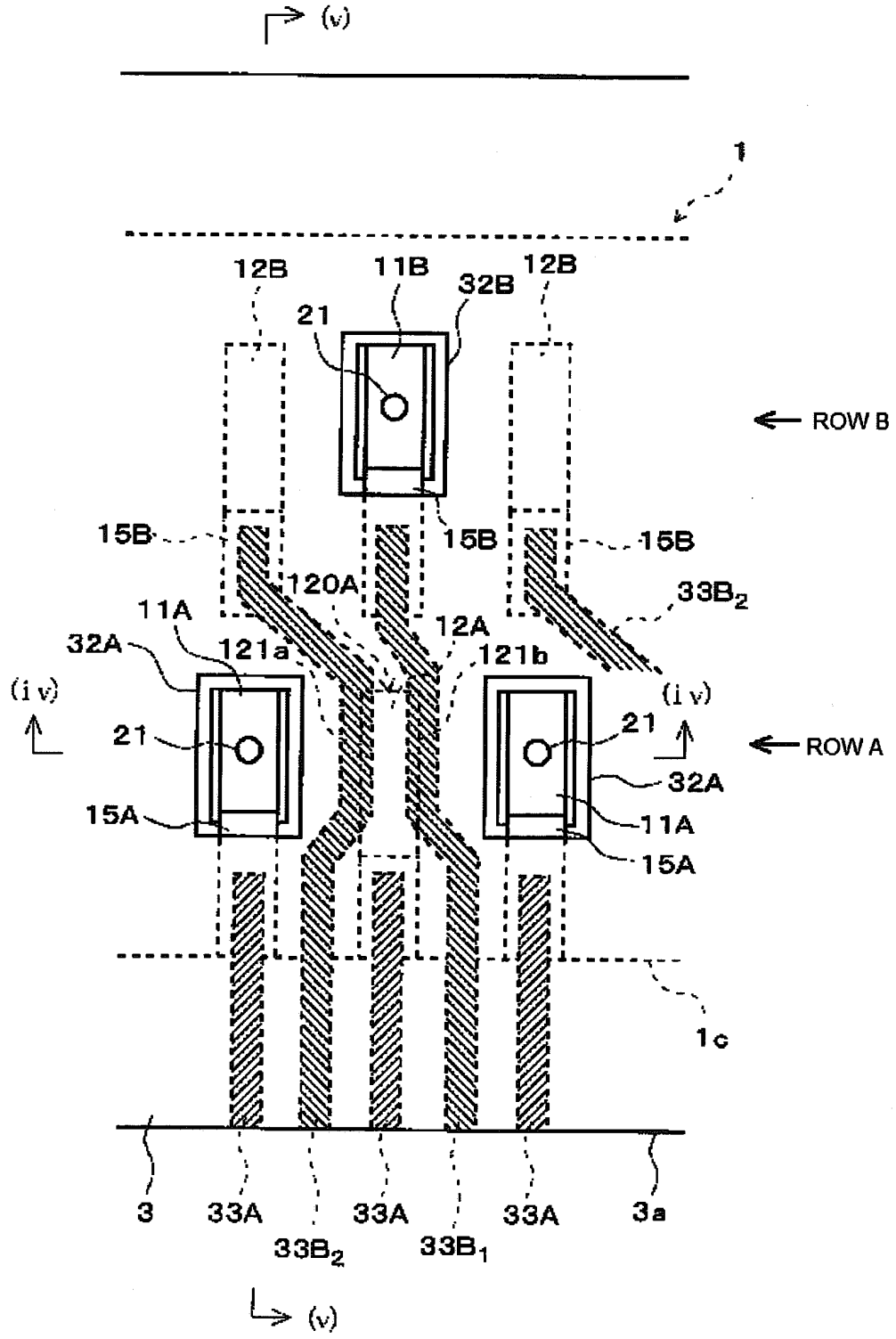

(v)
1
12B
11B
32B
12B
21
ROW B
15B
15B
15B
120A
33B2
11A
32A
121a
12A
121b
(iv)
(iv)
21
21
ROW A
32A
11A
15A
15A
1c
3
33A
33A
33A
3a
33B2
33B1
(v)

