

(19)



(11)

EP 3 381 693 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
03.10.2018 Bulletin 2018/40

(51) Int Cl.:
B41J 2/16^(2006.01)

(21) Application number: **18160607.0**

(22) Date of filing: **07.03.2018**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(30) Priority: **30.03.2017 JP 2017068477**

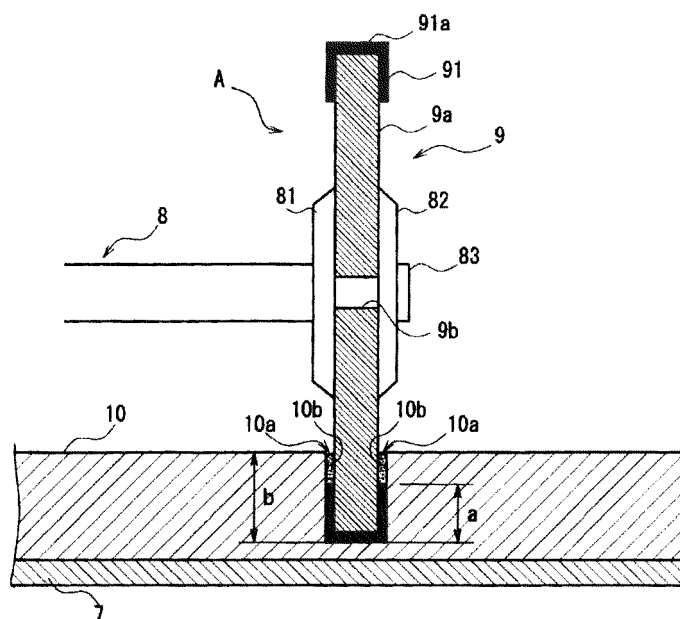
(54) **METHOD FOR PRODUCING HEAD CHIP AND METHOD FOR PRODUCING INKJET HEAD**

(57) A method for producing a head chip and a method for producing an inkjet head which reduce an influence cutting chips when a ceramic substrate is cut or cut off by a dicing blade and enable machining with high accuracy are provided.

In a dicing blade A for cutting or cutting off a ceramic substrate 10, an annular blade portion 91 made of an

abrasive grain layer over the entire circumference is formed on both surfaces on peripheral edge sides of a disc-shaped base metal 9, and an inner-peripheral side portion 9a is thinner than a peripheral-edge side portion, and a width a of the annular blade portion 91 in a radial direction is smaller than a cutting depth b of the ceramic substrate 10 to be cut or cut off.

Fig. 1



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Description

BACKGROUND

5 TECHNOLOGICAL FIELD

10 **[0001]** The present invention relates to a method for producing a head chip and a method for producing an inkjet head and more particularly relates to a method for producing a head chip and a method for producing an inkjet head which reduces an influence of cutting chips between a ceramic substrate and a dicing blade when the ceramic substrate is cut or cut off by the dicing blade and enables machining with higher accuracy.

DESCRIPTION OF THE RELATED ART

15 **[0002]** Conventionally, an inkjet head of a shear mode type including a head chip in which a channel and a driving wall are alternately juxtaposed is known. In this inkjet head, by applying a voltage to an electrode formed on the driving wall, the driving wall is deformed to a bent shape so that an ink in the channel is ejected from a nozzle.

[0003] As this type of inkjet heads, there is the one including a head chip with a structure in which an inlet to the channel and an outlet from the channel are opened on a rear surface and a front surface of the head chip, respectively. This type of head chips can be produced in a large number at once by full-cut (cutting-off) of a lengthy ceramic substrate (piezoelectric substrate) on which the channels are juxtaposed at a pitch corresponding to a desired channel number in a direction orthogonal to a length direction of the channel, which has extremely good productivity. The full-cut of the ceramic substrate is performed by a dicing blade 101 attached to a dicing saw 100 and rotated as illustrated in Fig. 20. The dicing blade 101 is constituted by forming a blade portion made of an abrasive grain layer on both surfaces of a disc-shaped base metal.

25 **[0004]** Moreover, as an example of a manufacturing process of this type of head chips, there is a process of forming a plurality of elongated ejection grooves by cutting the ceramic substrate constituting the head chip by using the dicing blade (Patent Document 1). Furthermore, a process of forming a plurality of openings through which a common ink chamber is made to communicate with each of a plurality of the channels by a channel-shaped groove penetrating a bottom surface of a recess groove is also carried out by using the dicing blade (Patent Document 2).

30 **[0005]** By performing dicing machining or the like for making a cut in a plate-shaped member by using the dicing blade, a plurality of openings that cannot be formed by sandblast machining or laser machining can be formed at a micro pitch. Thus, easy and efficient machining can be performed.

CITATION LIST

35 PATENT DOCUMENT

[0006]

40 Patent Document 1: JP-A-2015-024516

Patent Document 2: JP-A-2008-201022

45 Patent Document 3: JP-A-S58-165965

SUMMARY

PROBLEM TO BE SOLVED BY THE INVENTION

50 **[0007]** Recently, more high-definition image recording is required in the inkjet head, and a much higher density of a nozzle is in demand with that. Thus, a number of rows of the channels provided on the head chip has been increasing, and there is a need to manufacture a head chip by the full-cut (cutting-off) of a thick laminated object on which a plurality of ceramic substrates are laminated so as to have a desired number of channel rows.

55 **[0008]** As illustrated in Fig. 20, when a head chip on which a plurality of channel rows is juxtaposed was produced by the full cut using the dicing blade 101, it was found that a cut surface 201a on one surface side of the dicing blade 101 and a cut surface 201b on the other surface side were not in parallel, and a head chip thickness (a thickness in a length direction of the channel) became uneven. Concerning this unevenness, a difference in the thickness between one end portion and the other end portion of the head chip was approximately 10 μm . If the head chip thickness (the thickness

in the length direction of the channel) is uneven, a difference is generated in the channel length among channel rows, and ejection performances are varied among the channel rows. Moreover, it leads to defective adhesion of a nozzle plate bonded to the head chip, defective adhesion of a wiring substrate to the head chip and defective conduction.

[0009] The inventor has keenly examined this problem and obtained finding that a cutting chip 202 generated at the full-cut of the ceramic substrate 201 is a cause of that. That is, when the ceramic substrate 201 is subjected to the full-cut by using the dicing blade 101, a large amount of cutting chips 202 are generated, and the cutting chips 202 remain between the cut surfaces 201a, 201b of the ceramic substrate 201 and the dicing blade 101. The cutting chips 202 are discharged with rotation of the dicing blade 101, but they are rubbed on the cut surfaces 201a, 201b of the ceramic substrate at the discharge and further cut the cutting surfaces 201a, 201b. As described above, and since the cut surfaces 201a, 201b after the cutting are further cut back, the cut surfaces 201a, 201b become uneven.

[0010] The larger the number of laminations of the ceramic substrate 201 becomes and the thicker the cutting thickness becomes, the larger the generation amount of the cutting chips 202 gets, and this problem occurs remarkably.

