



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

(21) International Application Number:
PCT/JP2016/001643

(22) International Filing Date:
22 March 2016 (22.03.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2015-060258 24 March 2015 (24.03.2015) JP

(71) Applicant: SEIKO EPSON CORPORATION [JP/JP]; 1-6, Shinjuku 4-chome, Shinjuku-ku, Tokyo, 1608801 (JP).

(72) Inventor: CHIKAMOTO, Motonori; c/o SEIKO EPSON CORPORATION, 3-5, Owa 3-chome, Suwa-shi, Nagano, 3928502 (JP).

(74) Agents: FUSE, Yukio et al.; 8th Floor, Hirata Building, 8-16, Sarugaku-cho 2-chome, Chiyoda-ku, Tokyo, 1010064 (JP).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

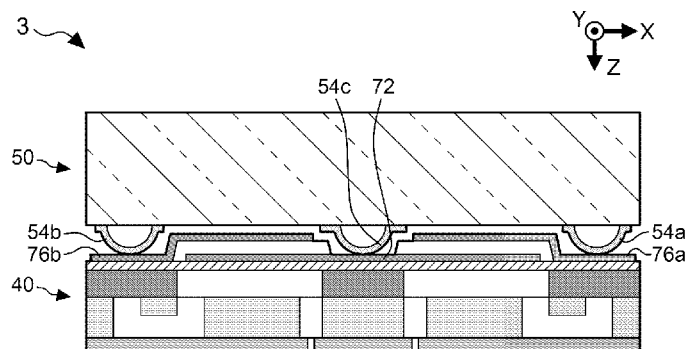
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: HEAD UNIT AND LIQUID EJECTING DEVICE

[Fig. 6]



(57) Abstract: A head unit includes: a structure; and a driver IC, the structure including a plurality of ejection sections, the plurality of ejection sections being divided into a first array and a second array that differs from the first array, each of the plurality of ejection sections including an actuator and ejecting a liquid corresponding to a drive signal applied to one end of the actuator, the driver IC including: a first block that is electrically connected to one end of the actuator included in the first array, and applies the drive signal to the actuator included in the first array; a second block that is electrically connected to one end of the actuator included in the second array, and applies the drive signal to the actuator included in the second array; and a third block that is electrically connected to the other end of the actuator included in the first array and the other end of the actuator included in the second array, and applies a hold signal to the actuator included in the first array and the actuator included in the second array, the driver IC being mounted on the structure so as to seal the actuator included in the first array and the actuator included in the second array, and the third block being situated between the first block and the second block when viewed perpendicular to a mounting surface of the driver IC that is mounted on the structure.

Description

Title of Invention: HEAD UNIT AND LIQUID EJECTING DEVICE

Technical Field

[0001] The present invention relates to a head unit and a liquid ejecting device.

Background Art

[0002] A liquid ejecting device that ejects a liquid (e.g., ink) to print an image or a document is known. An ejection section that ejects the liquid typically includes a plurality of piezoelectric elements (piezo elements), and is configured so that a predetermined amount of liquid (e.g., ink) is ejected from a nozzle at a predetermined timing when a drive signal is supplied to one end of each piezoelectric element from a driver circuit.

[0003] It is necessary to increase the resolution of the product in order to obtain a high-quality and high-definition product by such a liquid ejecting device. It is necessary to increase the degree of integration of the ejection sections in order to increase the resolution. It is possible to increase the resolution that depends on the distance between the ejection sections by increasing the degree of integration of the ejection sections.

[0004] An integration technique that mounts (integrates) a driver IC that drives a piezoelectric element directly on an actuator substrate (structure) that includes a flow channel and a piezoelectric element provided to an ejection section has been known (see Patent Literature 1).

Citation List

Patent Literature

[0005] [PTL 1] JP-A-2014-51008

Summary of Invention

Technical Problem

[0006] It is necessary to reduce the nozzle arrangement pitch in order to increase the resolution. It is necessary to reduce the connection pitch with the driver IC when the nozzle arrangement is reduced. When the driver IC is mounted on the actuator substrate, the ejection section may malfunction (e.g., erroneous ink ejection) due to interference between the actuator substrate and the driver IC, and the quality of the product may deteriorate.

[0007] An object of several aspects of the invention is to provide technology that solves the problems that may occur when the driver IC is mounted on the actuator substrate.

Solution to Problem

- [0008] According to one aspect of the invention, there is provided a head unit including:
a structure; and
a driver IC,
the structure including a plurality of ejection sections,
the plurality of ejection sections being divided into a first array and a second array that differs from the first array, each of the plurality of ejection sections including an actuator and ejecting a liquid corresponding to a drive signal applied to one end of the actuator,
the driver IC including:
a first block that is electrically connected to one end of the actuator included in the first array, and applies the drive signal to the actuator included in the first array;
a second block that is electrically connected to one end of the actuator included in the second array, and applies the drive signal to the actuator included in the second array; and
a third block that is electrically connected to the other end of the actuator included in the first array and the other end of the actuator included in the second array, and applies a hold signal to the actuator included in the first array and the actuator included in the second array,
the driver IC being mounted on the structure so as to seal the actuator included in the first array and the actuator included in the second array, and
the third block being situated between the first block and the second block when viewed perpendicular to a mounting surface of the driver IC that is mounted on the structure.
- [0009] According to the head unit, the first block and the second block that supply a high-voltage signal are provided on either side of the third block that supplies a low-voltage signal. This makes it possible to decrease the density of the terminals of the driver IC that are connected to one end of the actuators, and facilitates connection. It is also possible to reduce or suppress the effect of a change in voltage on the peripheral area (i.e., interference).
- [0010] In the head unit, the third block may be formed over a non-doped region of the driver IC when viewed perpendicular to the mounting surface of the driver IC.
- [0011] According to this configuration, since the third block that applies the hold signal to the other end of each actuator is formed over the non-doped region, it is possible to reduce the effect of noise due to a current that flows through the other end of the actuator on the element (e.g., transistor) included in the driver IC, even when a large amount of current flows through the other end of the actuator. This makes it possible to suppress deterioration in the quality of the product. Note that the expression “A is formed over B” used herein means that A is formed temporally after B during the

production process, and is irrelevant to the position in the gravitational direction.

- [0012] In the head unit, the third block may be isolated from each of the first block and the second block through a buffer area when viewed perpendicular to the mounting surface of the driver IC.
- [0013] According to this configuration, even when a large amount of current flows through the other end of the actuator, noise due to the current that flows through the other end of the actuator rarely reaches the first block and the second block due to the presence of the buffer area.
- [0014] In the head unit, a guard wiring section may be provided between the third block and the first block and between the third block and the second block when viewed perpendicular to the mounting surface of the driver IC.
- [0015] According to this configuration, even when a large amount of current flows through the other end of the actuator, noise due to the current that flows through the other end of the actuator rarely reaches the first block and the second block due to the presence of the guard wiring section.
- [0016] The invention is not limited to a head unit, and may be implemented in various other ways. For example, the invention may be applied to a liquid ejecting device that includes the above head unit. Note that the term “liquid ejecting device” used herein refers to a device that ejects a liquid. The liquid ejecting device may be a printer (described later), a three-dimensional printer (3D printer), a device (printer) that dyes cloth, or the like.
- [0017] When the invention is applied to a liquid ejecting device, a plurality of head units may be arranged in parallel when viewed perpendicular to the liquid ejection plane.

Brief Description of Drawings

- [0018] [fig.1]FIG. 1 illustrates a schematic configuration of a printer according to the first embodiment.
- [fig.2]FIG. 2 is a plan view illustrating the configuration of a head unit.
- [fig.3]FIG. 3 illustrates the electrical configuration of a printer.
- [fig.4]FIG. 4 illustrates the arrangement of drive electrodes provided to an actuator substrate.
- [fig.5]FIG. 5 is a cross-sectional view illustrating the configuration of a head unit.
- [fig.6]FIG. 6 is a cross-sectional view illustrating the main part of the configuration of a head unit.
- [fig.7]FIG. 7 illustrates the mounting surface of a driver IC.
- [fig.8]FIG. 8 is a partial cross-sectional view illustrating the configuration of a driver IC.
- [fig.9]FIG. 9 illustrates the mounting surface of a driver IC included in a printer

according to the second embodiment.