FIG. 4

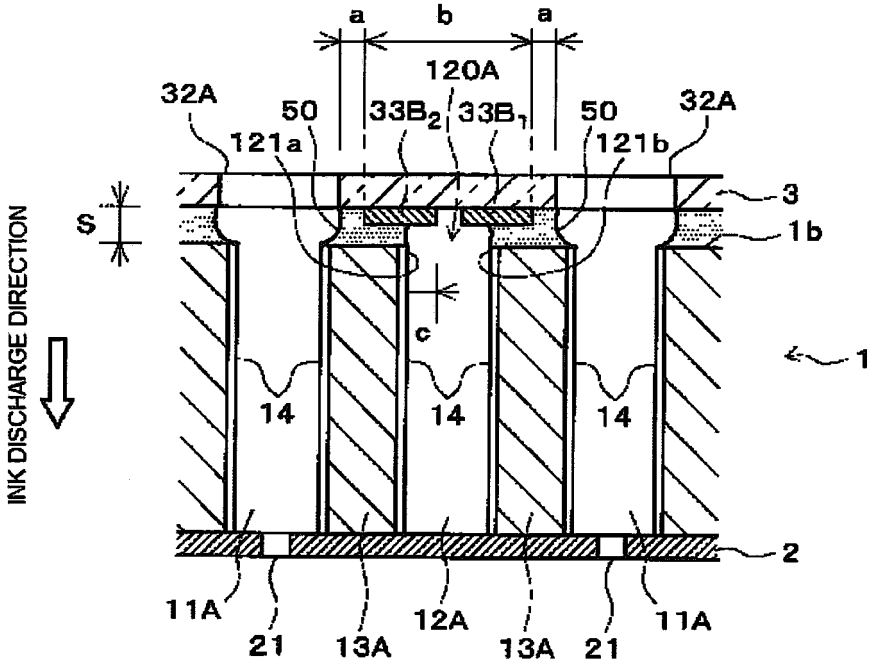

a
b
a
120A
32A
50
33B2
33B1
50
32A
121a
121b
3
S
1b
c
1
INK DISCHARGE DIRECTION
14
14
14
2
11A
21
13A
12A
13A
21
11A

FIG. 5

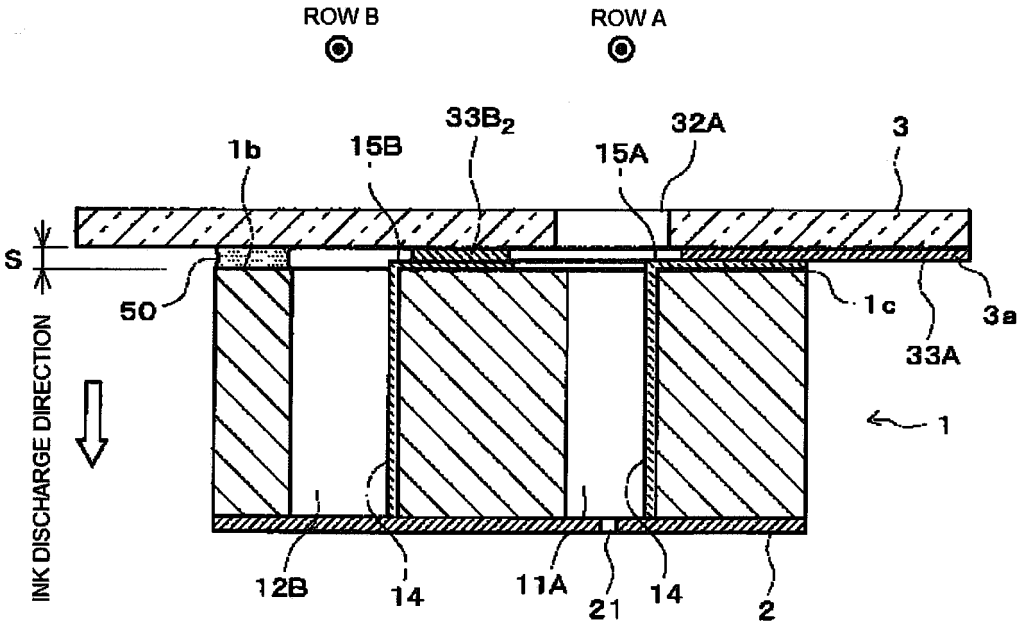