[0011] A dicing blade on which a blade portion made of an abrasive grain layer is formed only in an annular region on a peripheral side surface and a peripheral edge side of the disc-shaped base metal is proposed (Patent Document 3), but this dicing blade is assumed to cut a semiconductor wafer which is thinner than a width of the blade portion of the annular region and has an object of suppressing expansion of the disc-shaped base metal by the blade portion and thus, it does not solve the aforementioned problem of the cutting chips in cutting of the ceramic substrate having a large lamination number and a large cutting thickness.

[0012] Thus, the present invention has an object to provide a method for producing a head chip and a method for producing an inkjet head which reduce an influence of the cutting chips between the ceramic substrate and the dicing blade when the ceramic substrate is cut or cut off by the dicing blade and enable machining with higher accuracy.

[0013] The other objects of the present invention will be made apparent from the description below.

MEANS FOR SOLVING PROBLEM

[0014] The aforementioned problems are solved by each of the following inventions.

1. A method for producing a head chip comprising:

cutting or cutting-off of a ceramic substrate (10) constituting a head chip (1) in an inkjet head (H) by using a dicing blade (A), wherein
the dicing blade (A) has an annular blade portion (91) made of an abrasive grain layer formed over an entire circumference on both surfaces on peripheral edge sides of a disc-shaped base metal (9);
an inner-peripheral side portion (9a) of the disc-shaped base metal (9), on which the annular blade portion (91) is not formed, is thinner than a peripheral-edge side portion including the annular blade portion (91); and
a width (a) of the annular blade portion (91) in a radial direction is smaller than a cutting depth (b) of the ceramic substrate (10) to be cut or to be cut off.

2. The method for producing a head chip according to 1, wherein

in cutting of the ceramic substrate (10),
the ceramic substrate (10) is bonded onto a dicing sheet (7) made of a resin and fixed, and the dicing blade (A) is advanced to the ceramic substrate (10) from a side opposite to the dicing sheet (7) and cuts off the ceramic substrate (10) and cuts a part of the dicing sheet (7); and
a cutting depth (c) to the dicing sheet (7) is smaller than the width (a) of the annular blade portion (91) in the radial direction.

3. The method for producing a head chip according to 1 or 2 wherein

on the dicing blade (A), a peripheral-surface blade portion (91a) made of an abrasive grain layer is formed on a peripheral side surface of the disc-shaped base metal (9).

4. The method for producing a head chip according to 3, wherein

the peripheral-surface blade portion (91a) is formed flatly along the peripheral side surface of the disc-shaped base metal (9).

5. The method for producing a head chip according to any one of 1 to 4, wherein

the dicing blade (A) is used by sandwiching and fixing the disc-shaped base metal (9) by a pair of flanges (81, 82); and
an arithmetic average roughness (Ra) of a surface of a sandwiched portion of the disc-shaped base metal (9) by the flanges (81, 82) is not smaller than an arithmetic average roughness on a surface of the annular blade portion (91).

6. The method for producing a head chip according to any one of 1 to 5, wherein the dicing blade (A) is used by sandwiching and fixing the disc-shaped base metal (9) by a pair of flanges (81, 82); and a maximum static frictional force moment between the surface of the sandwiched portion of the disc-shaped base metal (9) by the flanges (81, 82) is not smaller than (a) dynamic frictional force moment between the surface of the annular blade portion (91) and the ceramic substrate (10).

7. The method for producing a head chip according to any one of 1 to 6, wherein the annular blade portion (91) is thinner as it goes to the inner peripheral side of the disc-shaped base metal (9) and thicker as it goes to the outer peripheral side of the disc-shaped base metal (9), and its surface is an inclined surface from the inner peripheral side to the outer peripheral side.

8. The method for producing a head chip according to any one of 1 to 6, wherein the annular blade portion (91) is thinner as it goes to the inner peripheral side of the disc-shaped base metal (9) and thicker as it goes to the outer peripheral side of the disc-shaped base metal (9), and its surface has a stepped shape from the inner peripheral side to the outer peripheral side.

9. The method for producing a head chip according to any one of 1 to 8, wherein cutting of the ceramic substrate (10) comprises forming of a plurality of grooves constituting a plurality of channels (13) in the ceramic substrate (10) and forming of a plurality of the juxtaposed channels (13) and a driving partition wall (14) separating the channels (13) from each other.

10. The method for producing a head chip according to any one of 1 to 9, wherein cutting-off of the ceramic substrate (10) comprises cutting-off of the ceramic substrate (10) so as to form at least either one of a nozzle-plate bonding surface 1a to which a nozzle plate (2) on which a plurality of nozzles (2a) is formed is bonded and a wiring-substrate bonding surface (1b) to which a wiring substrate (3) on which a wiring pattern for feeding electricity to the partition wall (14) separating the plurality of channels (13) from each other is formed is bonded.

11. The method for producing a head chip according to 10, wherein in cutting-off of the ceramic substrate (10), in the ceramic substrate (10) before the cutting, grooves constituting a plurality of channels (13) are formed, and an electrode (15) for feeding electricity to a piezoelectric element for generating a capacity change in the channel (13) is formed.

12. The method for producing a head chip according to 10 or 11, wherein in cutting-off of the ceramic substrate (10), on the ceramic substrate (10) before the cutting, a plurality of cutting-chip discharge grooves (21) is formed.

13. A method of producing an inkjet head comprising:

bonding a nozzle plate (2) on which a plurality of nozzles (2a) is formed to a head chip (1) driven by the partition wall (14) on which a plurality of channels (13) is formed by being juxtaposed and separating the channels (13) from each other by corresponding the nozzle (2a) to the channel (13); and

bonding of a wiring substrate (3) on which a wiring pattern for feeding electricity to the partition wall (14) is formed to the head chip (1), wherein

at least either one of a nozzle-plate bonding surface (1a) to which a nozzle plate (2) of the ceramic substrate (10) constituting the head chip (1) is bonded and a wiring-substrate bonding surface (1b) to which the wiring substrate (3) is bonded is formed by cutting-off using the dicing blade (A) according to any one of 1 to 8.