[fig.10]FIG. 10 is a partial cross-sectional view illustrating the configuration of a driver IC.

Description of Embodiments

[0019] Exemplary embodiments of the invention are described below with reference to the drawings taking a printer as an example.

[0020] FIG. 1 is a perspective view illustrating a schematic configuration of a printer according to the first embodiment.

[0021] A printer 1 is a liquid ejecting device that forms ink dots on a medium P (e.g., paper) by ejecting an ink (i.e., liquid) to print an image (including a character, a figure, and the like).

[0022] As illustrated in FIG. 1, the printer 1 includes a moving mechanism 6 that moves (reciprocates) a carriage 20 in the main scan direction (X-direction).

[0023] The moving mechanism 6 includes a carriage motor 61 that moves the carriage 20, a carriage guide shaft 62 that is secured on each end, and a timing belt 63 that extends almost parallel to the carriage guide shaft 62, and is driven by the carriage motor 61.

[0024] The carriage 20 is reciprocally supported by the carriage guide shaft 62, and is secured on part of the timing belt 63. Therefore, when the timing belt 63 is moved forward and backward by the carriage motor 61, the carriage 20 reciprocates while being guided by the carriage guide shaft 62.

[0025] A print head 22 is provided to the carriage 20. The print head 22 includes a plurality of nozzles that are provided in an area opposite to the medium P, and independently eject the ink in the Z-direction. The print head 22 is schematically divided into four blocks in order to implement color printing. Each block ejects a black (Bk) ink, a cyan (C) ink, a magenta (M) ink, or a yellow (Y) ink.

[0026] Note that various control signals and the like are supplied to the carriage 20 from a main board (not illustrated in FIG. 1) through a flexible cable 190.

[0027] The printer 1 includes a feed mechanism 8 that feeds the medium P on a platen 80. The feed mechanism 8 includes a feed motor 81 (i.e., drive source), and a feed roller 82 that is rotated by the feed motor 81, and feeds the medium P in the sub-scan direction (Y-direction).

[0028] An image is formed on the surface of the medium P by repeating an operation that ejects the ink from the nozzle of the print head 22 and feeds the medium P by using the feed mechanism 8 in synchronization with the main scan operation of the carriage 20.

[0029] In the first embodiment, the main scan operation is implemented by moving the carriage 20, and the sub-scan operation is implemented by feeding the medium P. Note that the print head 22 may be fixed, and the medium P may be moved in the X-

Y-directions. Alternatively, both the carriage 20 and the medium P may be moved. It suffices that the medium P and the carriage 20 (print head 22) move relative to each other.

[0030] FIG. 2 illustrates the ink ejection plane of the print head 22 when viewed from the medium P.

[0031] As illustrated in FIG. 2, the print head 22 includes four head units 3. The four head units 3 are arranged in the X-direction (i.e., main scan direction), and respectively correspond to black (Bk), cyan (C), magenta (M), and yellow (Y). Each head unit 3 includes a plurality of nozzles N that are arranged in two rows along the Y-direction. The head unit 3 has a structure in which a piezoelectric element provided to an actuator substrate is sealed with a driver IC (as described in detail later).

[0032] The electrical configuration of the printer 1 is described below.

[0033] FIG. 3 is a block diagram illustrating the electrical configuration of the printer 1.

[0034] As illustrated in FIG. 3, the printer 1 has a configuration in which the head unit 3 is connected to a main board 100. The head unit 3 is roughly divided into an actuator substrate 40 and a driver IC 50.

[0035] The main board 100 supplies a control signal Ctr, a drive signal COM-A, a drive signal COM-B, and a voltage V_{BS} hold signal to the driver IC 50, and the driver IC 50 supplies the drive signal to one end of each of a plurality of piezoelectric elements Pzt provided to the actuator substrate 40, and relays a voltage V_{BS} to the other end of each of the plurality of piezoelectric elements Pzt.

[0036] The printer 1 has a configuration in which four head units 3 are provided, and the main board 100 controls the four head units 3 independently of each other. The four head units 3 are identical to each other except for the color of the ink that is ejected by each head unit 3. The following description focuses on one head unit 3 for convenience of explanation.

[0037] As illustrated in FIG. 3, the main board 100 includes a control section 110, driver circuits 120a and 120b, and a voltage generation circuit 130.

[0038] The control section 110 is a microcomputer that includes a CPU, a RAM, a ROM, and the like. When image data that represents the print target has been supplied from a host computer or the like, the control section 110 executes a predetermined program to output various control signals and the like that control each section.

[0039] Specifically, the control section 110 repeatedly supplies digital data dA to the driver circuit 120a, and repeatedly supplies digital data dB to the driver circuit 120b. The data dA represents (defines) the waveform of the drive signal COM-A that is supplied to the head unit 3, and the data dB represents (defines) the waveform of the drive signal COM-B that is supplied to the head unit 3.

[0040] The driver circuit 120a converts the data dA into an analog signal, subjects the

analog signal to class-D amplification or the like, and outputs the amplified signal as the drive signal COM-A. Likewise, the driver circuit 120b converts the data dB into an analog signal, amplifies the analog signal, and outputs the amplified signal as the drive signal COM-B.

[0041] Note that the driver circuits 120a and 120b differ as to only the input data and the waveform of the drive signal to be output, and have an identical circuit configuration.

[0042] The control section 110 supplies various control signals Ctr to the head unit 3 in synchronization with the control process performed on the moving mechanism 6 and the feed mechanism 8. Note that the control signals Ctr supplied to the head unit 3 include print data that represents the amount of ink to be ejected from the nozzle N, a clock signal that is used to transfer the print data, and a timing signal that represents the print cycle and the like, for example. The control section 110 controls the moving mechanism 6 and the feed mechanism 8. The configuration for controlling the moving mechanism 6 and the feed mechanism 8 is known in the art, and description thereof is omitted.

[0043] The voltage generation circuit 130 included in the main board 100 generates and outputs the voltage V_{BS} hold signal (that is constant temporally). Note that the voltage V_{BS} is used to hold the other end of each of the plurality of piezoelectric elements Pzt provided to the actuator substrate 40 in a constant state.

[0044] Although FIG. 3 illustrates an example in which the voltage generation circuit 130 is provided to the main board 100, the voltage generation circuit 130 may be provided to the driver IC 50 (as described later).

[0045] In the first embodiment, the ink is ejected from each nozzle N up to twice in the print cycle so that each dot can represent four grayscales (large dot, medium dot, small dot, and non-recording). In the first embodiment, the drive signals COM-A and COM-B are provided, and the print cycle is divided into a first-half period and a second-half period in order to represent the above four grayscales. The drive signal COM-A or COM-B is selected (or the drive signals COM-A and COM-B are not selected) according to the target grayscale in each of the first-half period and the second-half period of the print cycle, and supplied to one end of the piezoelectric element Pzt.

[0046] The waveform of each of the drive signals COM-A and COM-B is described below.

[0047] As illustrated in FIG. 3, the drive signal COM-A has a waveform that includes a trapezoidal waveform Adp1 provided in the first-half period of the print cycle, and a trapezoidal waveform Adp2 provided in the second-half period of the print cycle, the trapezoidal waveform Adp1 and the trapezoidal waveform Adp2 being provided continuously. The trapezoidal waveforms Adp1 and Adp2 are almost identical to each other. When each of the trapezoidal waveforms Adp1 and Adp2 is supplied to one end of the piezoelectric element Pzt, a specified amount (i.e., medium amount) of ink is

ejected from the nozzle N that corresponds to the piezoelectric element Pzt.