ROW B
ROW A
33B2
32A
3
1b
15B
15A
S
50
1c
3a
33A
1
INK DISCHARGE DIRECTION
12B
14
11A
21
14
2

FIG. 6

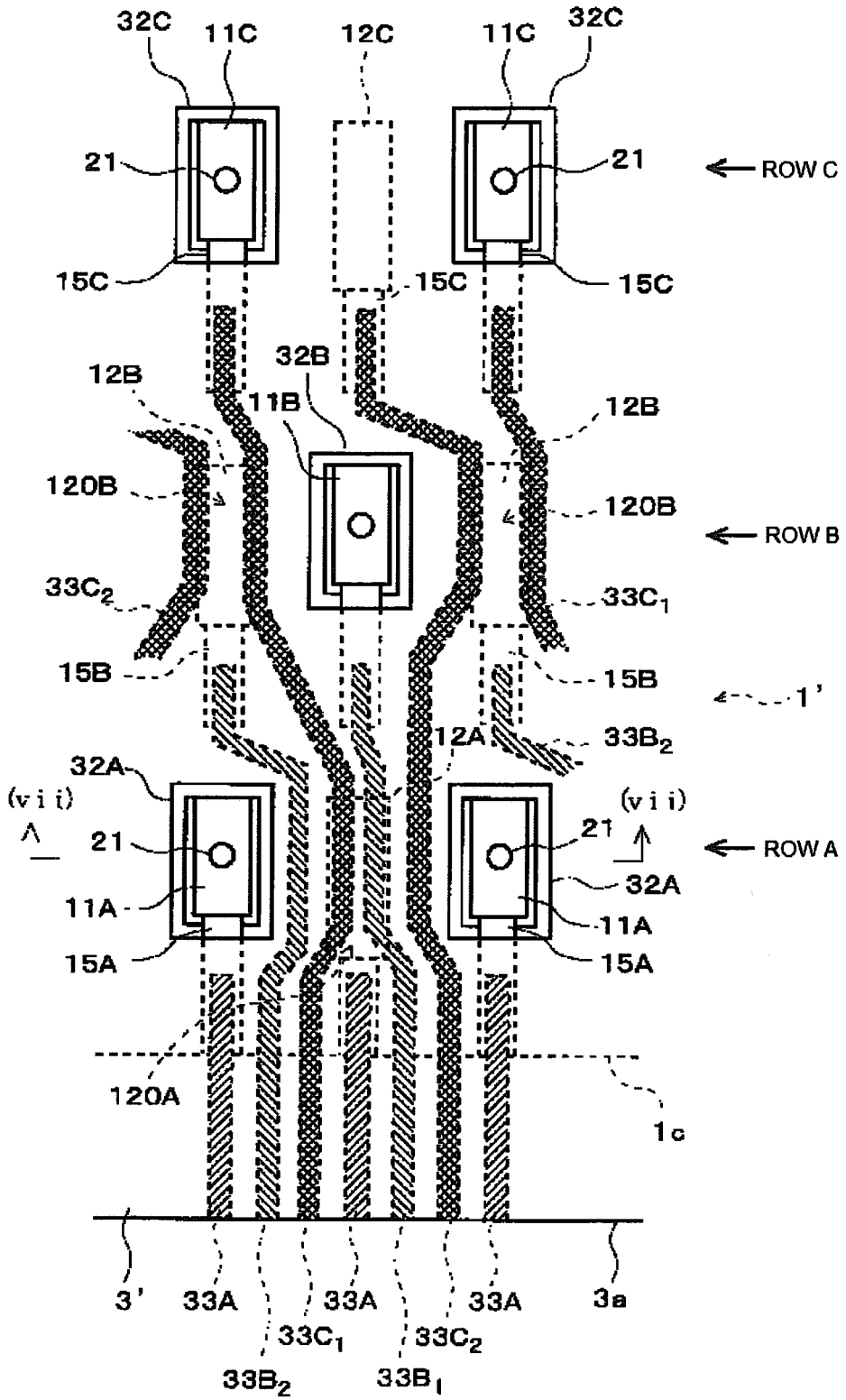

32C
11C
12C
11C
32C
21
21
ROW C
15C
15C
15C
12B
32B
11B
12B
120B
120B
ROW B