EFFECT OF THE INVENTION

[0015] According to the present invention, the method for producing the head chip and the method for producing the inkjet head which reduce the influence of the cutting chips between the ceramic substrate and the dicing blade when the ceramic substrate is cut or cut off by the dicing blade and enable machining with higher accuracy can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

Fig. 1 is a sectional view illustrating a constitution of a dicing blade used in a method for producing a head chip of the present invention;

Fig. 2 is a sectional view illustrating a cutting process using the dicing blade;

Fig. 3 is a side view illustrating a constitution of a ceramic substrate;

Fig. 4(a) is a perspective view of the ceramic substrate for explaining a state where a channel is formed and Fig. 4(b) is a sectional view of a direction orthogonal to the channel of the ceramic substrate on which the channel is formed;

Fig. 5 is an enlarged view of a channel portion on the ceramic substrate on which an electrode is formed;

Fig. 6 is a sectional view of a laminated substrate on which the six ceramic substrates are laminated;

Figs. 7(a) and 7(b) are sectional views illustrating another embodiment of the laminated substrate on which the six ceramic substrates are laminated;

Fig. 8 is a plan view of the laminated substrate on which a cutting-chip discharge groove is formed;

Fig. 9 is a sectional view of the laminated substrate on which the cutting-chip discharge groove is formed;

Fig. 10 is a front view of the ceramic substrate in which the channel is constituted by an ink channel and an air channel;

Fig. 11 is a sectional view for explaining a state of cutting the laminated substrate;

Fig. 12 is a partially enlarged plan view for explaining a state where the cutting chips flow when the laminated substrate is cut;

Fig. 13 is a sectional view illustrating an example of an inkjet head produced by the present invention;

Fig. 14 is a rear view of a head chip in the inkjet head;

Fig. 15 is a front view of a wiring substrate in the inkjet head;

Fig. 16 is a perspective view of the ceramic substrate for explaining a state where the channel according to another embodiment is formed;

Fig. 17(a) is a plan view of the laminated substrate on which a groove according to another embodiment is formed, and Fig. 17(b) is a sectional view along a b-b line in Fig. 17(a);

Fig. 18 is a sectional view illustrating another example of the constitution of the dicing blade used in the present invention;

Fig. 19 is a sectional view illustrating still another example of the constitution of the dicing blade used in the present invention; and

Fig. 20 is a front view illustrating the constitution of the dicing blade used in a method for producing a prior-art head chip.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0017] An embodiment of the present invention will be described below by using the attached drawings.

[0018] An inkjet head has a head chip on which a plurality of channels which become ink channels is formed by being juxtaposed and a partition wall separating the channels from each other is driven, a nozzle plate on which a plurality of nozzles is formed and each nozzle is bonded to the head chip by corresponding to each channel, and a wiring substrate on which a wiring pattern for feeding electricity to the partition wall is formed and bonded to the head chip. In a method for producing the head chip of the present invention, by using a dicing blade, a ceramic substrate constituting the head chip is cut or cut off.

[Constitution of dicing blade]

[0019] Fig. 1 is a sectional view illustrating a constitution of the dicing blade used in a method for producing the head chip of the present invention.

[0020] The dicing blade A is, as illustrated in Fig. 1, constituted in a disc shape by having a disc-shaped base metal 9. The dicing blade A has a center part of the disc-shaped base metal 9 mounted on a distal end side of a rotating shaft (spindle shaft) 8 of a dicing saw and is rotated/operated through this rotating shaft 8. On the distal end side of the rotating shaft 8, one flange 81 of a disc-shaped pair of flanges 81 and 82 is mounted and then, inserted into a center hole 9b of the disc-shaped base metal 9, and the other flange 82 is mounted by a nut 83. The disc-shaped base metal 9 of the dicing blade A has both surfaces on the center side sandwiched by the pair of flanges 81 and 82 and is fixed to the distal end side of the rotating shaft 8.

[0021] The dicing blade A is constituted by forming an annular blade portion 91 made of an abrasive grain layer over the entire circumference on the both peripheral-edge side surfaces of the disc-shaped base metal 9. The annular blade portion 91 is constituted by brazing the abrasive grains on the disc-shaped base metal 9. For the abrasive grains, super hard abrasive grains such as diamond, hexagonal boron nitride and the like are used. For brazing, a resin or a metal film formed by a gas phase method may be used, but an electroformed film is often used for brazing of the abrasive grains.

[0022] The annular blade portion 91 of the electroformed abrasive grain type is formed by providing an electroformed layer on the surface of the disc-shaped base metal 9 and by embedding the abrasive grains in the electroformed layer. This annular blade portion 91 can be formed by electroforming in a well-known electroforming bath or a nickel plating

bath such as a watts bath, a sulfamic acid bath, an electroless bath and the like. For the electroformed layer, hard metal or alloy such as well-known nickel based metals such as Ni metal or Ni-Co alloy, Ni-W alloy, Ni-P alloy and the like can be preferably used. Hardness of these nickel-based metals is approximately 150 to 600 Hz in general. An optimal embedding rate of the abrasive grains depends on an application of the annular blade portion 91 but it is relatively as high as 60 to 70%, 70 to 80%, 80 to 90%, 90 to 100% and the like. The embedding rate is an average thickness of the electroformed layer to an average grain size of the abrasive grains.

[0023] In this dicing blade A, an inner-peripheral side portion (9a) of the disc-shaped base metal (9), on which the annular blade portion (91) is not formed, is thinner than a peripheral-edge side portion including the annular blade portion 91. This difference in thickness is a thickness corresponding to a total of the thickness of the annular blade portion 91 on the both surfaces. The thickness of the annular blade portion 91 is approximately 5 to 20 μm , for example. The thickness of the disc-shaped base metal 9 is approximately 200 to 400 μm , for example.

[0024] Cutting or cutting-off of the ceramic substrate 10 by using the dicing blade A is preferably performed by causing the ceramic substrate 10 to be bonded to a dicing sheet 7 made of a resin and fixed. In this case, the dicing blade A is advanced to the fixed ceramic substrate 10 while being rotated from a side opposite to the dicing sheet 7 so as to cut or cut off the ceramic substrate 10.

[0025] In this dicing blade A, a width a of the annular blade portion 91 in a radial direction is smaller than a cutting depth b of the ceramic substrate 10 to be cut. The width a in the radial direction is preferably not larger than approximately (1/2) times of the cutting depth b of the ceramic substrate 10. The width a in the radial direction is approximately 300 μm , for example (when the cutting depth b of the ceramic substrate 10 is not smaller than 600 μm).

[0026] As described above, since the inner-peripheral side portion 9a of the disc-shaped base metal 9 is thinner than the peripheral-edge side portion and the width a of the annular blade portion 91 in the radial direction is smaller than the cutting depth b of the ceramic substrate 10, a gap is generated between both cutting surfaces 10b, 10b by the annular blade portion 91 on the both surfaces and the inner-peripheral side portion 9a of the disc-shaped base metal 9. In this gap, a cutting chip 10a remains and is discharged with rotation of the dicing blade A. Since the cutting chip 10a remains in the gap, it does not further cut the cutting surfaces 10b, 10b. Therefore, according to this dicing blade A, the ceramic substrate 10 with a thickness can be cut with accuracy. That is, the both cutting surfaces 10b, 10b formed by the annular blade portion 91 on the both surfaces are made flat surfaces accurately in parallel with each other. A degree of parallelism between the both cutting surfaces 10b, 10b is such that a difference in the thickness between one end portion and the other end portion of the head chip to be manufactured is less than 10 μm , for example.

[0027] Therefore, in this method for producing the head chip, variation in the shape of the channels 13 can be suppressed, and variation in ejection performances among nozzles of the inkjet head, defective adhesion of the nozzle plate bonded to the head chip, defective adhesion of the wiring substrate to the head chip and defective conduction can be suppressed.

[0028] The dicing blade described in the aforementioned Patent Document 3 has an object to suppress expansion of the disc-shaped base metal by the blade portion and thus, such a situation that the width of the annular blade portion in the radial direction becomes smaller than the cutting depth is not assumed, and an effect that the influence of the cutting chip is avoided, and machining accuracy is improved cannot be obtained.