[0048] The drive signal COM-B has a waveform that includes a trapezoidal waveform Bdp1 provided in the first-half period, and a trapezoidal waveform Bdp2 provided in the second-half period, the trapezoidal waveform Bdp1 and the trapezoidal waveform Bdp2 being provided continuously. The trapezoidal waveforms Bdp1 and Bdp2 differ from each other. The trapezoidal waveform Bdp1 is a waveform that prevents an increase in the viscosity of the ink by finely vibrating the ink that is situated in the vicinity of the nozzle N. Therefore, when the trapezoidal waveform Bdp1 is supplied to one end of the piezoelectric element Pzt, an ink droplet is not ejected from the nozzle N that corresponds to the piezoelectric element Pzt. When the trapezoidal waveform Bdp2 is supplied to one end of the piezoelectric element Pzt, the ink is ejected from the nozzle N that corresponds to the piezoelectric element Pzt in an amount smaller than the specified amount.

[0049] Therefore, when forming a large dot, the drive signal COM-A (trapezoidal waveforms Adp1 and Adp2) are selected and supplied to one end of the piezoelectric element Pzt that corresponds to the nozzle N that is used to form a large dot in the first-half period and the second-half period of the print cycle so that a medium amount of ink is ejected twice from the nozzle N. The ink droplets reach the medium P and unite to form a large dot.

[0050] When forming a medium dot, the drive signal COM-A (trapezoidal waveform Adp1) is selected and supplied to one end of the piezoelectric element Pzt that corresponds to the nozzle N that is used to form a medium dot in the first-half period of the print cycle, and the drive signal COM-B (trapezoidal waveform Bdp2) is selected and supplied to one end of the piezoelectric element Pzt that corresponds to the nozzle N that is used to form a medium dot in the second-half period of the print cycle so that a medium amount of ink and a small amount of ink are sequentially ejected from the nozzle N. The ink droplets reach the medium P and unite to form a medium dot.

[0051] When forming a small dot, the drive signals COM-A and COM-B are not selected in the first-half period of the print cycle, and the drive signal COM-B (trapezoidal waveform Bdp2) is selected and supplied to one end of the piezoelectric element Pzt that corresponds to the nozzle N that is used to form a small dot in the second-half period of the print cycle so that a small amount of ink is ejected once from the nozzle N. The ink droplet reaches the medium P to form a small dot.

[0052] When it is unnecessary to form a dot (non-recording), the drive signal COM-B (trapezoidal waveform Bdp1) is selected and supplied to one end of the piezoelectric element Pzt that corresponds to the nozzle N in the first-half period of the print cycle, and the drive signals COM-A and COM-B are not selected in the second-half period of the print cycle so that the ink that is situated in the vicinity of the nozzle N finely

vibrates only in the first-half period. Since the ink is not ejected from the nozzle N, a dot is not formed (non-recording).

[0053] The driver IC 50 included in the head unit 3 includes a selection control section 510, and selection sections 520 that correspond to the piezoelectric elements Pzt on a one-to-one basis. The selection control section 510 controls the selection operation performed by each selection section 520. More specifically, the selection control section 510 temporarily stores the print data supplied from the control section 110 in synchronization with the clock signal corresponding to several nozzles (piezoelectric elements Pzt) of the head unit 3, and instructs each selection section 520 to select the drive signal COM-A or COM-B according to the print data at the start timing of the print cycle (first-half period and second-half period) that is represented by the timing signal.

[0054] Each selection section 520 selects the drive signal COM-A or COM-B (or does not select the drive signals COM-A and COM-B) according to the instruction issued by the selection control section 510, and applies the selected drive signal COM-A or COM-B to one end of the corresponding piezoelectric element Pzt as a voltage Vout drive signal.

[0055] Since the selection control section 510 merely instructs the selection section 520 to select the drive signal COM-A or COM-B, the elements (transistors) that form the selection control section 510 can be designed according to a low-voltage specification.

[0056] Since the maximum voltage of the drive signal COM-A is about 40 V, the elements (transistors) (including a level shifter that converts the output from the selection control section 510 into a high-amplitude signal) that form the selection section 520 are designed according to a high-voltage specification so as to withstand such a high voltage.

[0057] The piezoelectric elements Pzt (actuators) are provided to the actuator substrate 40 so as to have a one-to-one relationship with the nozzles N. The other end of each of the piezoelectric elements Pzt is electrically connected in common, and the voltage V_{BS} generated by the voltage generation circuit 130 is applied to the other end of each of the piezoelectric elements Pzt.

[0058] The voltage Vout applied to one end of each of the piezoelectric elements Pzt changes corresponding to the size of the dot to be formed, and the voltage V_{BS} is applied in common to the other end of each of the piezoelectric elements Pzt. Therefore, a relatively large amount of current flows through the voltage V_{BS} path.

[0059] FIG. 4 illustrates the arrangement of the drive electrodes of the piezoelectric elements Pzt and the nozzles N provided to the actuator substrate 40. Note that FIG. 4 illustrates a state viewed from the driver IC 50 situated opposite to the medium P in the ink ejection direction. FIG. 4 illustrates a state before the driver IC 50 of the head unit

3 is provided.

[0060] The actuator substrate 40 (head unit 3) has a configuration in which a plurality of nozzles N are arranged in two rows (see above). These nozzle rows are referred to as nozzle rows Na and Nb for convenience of explanation.

[0061] Each of the nozzle rows Na and Nb includes a plurality of nozzles N that are arranged along the Y-direction at a pitch P1. The nozzle rows Na and Nb are spaced in the Y-direction by a pitch P2. The nozzles N that belong to the nozzle row Na and the nozzles N that belong to the nozzle row Nb are shifted in the Y-direction by half the pitch P1. It is possible to substantially double the resolution in the Y-direction as compared with the case where the nozzles N are arranged in one row by arranging the nozzles N in the two nozzle rows Na and Nb so that the nozzles N that belong to the nozzle row Na and the nozzles N that belong to the nozzle row Nb are shifted in the Y-direction by half the pitch P1.

[0062] FIG. 5 is a cross-sectional view illustrating the structure of the actuator substrate 40 taken along the line g-g in FIG. 4. FIG. 5 also illustrates the driver IC 50 that is mounted on the actuator substrate 40.

[0063] FIG. 6 illustrates a state in which the driver IC 50 is mounted on the actuator substrate 40.

[0064] As illustrated in FIG. 5, the actuator substrate 40 is a structure in which a pressure chamber substrate 44 and a diaphragm 46 are provided on the -Z-direction-side surface of a flow channel substrate 42, and a nozzle plate 41 is provided on the +Z-direction-side surface of the flow channel substrate 42.

[0065] Each element of the actuator substrate 40 is an approximately tabular member that extends in the Y-direction, and is secured with an adhesive, for example. The flow channel substrate 42 and the pressure chamber substrate 44 are formed of a monocrystalline silicon substrate, for example.

[0066] The nozzles N are formed in the nozzle plate 41. As described above with reference to FIG. 4, the actuator substrate 40 is formed so that the structure that corresponds to the nozzles that belong to the nozzle row Na and the structure that corresponds to the nozzles that belong to the nozzle row Nb are shifted in the Y-direction by half the pitch P1, but are formed to be approximately symmetrical to each other. The structure of the actuator substrate 40 is described below by focusing on the nozzle row Na.

[0067] The flow channel substrate 42 is a tabular member (material) that forms an ink flow channel. An opening 422, a supply flow channel 424, and a communication flow channel 426 are formed in the flow channel substrate 42. The supply flow channel 424 and the communication flow channel 426 are formed on a nozzle basis. The opening 422 is continuously formed over a plurality of nozzles, and an ink in the corresponding color is supplied to the opening 422. The opening 422 functions as a liquid reservoir

Sr, and the bottom of the liquid reservoir Sr is formed by the nozzle plate 41, for example. More specifically, the nozzle plate 41 is secured on the bottom of the flow channel substrate 42 so as to close the opening 422, the supply flow channel 424, and the communication flow channel 426 formed in the flow channel substrate 42.