33C2
33C1
15B
15B
1'
12A
33B2
32A
(vii)
(vii)
21
21
ROW A
32A
11A
11A
15A
15A
120A
1c
3'
33A
33A
33A
3a
33C1
33C2
33B2
33B1

FIG. 7

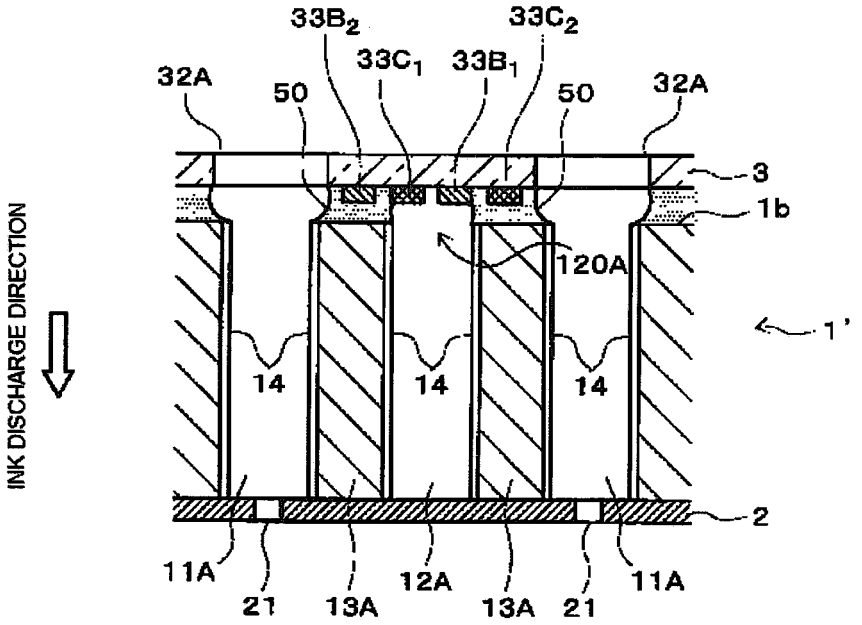
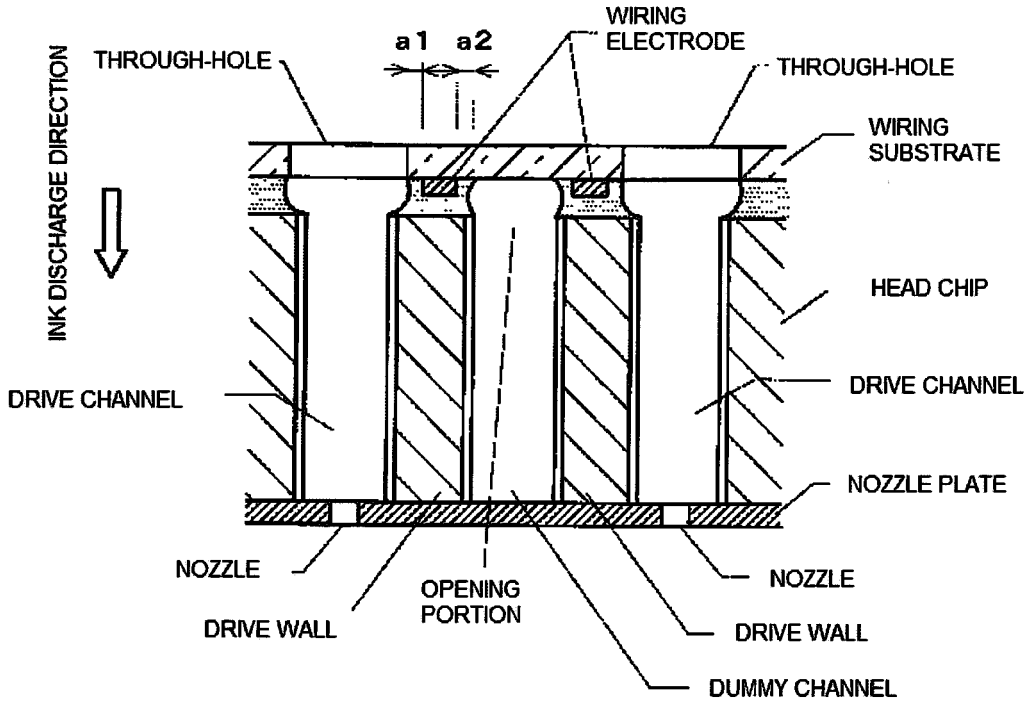