[0029] In the dicing blade A, a peripheral-surface blade portion 91a made of an abrasive grain layer is preferably formed also on a peripheral side surface of the disc-shaped base metal 9. This peripheral-surface blade portion 91a is formed by a material and a forming method similar to those of the annular blade portion 91. Since this peripheral-surface blade portion 91a is formed, such a situation that the disc-shaped base metal 9 is deviated and a cutting position is shifted does not occur, and the ceramic substrate 10 is not cut diagonally.

[0030] Moreover, the peripheral-surface blade portion 91a is formed flatly along the peripheral side surface of the disc-shaped base metal 9. Since the peripheral-surface blade portion 91a is formed flatly, a burr is not left on the cutting surface.

[0031] Fig. 2 is a sectional view illustrating a cutting process using the dicing blade A.

[0032] As illustrated in Fig. 2, in this dicing blade A, it is effective also in a process of cutting the ceramic substrate 10 that the width a of the annular blade portion 91 in the radial direction is smaller than the cutting depth (that is, the thickness of the ceramic substrate 10) b of the ceramic substrate 10 and that the peripheral-surface blade portion 91a is formed flatly. In order to cut the ceramic substrate 10, the ceramic substrate 10 is bonded onto the dicing sheet 7 made of a resin and fixed, and the dicing blade A is advanced to the ceramic substrate 10 from the side opposite to the dicing sheet 7. At this time, the ceramic substrate 10 is cut off, and a part of the dicing sheet 7 is cut.

[0033] The cutting depth c to the dicing sheet 7 at this time is preferably smaller than the width a of the annular blade portion 91 in the radial direction. The thickness of the dicing sheet 7 is approximately 100 to 200 μm in general. The cutting depth c to the dicing sheet 7 is a thickness obtained by subtracting approximately 30 to 100 μm from the thickness of the dicing sheet 7, for example.

[0034] If the cutting depth c to the dicing sheet 7 is larger than the width a of the annular blade portion 91 in the radial direction, that is, if the entire width of the annular blade portion 91 goes through the opposite side of the ceramic substrate 10, since the dicing sheet 7 is softer than the ceramic substrate 10, the peripheral edge portion of the dicing blade A is

not stabilized, and there is a concern that a resin material forming the dicing sheet 7 causes vibration and there is a concern that the ceramic substrate 10 is cut off diagonally or the interval between the both cutting surfaces 10b, 10b formed by the annular blade portion 91 on the both surfaces becomes wider. By making the cutting depth c to the dicing sheet 7 smaller than the width a of the annular blade portion 91 in the radial direction, the peripheral edge portion of the dicing blade A is stabilized, the ceramic substrate 10 with a thickness can be cut with accuracy, and the both cutting surfaces 10b, 10b formed by the annular blade portion 91 on the both surfaces are made flat surfaces accurately in parallel with each other.

[0035] In this cutting process, too, the cutting chip 10a remains in the gap between the both cutting surfaces 10b, 10b by the annular blade portion 91 on the both surfaces and the inner-peripheral side portion 9a of the disc-shaped base metal 9 and does not further cut the cutting surfaces 10b, 10b. Therefore, according to this dicing blade A, the ceramic substrate 10 with a thickness can be cut with accuracy. That is, the both cutting surfaces 10b, 10b formed by the annular blade portion 91 on the both surfaces are made flat surfaces accurately in parallel with each other.

[0036] In this dicing blade A, an arithmetic average roughness Ra on the surface of a sandwiched portion by the flanges 81 and 82 of the disc-shaped base metal 9 is preferably not smaller than the arithmetic average roughness (0.2 to 0.3 μm or more) on the surface of the annular blade portion 91. The arithmetic average roughness Ra is a parameter representing the surface roughness acquired on the basis of JIS (Japanese Industrial Standards) B0601: 1994 and is specifically expressed by the following equation:

[Formula 1]

$$Ra = \frac{1}{L} \int_0^L |f(x)| dx$$

[0037] Since the arithmetic average roughness Ra on the surface of the sandwiched portion by the flanges 81, 82 is not smaller than the arithmetic average roughness on the surface of the annular blade portion 91, the dicing blade A can prevent start of idling with respect to the flanges 81, 82 in the process of cutting of cutting-off the ceramic substrate 10.

[0038] Moreover, the dicing blade A preferably has a maximum static frictional force moment (maximum static frictional force x distance from rotation center) between the surface of the sandwiched portion by the flanges 81, 82 of the disc-shaped base metal and the flanges 81, 82 not smaller than a dynamic frictional force moment (dynamic frictional force x distance from rotation center) between the surface of the annular blade portion 91 and the ceramic substrate 10.

[0039] Since the maximum static frictional force moment between the surface of the sandwiched portion by the flanges 81, 82 and the flanges 81, 82 is not smaller than a dynamic frictional force moment between the surface of the annular blade portion 91 and the ceramic substrate 10, the dicing blade A does not start idling with respect to the flanges 81, 82 in the process of cutting or cutting-off the ceramic substrate 1.

[Manufacturing process of head chip]

[0040] One example of the method for producing the head chip of the present invention will be described by using Figs. 3 to 12.

[0041] Fig. 3 is a side view illustrating the constitution of the ceramic substrate.

[0042] First, as illustrated in Fig. 3, two piezoelectric element substrates 12a, 12b are subjected to poling process, respectively, are bonded onto the substrate 11 made of ceramics so as to create the ceramic substrate 10 constituting the head chip having a piezoelectric element layer on the surface.

[0043] As a piezoelectric material used in each of the piezoelectric element substrates 12a, 12b, a well-known piezoelectric material generating deformation by application of a voltage such as lead zirconate titanate (PZT) can be used, for example. The two piezoelectric element substrates 12a, 12b are laminated with the polling directions (indicated by arrows) directed to directions opposite to each other and are bonded to the substrate 11 by using an adhesive.

[Channel forming process (cutting process)]

[0044] Fig. 4(a) is a perspective view of the ceramic substrate for explaining a state where a channel is formed, and Fig. 4(b) is a sectional view of a direction orthogonal to the channel of the ceramic substrate on which the channel is formed.

[0045] This method for producing the head chip has, as illustrated in Fig. 4, a process of forming a plurality of grooves constituting a plurality of the channels 13 on the ceramic substrate 10. This process can be performed by cutting using the dicing blade A which is a rotary blade but may be performed by another method. When the dicing blade A is used, in this process, a plurality of the parallel channels 13 is cut into groove shapes by using the dicing blade A across the two piezoelectric element substrates 12a and 12b from the surface of the ceramic substrate 1.

[0046] As a result, driving walls 14 made of the piezoelectric elements with the polling directions opposite in a height direction are juxtaposed between the adjacent channels 13.

[0047] When this process is performed by using the aforementioned dicing blade A, the width of the groove constituting the channel 13 can be cut with accuracy. That is, the both side walls of the width are made flat surfaces accurately in parallel with each other.