[0068] The diaphragm 46 is provided on the surface of the pressure chamber substrate 44 that is situated opposite to the flow channel substrate 42. The diaphragm 46 is a tabular member that can vibrate elastically. For example, the diaphragm 46 is a laminate that includes an elastic film that is formed of an elastic material (e.g., silicon oxide), and an insulating film that is formed of an insulating material (e.g., zirconium oxide). The diaphragm 46 and the flow channel substrate 42 face each other at an interval inside each opening 422 of the pressure chamber substrate 44. The space that is formed by each opening 422 and situated between the flow channel substrate 42 and the diaphragm 46 functions as a cavity 442 that applies pressure to the ink. Each cavity 442 communicates with the nozzle N through the communication flow channel 426 formed in the flow channel substrate 42.

[0069] The piezoelectric element Pzt is formed on the surface of the diaphragm 46 that is situated opposite to the pressure chamber substrate 44, the piezoelectric element Pzt being provided corresponding to each nozzle N (cavity 442).

[0070] The piezoelectric element Pzt includes a drive electrode 72 that is formed on the surface of the diaphragm 46 and provided common to a plurality of piezoelectric elements Pzt, a piezoelectric material 74 that is formed on the surface of the drive electrode 72, and a drive electrode 76a that is formed on the surface of the piezoelectric material 74 and provided corresponding to each piezoelectric element Pzt. An area in which the piezoelectric material 74 is sandwiched between the drive electrodes 72 and 76a functions as the piezoelectric element Pzt.

[0071] Note that the piezoelectric element Pzt that corresponds to the nozzle row Nb includes the drive electrode 72, the piezoelectric material 74, and a drive electrode 76b. Note that one of the drive electrodes of the piezoelectric element Pzt that corresponds to the nozzle row Na is referred to as the drive electrode 76a, and one of the drive electrodes of the piezoelectric element Pzt that corresponds to the nozzle row Nb is referred to as the drive electrode 76b in order to electrically discriminate the piezoelectric element Pzt that corresponds to the nozzle row Na and the piezoelectric element Pzt that corresponds to the nozzle row Nb.

[0072] The piezoelectric material 74 is formed by a process that includes a heat treatment (calcining), for example. Specifically, the piezoelectric material 74 is formed by applying a piezoelectric substance to the surface of the diaphragm 46 on which the drive electrode 72 is formed, calcining the piezoelectric substance by performing a heat treatment inside a calcination furnace, and forming (e.g., plasma milling) the

calcined piezoelectric substance corresponding to each piezoelectric element Pzt.

[0073] Although an example in which the drive electrode 72 is provided under the piezoelectric material 74 and the drive electrode 76a (76b) (independent drive electrode) is provided on the piezoelectric material 74 has been described above, the drive electrode 72 may be provided on the piezoelectric material 74, and the drive electrode 76a (76b) may be provided under the piezoelectric material 74.

[0074] As described above, the voltage Vout of the drive signal that corresponds to the amount of ink that should be ejected is independently applied to the drive electrode 76a (76b) (i.e., one end) of the piezoelectric element Pzt, and the voltage V_{BS} hold signal (that is constant temporally) is applied to the drive electrode 72 (i.e., the other end) of the piezoelectric element Pzt. The piezoelectric element Pzt is displaced upward or downward corresponding to the voltage Vout of the drive signal applied to the drive electrode 76a (76b).

[0075] More specifically, the center part of the piezoelectric element Pzt is deformed upward with respect to each end when the voltage Vout of the drive signal applied through the drive electrode 76a (76b) has decreased, and deformed downward when the voltage Vout has increased.

[0076] When the center part of the piezoelectric element Pzt has been deformed upward, the inner volume of the cavity 442 increases (i.e., a decrease in pressure occurs), and the ink is introduced from the liquid reservoir Sr. On the other hand, when the center part of the piezoelectric element Pzt has been deformed downward, the inner volume of a pressure chamber Sc decreases (i.e., an increase in pressure occurs), and an ink droplet is ejected from the nozzle N corresponding to the decrease in the inner volume of the pressure chamber Sc. Specifically, when an appropriate drive signal has been applied to the piezoelectric element Pzt, the ink is ejected from the nozzle N due to the displacement of the piezoelectric element Pzt.

[0077] The arrangement of the drive electrodes 72, 76a, and 76b of the piezoelectric elements Pzt having the above structure is described below with reference to FIG. 4. Note that the piezoelectric material 74 is omitted in FIG. 4.

[0078] As illustrated in FIG. 4, the drive electrode 72 is patterned to have a rectangular shape that extends in the Y-direction in a plan view. The drive electrodes 76a are formed on the drive electrode 72 through the piezoelectric material 74 (not illustrated in FIG. 4) corresponding to the nozzles N that belong to the nozzle row Na. Part of the drive electrode 76a projects from the drive electrode 72 in the +X-direction (rightward direction) in a plan view. Likewise, part of the drive electrode 76b projects from the drive electrode 72 in the -X-direction (leftward direction).

[0079] Note that a bump 54a (54b) of the driver IC 50 is connected to the area of the drive electrode 76a (76b) that projects from the drive electrode 72 at the position indicated

by the black circle. A bump 54c of the driver IC 50 is connected to the drive electrode 72 at each of the positions indicated by the black circles that are arranged in one row along the Y-direction between the nozzle rows Na and Nb.

[0080] FIG. 7 is a plan view illustrating the mounting surface of the driver IC 50.

[0081] In FIG. 7, the bumps 54a are provided in one row along the Y-direction so as to have a one-to-one relationship with the drive electrodes 76a in an area 560a that is situated on the +X-direction (left)-side end of the driver IC 50 and extends along the edge of the driver IC 50. Likewise, the bumps 54b are provided in one row along the Y-direction so as to have a one-to-one relationship with the drive electrodes 76b in an area 560b that is situated on the -X-direction (right)-side end of the driver IC 50 and extends along the edge of the driver IC 50.

[0082] A wiring pattern 550 is formed on the mounting surface of the driver IC 50 so as to be situated at approximately the center of the driver IC 50 and have a rectangular shape that extends in the Y-direction.

[0083] An area 570a that is isolated from the area 560a and the wiring pattern 550 is provided between the area 560a and the wiring pattern 550 so as to extend along the Y-direction in a plan view, and an area 570b that is isolated from the area 560b and the wiring pattern 550 is provided between the area 560b and the wiring pattern 550 so as to extend along the Y-direction in a plan view.

[0084] Therefore, the wiring pattern 550 does not intersect the areas 560a, 560b, 570a, and 570b when viewed perpendicular to the mounting surface of the driver IC 50.

[0085] Although FIG. 7 illustrates an example in which the areas 570a and 570b are separated from each other, the areas 570a and 570b may be connected to each other on the +Y-direction (lower)-side end, for example.

[0086] The driver IC 50 is configured so that lines 200 that branch from the flexible cable 190 (see FIG. 1) are connected to the -Y-direction (upper)-side end of the driver IC 50, and the control signal Ctr, the drive signals COM-A and COM-B, and the voltage V_{BS} hold signal are supplied to the driver IC 50 from the main board 100. More specifically, the high-voltage drive signals COM-A and COM-B and a high-voltage signal (e.g., high-voltage power supply signal) are supplied through a left line group (1) and a right line group (2) included in the lines 200 (see FIG. 7), and the voltage V_{BS} hold signal is supplied through the line group (1) as a low-voltage signal, for example.

[0087] Since the high-voltage signal and the low-voltage signal are separately supplied to the driver IC 50 through the lines 200, it is possible to reduce or suppress the occurrence of interference.

[0088] Note that the voltage V_{BS} hold signal may be supplied through the line group (1) and the line group (3) as a high-voltage signal, and delivered to the center, or may be generated in the areas 570a and 570b.