33B2
33C2
33C1
33B1
32A
50
50
32A
3
1b
120A
1'
INK DISCHARGE DIRECTION
14
14
14
2
11A
21
13A
12A
13A
21
11A

FIG. 8


WIRING
ELECTRODE
a1
a2
THROUGH-HOLE
THROUGH-HOLE
WIRING
SUBSTRATE
INK DISCHARGE DIRECTION
HEAD CHIP
DRIVE CHANNEL
DRIVE CHANNEL
NOZZLE PLATE
NOZZLE
NOZZLE
OPENING
PORTION
DRIVE WALL
DRIVE WALL
DUMMY CHANNEL

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/060716

A. CLASSIFICATION OF SUBJECT MATTER
B41J2/045(2006.01)i, *B41J2/055*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B41J2/045, B41J2/055

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2009-274327 A (Konica Minolta IJ Technologies, Inc.), 26 November 2009 (26.11.2009), paragraphs [0058], [0095] to [0112]; fig. 13 to 16 & US 2009/0284569 A1 & EP 2119566 A1	1-4
A	JP 2009-226677 A (Konica Minolta IJ Technologies, Inc.), 08 October 2009 (08.10.2009), entire text; all drawings (Family: none)	1-4
A	JP 2001-10110 A (Kyocera Corp.), 16 January 2001 (16.01.2001), entire text; all drawings (Family: none)	1-4

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

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Date of the actual completion of the international search 14 May, 2012 (14.05.12)	Date of mailing of the international search report 22 May, 2012 (22.05.12)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/060716

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2006-35454 A (Konica Minolta Holdings, Inc.), 09 February 2006 (09.02.2006), entire text; all drawings & US 2006/0017778 A1	1-4
A	JP 2003-326710 A (Sharp Corp.), 19 November 2003 (19.11.2003), entire text; all drawings (Family: none)	1-4
A	JP 2003-80697 A (Sharp Corp.), 19 March 2003 (19.03.2003), entire text; all drawings (Family: none)	1-4

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2002178509 A **[0009]**
- JP 2008143167 A **[0009]**