[0048] Here, since the channel 13 is formed from before one end to before the other end of the ceramic substrate 10, both ends of the channel 13 in the length direction do not reach the end portions of the ceramic substrate 10 and are not open to sides of the ceramic substrate 10.

[0049] Moreover, though not shown, it may be so configured that, by using the piezoelectric element substrate 12b which is made thicker instead of using the substrate 11 and by cutting the channel 13 from the thinner piezoelectric element substrate 12a side to a middle part of the thicker piezoelectric element substrate 12b, a part of the substrate 11 is formed integrally by a piezoelectric element substrate 12b at the same time as the driving wall 14 with the polling direction opposite in the height direction is formed.

[Electrode forming process]

[0050] Fig. 5 is an enlarged view of the channel portion in the ceramic substrate on which the electrode is formed.

[0051] In this method for producing the head chip, in the process of cutting the ceramic substrate 10, grooves constituting the plurality of channels 13 are formed on the ceramic substrate 10 before cutting as described above, and an electrode 15 for feeding electricity to the piezoelectric element generating a capacity change of the channel 13 is formed.

[0052] That is, as illustrated in Fig. 5, the electrode 15 is formed on an inner surface of each of the channels 13.

[0053] As metal forming the electrode 15, Ni, Co, Cu, Al and the like can be used, and Al or Cu is preferably used in terms of electric resistance, but Ni is preferably used in terms of erosion, strength, and a cost. A laminating structure in which Au is further laminated on Al may be also used. As a method of forming the electrode 15, in addition to a plating method, a method of forming a metal film by a method using a vacuum device such as a deposition method, a sputtering method, CVD (chemical vapor deposition) and the like can be cited.

[0054] Since the electrode 15 needs to be independent for each channel 13, the metal film is prevented from being formed on an upper end surface of the driving wall 14. Thus, the electrode 15 is formed selectively on a side surface of each of the driving walls 14 facing an inside of the channel 13 and a bottom surface of each channel 13 by bonding a dry film in advance on the upper end surface of each driving wall 14 or by forming a resist film, and they are removed after the metal film is formed.

[0055] In description of the manufacturing process of the head chip below, illustration of the electrode 15 is omitted.

[Laminated substrate manufacturing process]

[0056] Fig. 6 is a sectional view of the laminated substrate in which six ceramic substrates are laminated.

[0057] Subsequently, through lamination using a plurality of (six, here) ceramic substrates 10 produced as above, a laminated substrate 20 which is a laminated object of the ceramic substrates 10 is produced.

[0058] The lamination structure of the plurality of ceramic substrates 10 does not matter much and as illustrated in Fig. 6, for example, open surfaces of upper surfaces in the channels 13 are aligned in the same direction and three each channels 13 are aligned in the length direction and laminated as a set, the upper surface of the channel 13 on the uppermost layer of each set is faced with each other, and the both are bonded integrally by sandwiching a cover substrate 16 made of ceramics between them so that the laminated substrate 20 having six rows of the channels 13 can be produced.

[0059] Figs. 7(a) and 7(b) are sectional views illustrating another embodiment of the laminated substrate in which the six ceramic substrates are laminated.

[0060] Besides, as illustrated in Fig. 7(a), the directions of the open surfaces in the channels 13 of ceramic substrates 10 are all aligned to the same direction and laminated so that the open surface of the channel 13 on its most-end layer is covered by the cover substrate 16, whereby the laminated substrate 20 having six channel rows may be formed. Moreover, as illustrated in Fig. 7(b), the open surfaces of the channels 13 in the two ceramic substrates 10 are faced with each other, and the laminated substrate 20 having six channel rows may be formed by using three sets of the laminated bodies each having two channel rows sandwiching the cover substrate 16 between the both.

[Cutting-chip discharge groove forming process]

[0061] Fig. 8 is a sectional view of the laminated substrate in which the cutting-chip discharge groove is formed, and Fig. 9 is a plan view of the laminated substrate in which the cutting-chip discharge groove is formed.

[0062] In this method for producing the head chip, in the process of cutting the ceramic substrate, a plurality of cutting-chip discharge grooves 21 is preferably formed in the ceramic substrate before the cutting. That is, in the laminated

substrate 20, as illustrated in Figs. 8 and 9, the cutting-chip discharge groove 21 having a predetermined depth is formed.

[0063] Here, the cutting-chip discharge groove 21 is formed in the laminated substrate 20 illustrated in Fig. 6. The cutting-chip discharge groove 21 is formed from one surface (an upper surface in Fig. 8) of the laminated substrate 20 toward the other surface (a lower surface in Fig. 8), a direction crossing the channel 13 or preferably along a direction orthogonal to the length direction (a right-and-left direction in Figs. 8 and 9) of the channel 13.

[0064] The cutting-chip discharge groove 21 is preferably formed over all the channels 13 of the laminated substrate 20 by using the dicing blade (not shown) and recessed so as to have a depth from the surface of the ceramic substrate 10 on the uppermost layer in Fig. 8 to the channel 13 in the ceramic substrate 10 on the lowermost layer or preferably a depth not smaller than the depth of the channel 13 of the ceramic substrate 10 on the lowermost layer.

[0065] Here, the depth not smaller than the depth of the channel 13 refers to the depth not smaller than the depth from the one surface of the laminated substrate 20 to the bottom surface of the channel 13 in the ceramic substrate 10 on the lowermost layer. The bottom surface of the channel 13 refers to the surface on the lower side in the channel 13 in the laminated substrate 20 at a portion on which the cutting-chip discharge groove 21 is formed. The laminated substrate 20 illustrated in Fig. 8 has a taper portion 13a where both ends of the channel 13 become gradually shallow grooves, and when the cutting-chip discharge groove 21 is to be formed at a position of this taper portion 13a, the surface of the taper portion 13a in the channel 13 of the ceramic substrate 10 on the lowermost layer becomes the bottom surface of the channel 13.

[0066] Moreover, in the case of the laminated substrate 20 illustrated in Fig. 7(a), the cover substrate 16 is disposed on the lowermost layer, but in this case, the bottom surface of the channel 13 of the ceramic substrate 10 on the lowermost layer is an upper surface 16a (the face facing the inside of the channel 13) of the cover substrate 16.

[0067] Fig. 10 is a front view of the ceramic substrate in which the channel is constituted by an ink channel and an air channel.

[0068] Furthermore, there is a head chip in which the ink channel ejecting an ink and an air channel not ejecting the ink are alternately juxtaposed. In this case of each channel of the ceramic substrate 10, as illustrated in Fig. 10, the depth of the air channel 132 is formed larger than the depth of the ink channel 131 in some cases. When the ceramic substrates 10 having the ink channels 131 and the air channels 132 with different depths as above are laminated in plural as in Fig. 6 or Fig. 7(b), the bottom surface of the channel 13 refers to the bottom surface of the air channel 132 with the depth deeper in the ceramic substrate 10 on the lowermost layer.