- [0089] The mounting surface of the driver IC 50 (see FIG. 7) is mounted (face-down mounted) on the surface of the actuator substrate 40 on which the electrodes are formed (see FIG. 4) (see FIG. 6). The bumps 54a, the bumps 54b, and the bumps 54c provided to the mounting surface of the driver IC 50 are thus connected to the drive electrodes 76a, the drive electrodes 76b, and the drive electrode 72, respectively.
- [0090] Since the drive electrode 72 and the wiring pattern 550 are connected in parallel through the bumps 54c, the resistance of the voltage V_{BS} path of the head unit 3 (through which the voltage V_{BS} is applied) decreases. Since the voltage V_{BS} is stabilized even if a relatively large amount of current flows through the voltage V_{BS} path due to a decrease in resistance, it is possible to improve the ink ejection accuracy, and implement high-quality printing. After mounting the driver IC 50 on the actuator substrate 40, the peripheral area of the connection part is sealed with a sealing material to prevent deterioration in the piezoelectric element Pzt (piezoelectric material 74).
- [0091] FIG. 8 is a cross-sectional view illustrating the main part of the structure of the driver IC 50 taken along the line h-h in FIG. 7. Note that the expression “A is formed over B” used hereinafter means that A is formed temporally after B during a semiconductor process, and is irrelevant to the position in the gravitational direction.
- [0092] As illustrated in FIG. 8, the driver IC 50 has a structure in which an oxide film 581 is locally formed on an Si substrate 51 by a LOCOS (local oxidation of silicon) method to form an element isolation region. Doped regions 563 and 565 are formed in the areas in which the oxide film 581 is not formed by ion implantation (dopant implantation) that utilizes the oxide film 581 as a mask. Note that the doped regions 563 and 565 are either a P-type region or an N-type region (not indicated in FIG. 8).
- [0093] An interlayer insulating film (interlayer dielectric) 583 is formed to cover the oxide film 581 and the doped regions 563 and 565.
- [0094] The elements of the selection sections 520 that correspond to the nozzle row Na are formed in the area 560a, and the elements of the selection sections 520 that correspond to the nozzle row Nb are formed in the area 560b. Specifically, the area 560a forms a first block which corresponds to the nozzle row Na and in which high-voltage transistors are formed, and the area 560b forms a second block which corresponds to the nozzle row Nb and in which high-voltage transistors are formed.
- [0095] The elements (transistors) of the selection control section 510 are formed in the areas 570a and 570b.
- [0096] Note that the interlayer insulating film 583 is a multi-layer film, and a wiring layer is formed between the films that form the multi-layer film. Although FIG. 8 illustrates an example in which only the doped region 563 is formed in the areas 560a and 560b, and only the doped region 565 is formed in the areas 570a and 570b, both a P-type doped region and an N-type doped region may be formed in these areas.

- [0097] The wiring pattern 550 is provided over a non-doped region 575 that is situated between the areas 570a and 570b and is not doped. More specifically, the wiring pattern 550 is formed by forming a pattern of a metal layer (e.g., copper or aluminum layer) in the non-doped region of the Si substrate 51 (into which ions are not implanted, or a negligible trace amount of ions are implanted) through the oxide film 581 and the interlayer insulating film 583.
- [0098] The wiring pattern 550 applies the voltage V_{BS} hold signal in common to the other end of each of the piezoelectric elements Pzt provided to the actuator substrate 40 that respectively correspond to the nozzle rows Na and Nb, and forms a third block. When the voltage V_{BS} is generated in the areas 570a and 570b, the wiring pattern 550 and the areas 570a and 570b form the third block.
- [0099] Although FIG. 8 illustrates a state in which the wiring pattern 550 includes only one layer, it is preferable to employ a configuration in which a plurality of wiring layers are connected.
- [0100] As described above, the resistance of the voltage V_{BS} path of the head unit 3 decreases as a result of connecting the drive electrode 72 and the wiring pattern 550 in parallel. However, a relatively large amount of current flows through the voltage V_{BS} path. Therefore, the driver IC 50 may malfunction due to noise caused by a large amount of current that flows through the voltage V_{BS} path.
- [0101] According to the first embodiment, however, since the wiring pattern 550 is formed in (over) the non-doped region 575 in which an active device such as a transistor is not formed, and the wiring pattern 550 does not intersect the areas 560a, 560b, 570a, and 570b when viewed perpendicular to the mounting surface of the driver IC 50, it is possible to reduce the possibility that malfunction occurs due to noise.
- [0102] The actuator substrate 40 illustrated in FIG. 4 may be formed to have a configuration in which the connection point of the drive electrode 76a with the bump 54a and the connection point of the drive electrode 76b with the bump 54b are shifted toward the center. In this case, however, it may be difficult to connect the actuator substrate 40 and the driver IC 50 since the bumps 54a and 54b are overcrowded.
- [0103] According to the first embodiment, since the actuator substrate 40 is formed to have a configuration in which the connection point of the drive electrode 76a with the bump 54a is situated close to the right edge of the actuator substrate 40, and the connection point of the drive electrode 76b with the bump 54b is situated close to the left edge of the actuator substrate 40, the bumps 54a and 54b are dispersed, and the interval between the bumps (54a, 54b) can be increased to the pitch P1. Therefore, it is possible to easily connect the actuator substrate 40 and the driver IC 50.
- [0104] In other words, the mounting surface illustrated in FIG. 7 is designed as described below. As illustrated in FIG. 8, the area 570a (in which a low-voltage transistor and the

like are formed) and the area 560a (in which a high-voltage transistor and the like are formed) are isolated from each other by a buffer area 565a, and the area 570b and the area 560b are isolated from each other by a buffer area 565b. Note that the buffer area is a non-doped region.

[0105] FIG. 9 is a plan view illustrating the mounting surface of the driver IC 50 applied to a printer 1 according to the second embodiment. FIG. 10 is a cross-sectional view illustrating the main part of the structure of the driver IC 50 taken along the line k-k in FIG. 9.

[0106] As illustrated in FIGS. 9 and 10, a wiring pattern 552 (guard wiring section) is provided to surround the wiring pattern 550 so that the wiring pattern 552 is electrically insulated from the wiring pattern 550. The wiring pattern 552 is formed in (over) the non-doped region 575, and isolated from the areas 570a and 570b. Note that the wiring pattern 552 is grounded, for example.

[0107] According to this configuration, since the wiring pattern 550 is surrounded by the wiring pattern 552 that is set to the ground potential, it is possible to reduce the effect of a change in the voltage V_{BS} of the wiring pattern 550 on the circuits formed in the areas 570a and 570b.

[0108] Although an example in which the voltage V_{BS} hold signal from the main board 100 is applied to the actuator substrate 40 through the driver IC 50 has been described above, the voltage V_{BS} hold signal from the main board 100 may be supplied directly to the actuator substrate 40. In either case, the resistance of the voltage V_{BS} path decreases since the drive electrode 72 and the wiring pattern 550 are connected in parallel.

[0109] Although an example in which the liquid ejecting device is a printer has been described above, the liquid ejecting device may be a three-dimensional printer that forms a three-dimensional object by ejecting a liquid, a printer that dyes cloth by ejecting a liquid, or the like.

Reference Signs List

[0110] 1: printer (liquid ejecting device), 3: head unit, 50: driver IC, 54a, 54b, 54c: bump, 40: actuator substrate (structure), 442: cavity, 100: main board, 550: wiring pattern, Pzt: piezoelectric element, N: nozzle

Claims

[Claim 1]

A head unit comprising:
a structure; and
a driver IC,
the structure including a plurality of ejection sections,
the plurality of ejection sections being divided into a first array and a second array that differs from the first array, each of the plurality of ejection sections including an actuator and ejecting a liquid corresponding to a drive signal applied to one end of the actuator,
the driver IC including:
a first block that is electrically connected to one end of the actuator included in the first array, and applies the drive signal to the actuator included in the first array;
a second block that is electrically connected to one end of the actuator included in the second array, and applies the drive signal to the actuator included in the second array; and
a third block that is electrically connected to the other end of the actuator included in the first array and the other end of the actuator included in the second array, and applies a hold signal to the actuator included in the first array and the actuator included in the second array,
the driver IC being mounted on the structure so as to seal the actuator included in the first array and the actuator included in the second array, and
the third block being situated between the first block and the second block when viewed perpendicular to a mounting surface of the driver IC that is mounted on the structure.

[Claim 2]

The head unit as defined in claim 1,
the third block being formed over a non-doped region of the driver IC when viewed perpendicular to the mounting surface.

[Claim 3]

The head unit as defined in claim 1,
the third block being isolated from each of the first block and the second block through a buffer area when viewed perpendicular to the mounting surface.

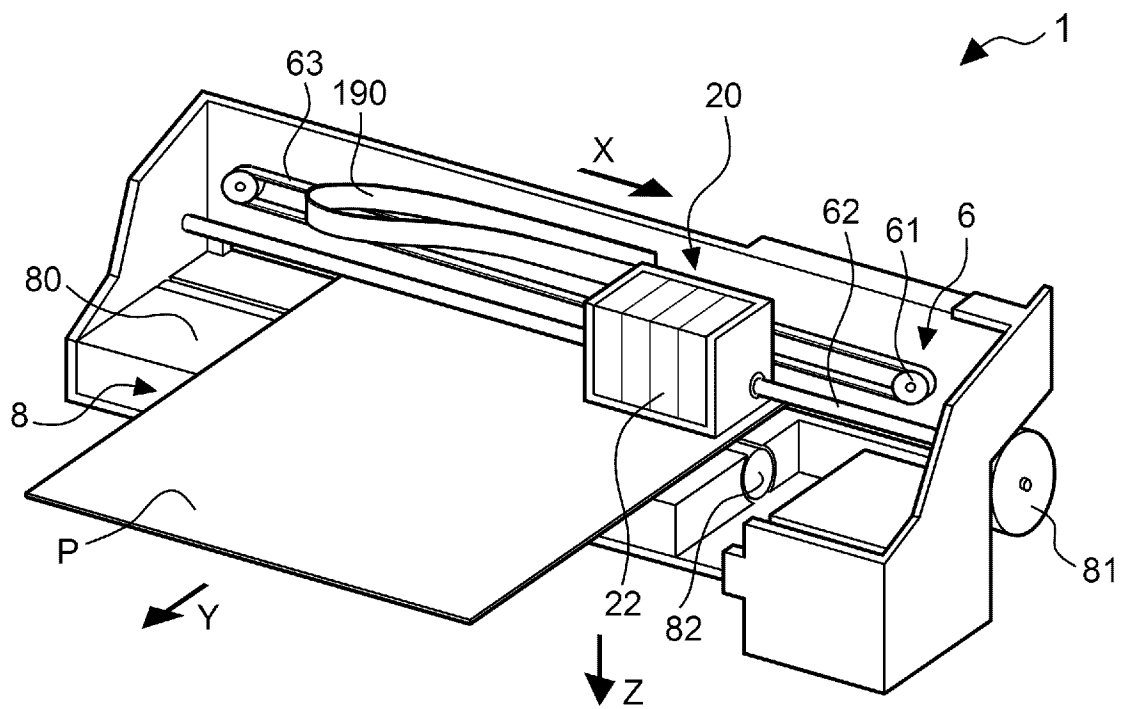
[Claim 4]

The head unit as defined in claim 1,
a guard wiring section being provided between the third block and the first block and between the third block and the second block when viewed perpendicular to the mounting surface.

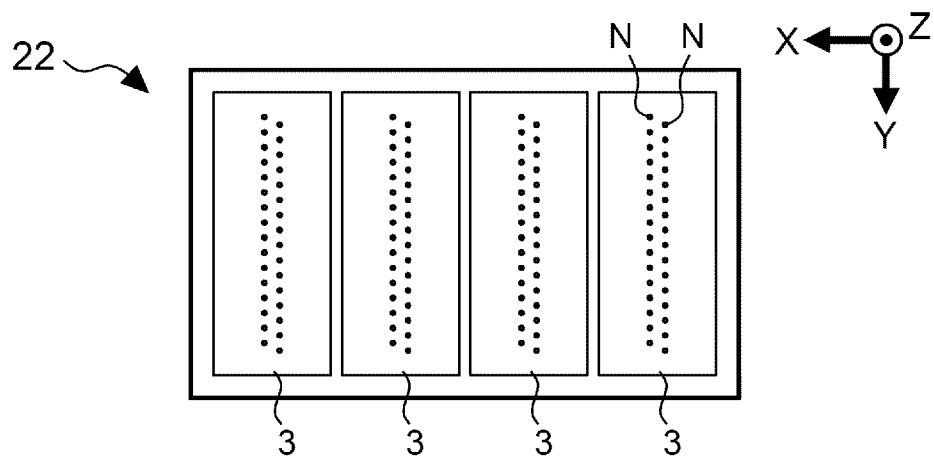
[Claim 5]

A liquid ejecting device comprising:
a head unit; and
a relative moving section that moves the head unit relative to a medium,
the head unit including:
a structure; and
a driver IC,
the structure including a plurality of ejection sections,
the plurality of ejection sections being divided into a first array and a second array that differs from the first array, each of the plurality of ejection sections including an actuator and ejecting a liquid by using the actuator,
the driver IC including:
a first block that is electrically connected to one end of the actuator included in the first array, and applies the drive signal to the actuator included in the first array;
a second block that is electrically connected to one end of the actuator included in the second array, and applies the drive signal to the actuator included in the second array; and
a third block that is electrically connected to the other end of the actuator included in the first array and the other end of the actuator included in the second array, and applies a hold signal to the actuator included in the first array and the actuator included in the second array,
the driver IC being mounted on the structure so as to seal the actuator included in the first array and the actuator included in the second array, and
the third block being situated between the first block and the second block when viewed perpendicular to a mounting surface of the driver IC that is mounted on the structure.

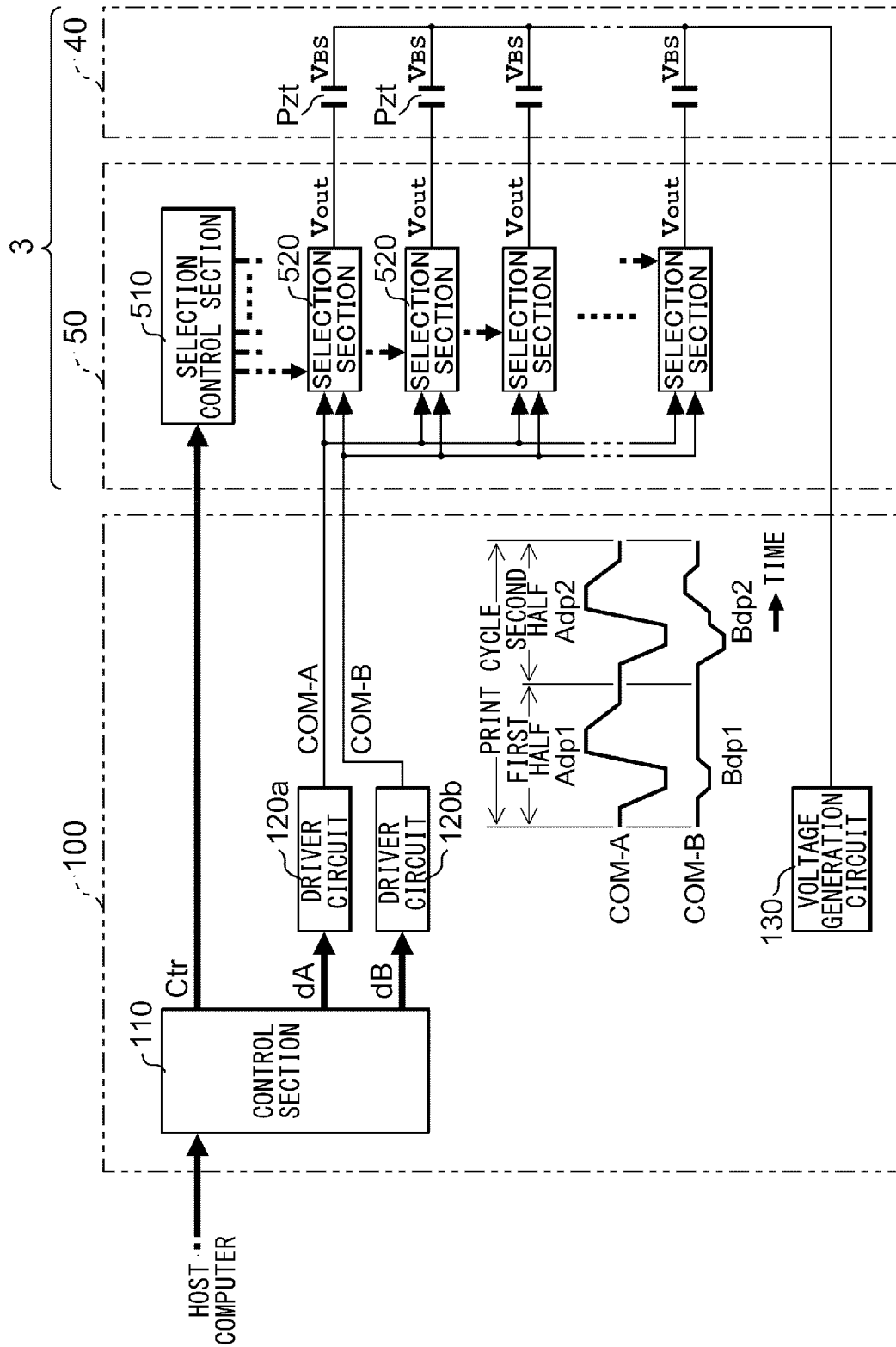
[Fig. 1]