[0069] This cutting-chip discharge groove 21 is also to prevent clogging, in the channel 13, of the cutting chips generated in the full-cut of the laminated substrate 20 which will be describe later. By making the cutting-chip discharge groove 21 having the depth not smaller than the depth from the one surface of the laminated substrate 20 to the bottom surface of the channel 13 of the ceramic substrate 10 on the lowermost layer, the cutting-chip discharge groove 21 completely divides all the channels 13 in each row over the thickness direction of the laminated substrate 20 and thus, discharge of the cutting chips generated in the cutting process which will be described later can be made favorable. Moreover, since the cutting-chip discharge groove 21 can be formed only from the one surface (upper surface on the uppermost layer) of the laminated substrate 20, there is a merit that a forming work of the cutting-chip discharge groove 21 can be simplified.

[0070] The cutting-chip discharge grooves 21 are formed at a predetermined interval along the length direction of the channel 13. The number of the cutting-chip discharge grooves 21 is set as appropriate in accordance with the length of the channel 13 (interval between the cut portions) of the head chip to be produced. The number of the cutting-chip discharge grooves 21 is preferably 2 or more, but a portion of the cutting-chip discharge groove 21 in the laminated substrate 20 is not necessary any more after cutting out the head chip 1 and thus, if the number is too large, the number of head chips 1 to be taken becomes smaller. Therefore, the number of cutting-chip discharge grooves 21 is preferably up to 4 to 5. The width of the cutting-chip discharge groove 21 is regulated by a width cut by the dicing blade.

[0071] In this method for producing the head chip, the cutting chips generated in cutting by the dicing blade A in the cutting process which will be described later is discharged through the cutting-chip discharge groove 21. By using the aforementioned dicing blade A, the cutting chips are reduced as compared with those in the past and thus, the cutting-chip discharge groove 21 is not clogged easily, the discharge of the cutting chips is made stable, and stable cutting can be realized.

[0072] As a working blade when this cutting-chip discharge groove 21 is machined, the dicing blade A used in the full-cut of the laminated substrate 20 in the cutting process which will be described later is preferably used. As a result, after the cutting-chip discharge groove 21 is formed, the process can proceed to the cutting process immediately.

[0073] Each cutting-chip discharge groove 21 is preferably formed such that, when it is recessed in the depth direction from the upper surface of the laminated substrate 20, at least one end in its length direction (up-and-down direction in Fig. 9) is opened to the side (upper side or lower side in Fig. 9) of the laminated substrate 20. As a result, the cutting chips generated in the full-cut can be discharged from the side of the laminated substrate 20 (each ceramic substrate 10) to an outside through the cutting-chip discharge groove 21.

[0074] Moreover, by forming each cutting-chip discharge groove 21 to completely cross the laminated substrate 20

from one side end to the other side end as illustrated in Fig. 9 so that both ends of the cutting-chip discharge groove 21 in the length direction are open to the sides of the laminated substrate 20, respectively, the discharge of the cutting chips to the outside can be performed more smoothly, which is preferable.

5 [Cutting process (cutting-out of head chip)]

[0075] Fig. 11 is a sectional view for explaining a state of cutting the laminated substrate.

[0076] Subsequently, by performing the full-cut (cutting) on the laminated substrate 20 at a plurality of cutting portions C arranged at a predetermined interval along the direction orthogonal to the length direction of the channel 13 by using the dicing blade A as illustrated in Fig. 11, a plurality of the head chips 1 having the channel 13 with a predetermined length is cut out.

[0077] Here, by providing the plurality of cutting portions C at the same pitch P on the laminated substrate 20 illustrated in Fig. 8, the length of the channel 13 in the head chip 1 to be cut out becomes the same at the pitch P. However, in the present invention, a plurality of types of the head chips 1 with different lengths of channels 13 may be cut out of the single laminated substrate 20 by making the interval between the plurality of cutting portion C different.

[0078] One of the cutting surfaces by the dicing blade A becomes a nozzle-plate bonding surface (front surface 1a) to which the nozzle plate is to be bonded. The nozzle plate is a flat plate on which a plurality of nozzles is formed and is bonded to the head chip 1 with each of the nozzles corresponding to each of the channels 13. Moreover, the other of the cutting surfaces by the dicing blade A becomes a wiring substrate bonding surface (rear surface 1b) to which the wiring substrate is to be bonded. In the present invention, at least either one of the nozzle-plate bonding surface (front surface 1a) and the wiring board bonding surface (rear surface 1b) only needs to be cut out by using the aforementioned dicing blade A, but to cut out the both surfaces is particularly preferable.

[0079] In this method for producing the head chip, by using the aforementioned dicing blade A, variation in an L length (length of the channel 13) in the head chip 1 can be reduced, and variation in head performances among the channels 13 can be suppressed. Moreover, defective adhesion of the nozzle plate, defective adhesion and defective conduction of the wiring substrate can be suppressed. Furthermore, by using the aforementioned dicing blade A, a cutting amount on the wall is decreased, and damage on the electrode 15 is reduced. That is, there has been a concern that the electrode 15 is peeled off when a condition is poor, but such a situation can be reduced.

[0080] When the cutting process of forming a groove constituting the channel 13 and a cutting process of cutting in the direction orthogonal to the length direction of the channel 13 are both performed by using the aforementioned dicing blade A, the width of the groove constituting the channel 13 can be cut with high accuracy and the length (L length) of the channel 13 can be cut with high accuracy and moreover, the machining can be performed by the same dicing blade A and thus, rapid and easy machining is realized.

[0081] In this cutting process, the cutting is performed while a liquid is injected to the vicinity of the dicing blade A. Liquid injection nozzles N, N are arranged in the vicinity of the dicing blade A, respectively, and the liquid is injected toward the surface of the dicing blade A or toward the cutting portion of the laminated substrate 20 to be cut by the dicing blade A from these liquid injection nozzles N, N. As the liquid, water is preferably used.

[0082] Fig. 12 is a partially enlarged plan view for explaining a state where the cutting chips flow when the laminated substrate is cut.

[0083] By injecting the liquid in the full-cut as above, most of the cutting chips cut by the dicing blade A is flicked off by the liquid, but a part of the cutting chips enters into each channel 13 from the cutting surface together with the liquid. However, since each of the channels 13 is faced with the inside of the cutting-chip discharge groove 21, the liquid containing the cutting chips enters into the cutting-chip discharge groove 21 from the channel 13 as indicated by an arrow in Fig. 12 and is discharged to the outside through the cutting-chip discharge groove 21 and thus, it is prevented from remaining inside the channel 13. Thus, unevenness of the cutting surface caused by clogging of the cutting chips in the channel 13 can be prevented.

[0084] Particularly as illustrated in this embodiment, if the cutting-chip discharge groove 21 is open also to the side of the laminated substrate 20, the liquid containing the cutting chips having entered into the cutting-chip discharge groove 21 can flow out of the end portion of the cutting-chip discharge groove 21 to the outside of the laminated substrate 20 and thus, occurrence of the clogging in the channel 13 can be prevented more reliably.