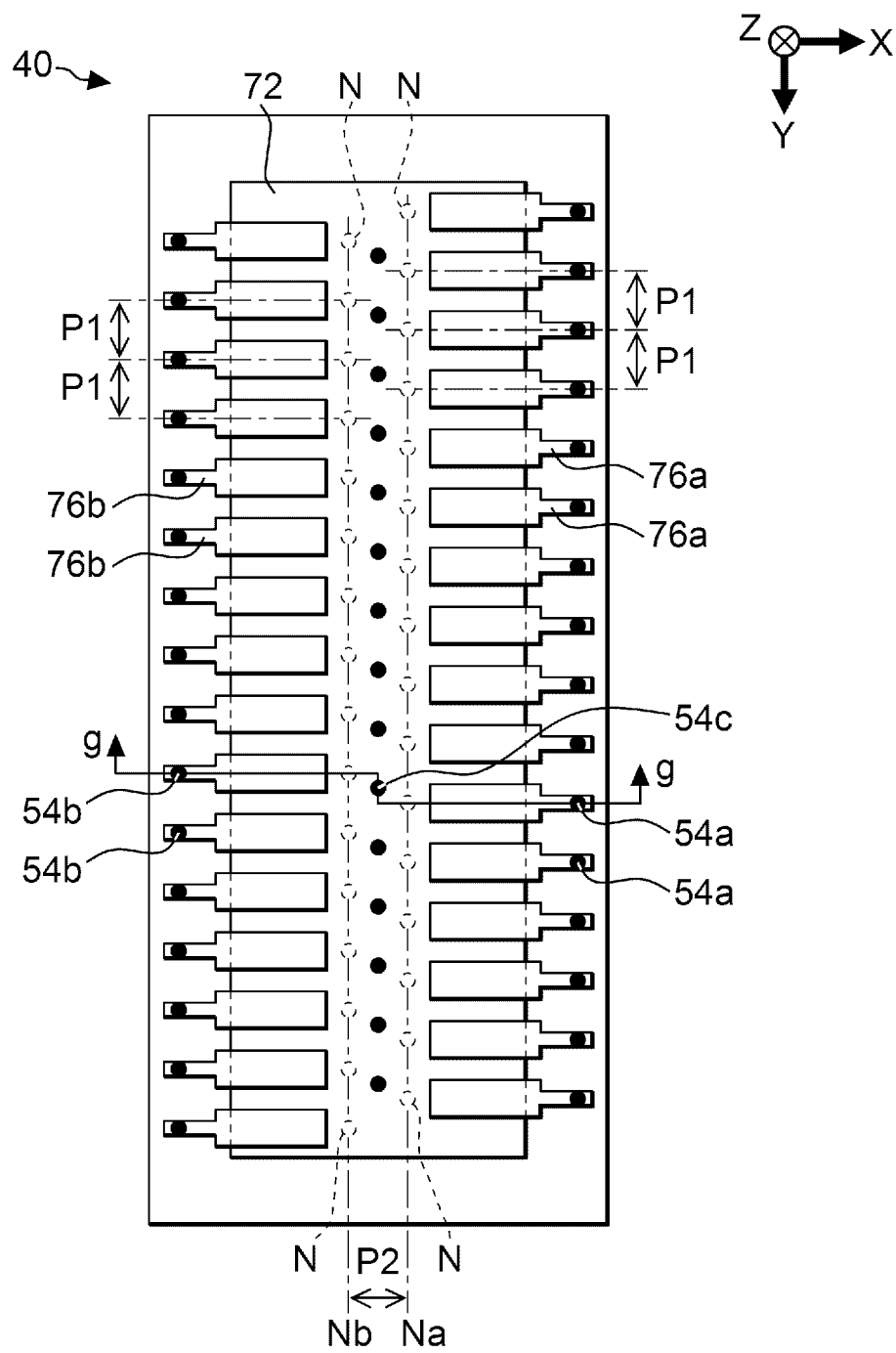
[Fig. 2]



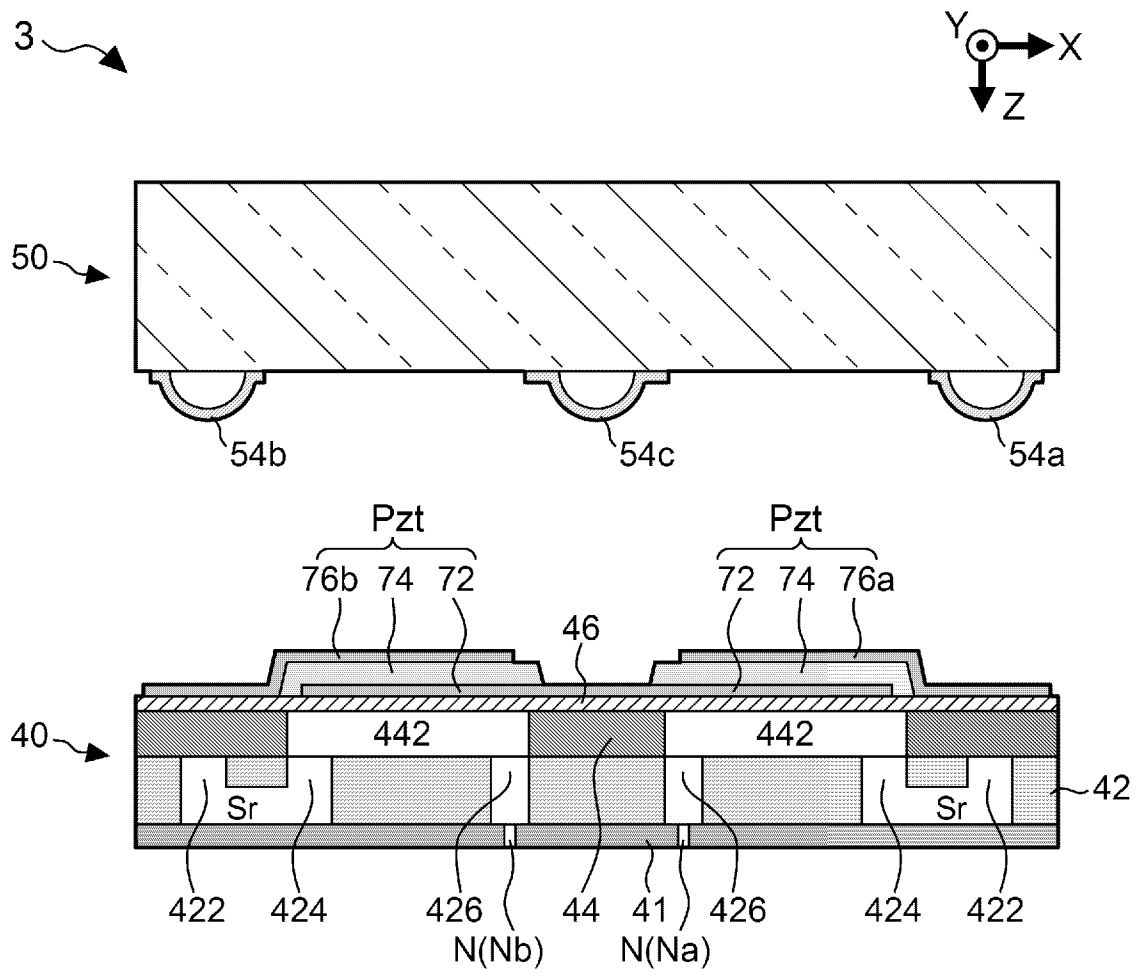
[Fig. 3]