[0085] The cutting by the dicing blade A is preferably performed from the same surface as the surface where formation of the cutting-chip discharge groove 21 on the laminated substrate 20 is started as illustrated in Fig. 11. When the same dicing blade A is used in the cutting-chip discharge groove forming process and the cutting process, there is no need to move the laminated substrate 20 after the forming work of the cutting-chip discharge groove 21 on the laminated substrate 20 but the cutting process can be performed as it is, whereby the work process can be simplified.

[0086] The cutting portion C where the cutting is performed by the dicing blade A is provided at least at two spots between the adjacent cutting-chip discharge grooves 21 in the laminated substrate 20. As a result, at any cutting portion C, the cutting chips can be discharged by at least either one of the adjacent two cutting-chip discharge grooves 21.

[0087] As illustrated in Fig. 11, the cutting portion C is arranged at a portion different from the cutting-chip discharge groove 21 in the laminated substrate 20. That is, in the cutting-chip discharge groove forming process, the cutting-chip discharge groove 21 is formed only at a position excluding the cutting portion C assumed in the subsequent cutting process. As a result, when the head chip 1 is cut out, the flat cutting surface on which the cutting-chip discharge groove 21 is not formed is obtained.

[0088] Moreover, as illustrated in Fig. 11, a distance d between the one cutting-chip discharge groove 21 and the cutting portion C which is the closest to this cutting-chip discharge groove 21 is shorter than a predetermined length (P, here) of the channel 13 in the head chip 1. That is, in the cutting-chip discharge groove forming process, the cutting-chip discharge groove 21 formed at a position adjacent to the cutting portion C assumed in the subsequent cutting process is arranged at a position where the distance d from the cutting portion C which is the closest to this cutting-chip discharge groove 21 becomes shorter than the predetermined length of the channel 13 in the head chip 1. As a result, discharging performances of the cutting chips are improved. Moreover, a waste caused by discarding of the portion where the cutting-chip discharge groove 21 is formed in the laminated substrate 20 can be reduced.

[0089] In the cutting process, in the full-cut of the laminated substrate 20 at a plurality of the cutting portions C, to first cut the cutting portion C on either one of the end portions in the alignment direction of the cutting portions C (the cutting portion C on the left end in Fig. 11, for example) is preferable in terms of improvement of the subsequent workability. In this case, the cutting-chip discharge groove 21 is preferably arranged on an outer side of the first cutting portion C. That is, in the cutting-chip discharge groove forming process, at least one cutting-chip discharge groove 21 is formed on the outer side of the cutting portion C on either one of the end portions to be cut for the first in a plurality of the cutting portions C assumed in the subsequent cutting process.

[0090] As a result, by means of the cutting-chip discharge groove 21 arranged in the vicinity of the outer side of the cutting portion to be cut for the first where the cutting chips are not discharged easily or preferably at a position where the distance d from the cutting portion C on the end portion is shorter than the predetermined length of the channel 13 of the head chip 1, discharging performances of the cutting chips can be improved effectively, and more flat cutting surfaces can be obtained.

[0091] Moreover, since the cutting-chip discharge groove 21 can be formed at an unnecessary portion on the end portion in the laminated substrate 20, the head chip 1 can be cut out efficiently and without a waste.

[0092] Moreover, the cutting-chip discharge groove 21 formed on the outer side of the cutting portion C as above is preferably formed on the outer sides of the cutting portions C, C on the both end portions in the alignment direction of the plurality of cutting portions C as illustrated in Fig. 11, respectively. As a result, the cutting surfaces of the cutting portions C, C on the both ends can be made cutting surfaces which are flatter than the case where the cutting-chip discharge groove 21 is not formed, and the head chip 1 can be cut out without waste and efficiently.

[0093] According to the present invention, the method for producing the head chip which can reduce the influence of the cutting chips between these ceramic substrate 10 and dicing blade A, when the ceramic substrate 10 is to be cut or cut off by the dicing blade A and enable machining with higher accuracy can be provided.

[0094] In the present invention, by using the aforementioned dicing blade A, machining with better accuracy can be made in the groove machining of the head chip or in the chip cutting.

[0095] Moreover, by using the dicing blade A of the present invention, since the influence of the cutting chips is reduced, damage on the electrode 15 can be decreased in the chip cutting of the ceramic substrate 10 with the electrode 15 provided such as a harmonica head of a shear mode.

[Constitution example of inkjet head]

[0096] An example of the inkjet head using the head chip 1 produced as above will be described by using Figs. 13 to 15.

[0097] Fig. 13 is a sectional view illustrating an example of the inkjet head produced by the present invention.

[0098] In this inkjet head H, as illustrated in Fig. 13, the nozzle plate 2 is bonded to the front surface (nozzle-plate bonding surface) 1a of the head chip 1, and the wiring substrate 3 is bonded to the rear surface (wiring substrate bonding surface) 1b of the head chip 1. On the nozzle plate 2, a nozzle 2a is formed at a position corresponding to each channel 13 of the head chip 1.

[0099] In the head chip 1 produced by using the dicing blade A by the method for producing the head chip according to the present invention, since its cutting surfaces (the front surface 1a, the rear surface 1b) are even, the nozzle plate 2 and the wiring substrate 3 can be bonded with high accuracy. As a result, the workability in the process subsequent to the manufacturing process of the head chip 1 is improved, defective adhesion of the nozzle plate, defective adhesion and defective conduction of the wiring substrate can be suppressed, whereby a yield can be improved.

[0100] On the rear surface 1b of the head chip 1, a lead-out electrode 17 is formed so as to correspond to each channel 13 in a one-to-one manner. One end of each lead-out electrode 17 is electrically connected to the electrode 15 in each channel 13.

[0101] This inkjet head H illustrates a state using the head chip 1 cut out of the laminated substrate 20 in Fig. 7(b).

[0102] Fig. 14 is a rear view of the head chip in the inkjet head.

[0103] As illustrated in Fig. 14, the lead-out electrode 17 corresponding to each channel 13 in an A channel row and an F channel row located on the outermost sides in the channel rows formed on the head chip 1 extends toward an upper end portion or a lower end portion in the rear surface 1b in the head chip 1, respectively, and the lead-out electrode 17 led out from each channel 13 in a B channel row located on an inner side and the lead-out electrode 17 led out from each channel 13 in a C channel row adjacent to that are extended in directions opposite to each other and are arranged between the B channel row and the C channel row so as not to be short-circuited with each other. Moreover, the lead-out electrode 17 led out from each channel 13 in a D channel row and the lead-out electrode 17 led out from each channel 13 in an E channel row adjacent to that are extended in the directions opposite to each other and are arranged between the D channel row and the E channel row so as not to be short-circuited with each other.

[0104] As illustrated in Figs. 13 and 14, the wiring substrate 3 is bonded to the rear surface 1b of the head chip 1 with a predetermined width along an outer peripheral edge of the rear surface 1b. The wiring substrate 3 is made of an insulating material such as glass, ceramics and the like, has a size of such a degree that expands to the side from the periphery of the rear surface 1b of the head chip 1 and has a rectangular opening 31 corresponding to each channel 13 facing the rear surface 1b of the head chip 1. Therefore, inlets of all the channels 13 in the head chip 1 are made to communicate toward the rear through any of the openings 31.