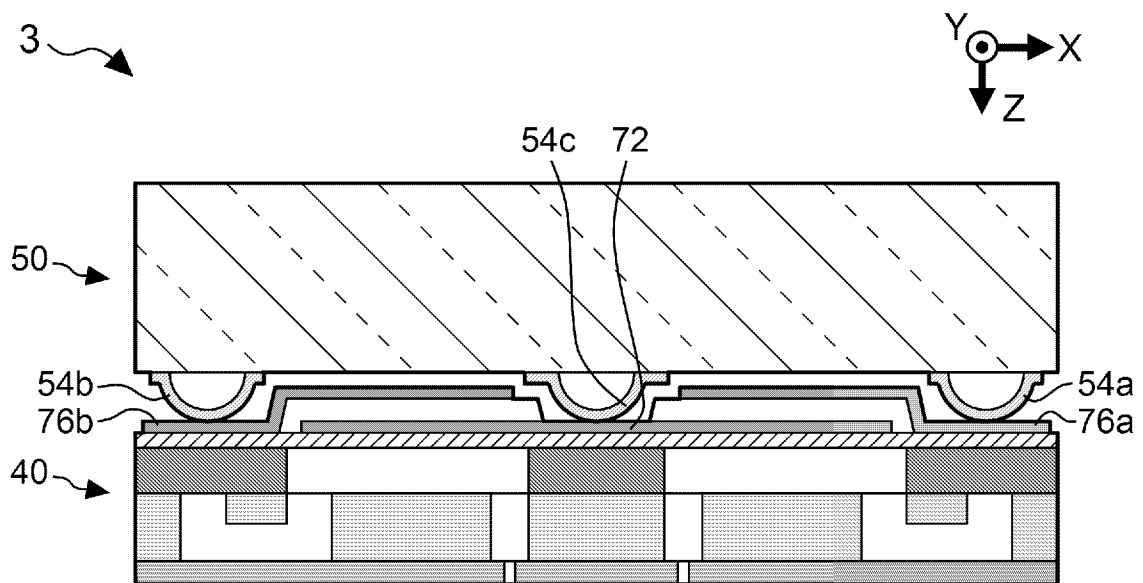
[Fig. 4]



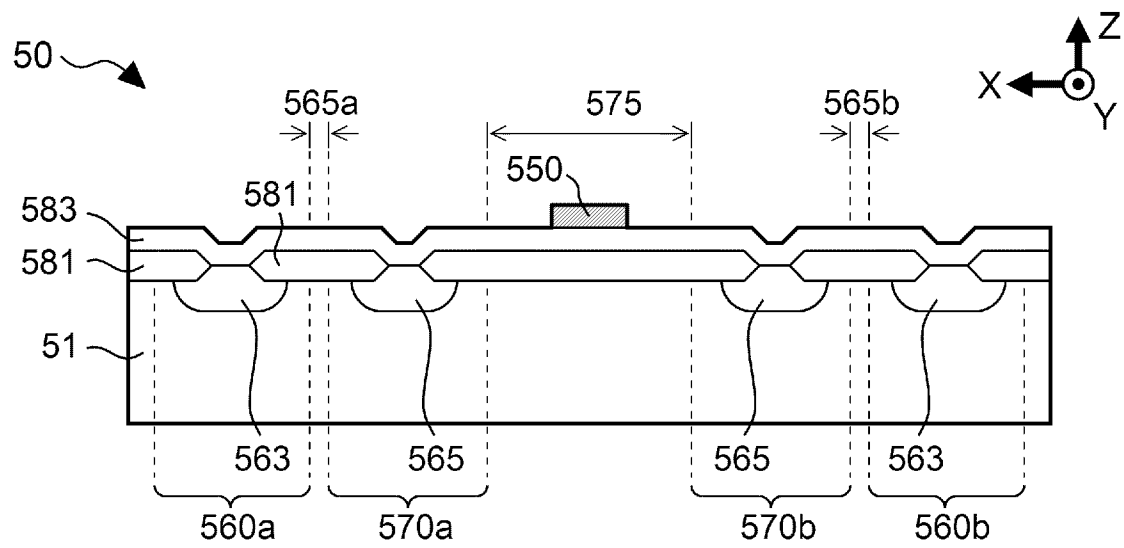
[Fig. 5]



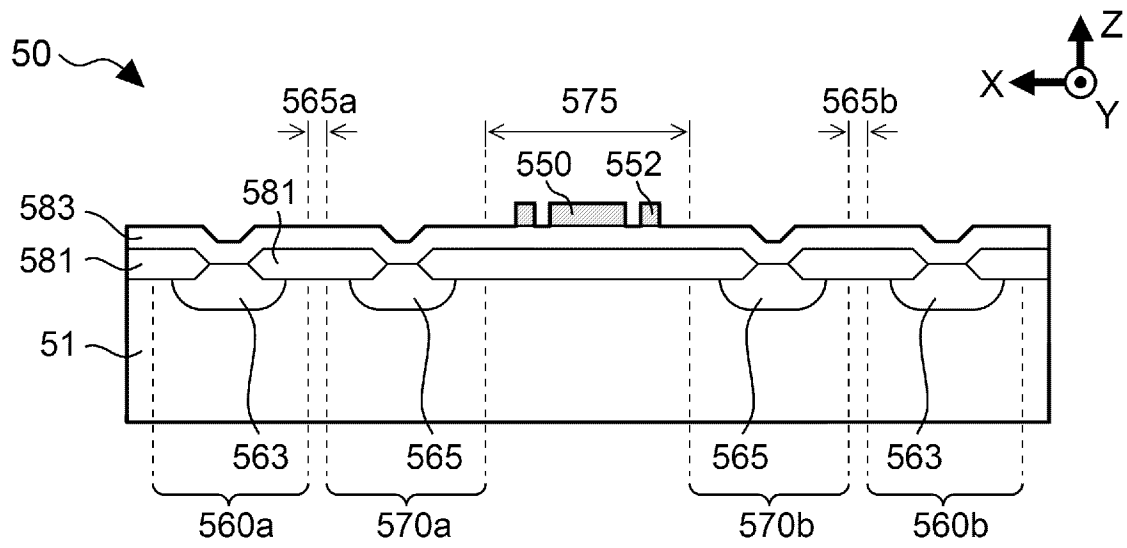
[Fig. 6]



[Fig. 8]



[Fig. 10]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/001643

A. CLASSIFICATION OF SUBJECT MATTER		
Int.Cl. B41J2/14 (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)		
Int.Cl. B41J2/01-2/215		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Published examined utility model applications of Japan 1922-1996 Published unexamined utility model applications of Japan 1971-2016 Registered utility model specifications of Japan 1996-2016 Published registered utility model applications of Japan 1994-2016		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2014-51008 A (BROTHER KOGYO KABUSHIKI KAISHA) 2014.03.20, Paragraphs [0033]-[0057], Figs. 1-8 (Family: none)	1, 3, 5 2, 4
Y A	JP 2013-159081 A (SEIKO EPSON CORPORATION) 2013.08.19, Paragraphs [0044]-[0054], Figs. 3-9 (Family: none)	1, 3, 5 2, 4
A	US 5889539 A (SEIKO EPSON CORPORATION) 1999.03.30, & JP 9-123449 A & EP 755792 A2 & DE 69611404 T2	1-5
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
12.05.2016		24.05.2016
Name and mailing address of the ISA/JP		Authorized officer
Japan Patent Office		SHIMOMURA, Teruaki
3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan		2P 9210
		Telephone No. +81-3-3581-1101 Ext. 3261