[0105] Fig. 15 is a front view of the wiring substrate in the inkjet head.

[0106] On a front surface (bonding surface with the rear surface 1b of the head chip 1) of the wiring substrate 3, as illustrated in Figs. 13 and 15, wiring electrodes 32 are pattern-formed from a peripheral edge of the opening 31 to an outer peripheral edge of the wiring substrate 3 at a pitch corresponding to the lead-out electrodes 17 led out from each channel 13 in each channel row in the head chip 1. The wiring substrate 3 is aligned so that these wiring electrodes 32 are electrically connected to the lead-out electrodes 17 in each channel row and are bonded to the rear surface 1b by using an anisotropic conductive film or the like, for example.

[0107] As a result, the electrode 15 in each channel 13 in each channel row is lead out to the side of the head chip 1, respectively, by the lead-out electrode 17 and the wiring electrode 32 of the wiring substrate 3. To the wiring electrode 32 of this wiring substrate 3, one end of an FPC6 for applying a driving signal from the driving circuit (not shown) to the electrode 15 in each channel 13 in each channel row, respectively, is electrically connected by being bonded by using anisotropic conductive film or the like, for example.

[0108] As a result, to the electrode 15 of each channel 13 in the head chip 1, the driving signal from the driving circuit can be applied through the FPC6, and the inkjet head H having the head chip 1 with high density can be easily constituted.

[0109] A common flow-passage member 5 has a surface faced with the rear surface 1b of the head chip 1 open and forms a box shape having a size equal to an outer shape of the wiring substrate 3 as illustrated in Fig. 13. The common flow-passage member 5 forms a space which becomes a common flow passage 51 for supplying the ink in common to all the channels 13 communicating through the opening 31 of the wiring substrate 3 by being bonded to the rear surface of the wiring substrate 3

[Another embodiment]

[0110] Fig. 16 is a perspective view of a ceramic substrate for explaining a state of forming a channel according to another embodiment.

[0111] In the aforementioned description, the channel 13 in the head chip 1 is formed so as to go over from before the one end to before the other end of the ceramic substrate 10, but the present invention may be formed so that the both ends of the channel 13 in the length direction are open to the sides of the ceramic substrate 10, respectively, by forming the channel 13 to completely cross from the one end to the other end of the ceramic substrate 10. In this case, the liquid containing the cutting chips generated in the cutting process can be discharged to the outside by using the end portion of each channel 13, which is preferable.

[0112] Fig. 17(a) is a plan view of a laminated substrate on which a groove according to another embodiment is formed, and Fig. 17(b) is a sectional view along a b-b line in Fig. 17(a).

[0113] In the aforementioned embodiment, by forming the cutting-chip discharge groove 21 so as to completely cross from the one side end to the other side end of the laminated substrate 20, the both ends in the length direction are formed so as to be open to the sides of the laminated substrate 20, respectively, but as illustrated in Fig. 17, the cutting-chip discharge groove 21 may be formed so that the both ends in the length direction are not open to the sides of the laminated substrate 20 by forming the laminated substrate 20 from before the one end to before the other end of the laminated substrate 20.

[0114] The cutting-chip discharge groove 21 in this case has a form open only on the upper surface side where formation of the cutting-chip discharge groove 21 in the laminated substrate 20 is started, but the cutting chips generated in the cutting process are received together with the liquid in this cutting-chip discharge groove 21 and can be further discharged to the upper surface side and thus, clogging of the cutting chips in each channel 13 is prevented.

[0115] Moreover, in the aforementioned description, the cutting-chip discharge groove 21 is formed from the one surface to the other surface, but the groove only needs to be formed from the surface of the laminated substrate 20 along the direction crossing the channel 13, and the groove reaching the surface of the cover substrate 16 may be formed from the upper surface and the lower surface of the laminated substrate 20 in Fig. 11 along the direction crossing the channel 13, for example.

[0116] As described above, in the cutting-chip discharge groove 21, each channel 13 in the laminated substrate 20 is preferably formed so as to communicate with the outside of the laminated substrate 20 through one or a plurality of the grooves, whereby in the cutting process, cutting can be performed while the cutting chips entering into the channel 13 are discharged together with the liquid to the outside of the laminated substrate 20 through the cutting-chip discharge groove 21.

[0117] Moreover, the cutting-chip discharge groove 21 may be formed in the direction (direction from the front side to the depth side on the paper surface of Fig. 11) crossing the lamination direction (up-and-down direction in Fig. 11) of the laminated substrate 20.

[0118] Moreover, in the aforementioned description, the head chip 1 having six channel rows by laminating six ceramic substrates 10 is produced, but the number of laminated ceramic substrates 10 may be one or a plural (other than six). Particularly when the laminated substrate 20 having three or more channel rows by laminating three or more ceramic substrates 10 is subjected to the full-cut, unevenness on the cutting surface caused by generated cutting chips is caused apparently and thus, the present invention can be preferably applied to a case of manufacturing the head chip 1 from the laminated substrate 20 in which three or more ceramic substrates 10 are laminated.

[0119] Furthermore, in the aforementioned description, it is described that the electrode 15 is formed in each channel 13 after the channel 13 is formed on the ceramic substrate 10 and before each ceramic substrate 10 is laminated, but the electrode 15 may be formed by plating or the like in each channel 13 of the head chip 1 after being cut out from the laminated substrate 20.

[0120] Moreover, the head chip or the inkjet head produced by the method for producing the head chip or by the method for producing the inkjet head of the present invention is not limited to those formed with the channels 13 juxtaposed as described above but may be those with the channels 13 disposed two-dimensionally.

[Another form of dicing blade]

[0121] Fig. 18 is a sectional view illustrating another example of the constitution of the dicing blade used in the present invention.

[0122] In the dicing blade A used in the method for producing the head chip of the present invention, the annular blade portion 91 may be made thinner as it goes closer to the inner peripheral side of the disc-shaped base metal 9 and thicker as it goes to the outer peripheral side of the disc-shaped base metal 9, and the surface thereof is made an inclined surface from the inner peripheral side to the outer peripheral side as illustrated in Fig. 18.

[0123] By making the inner peripheral side of the disc-shaped base metal 9 thinner as above, a gap is generated between the both cutting surfaces 10b, 10b by the annular blade portion 91 on the both surfaces and the annular blade portion 91, and the cutting chips 10a remain in this gap. Since the cutting chips 10a remain in the gap, they do not further cut the cutting surfaces 10b, 10b but are discharged favorably. Therefore, the both cutting surfaces 10b, 10b formed by the annular blade portion 91 on the both surfaces are made flat surfaces accurately in parallel with each other. In the annular blade portion 91, the ceramic substrate 10 is preferably cut by an arc portion when groove machining, cutting or the like is performed, and it is preferable that cutting is not performed on the side surface portion.

[0124] Fig. 19 is a sectional view illustrating still another example of the constitution of the dicing blade used in the present invention.

[0125] Moreover, in the dicing blade A used in the method for producing the head chip in the present invention, the annular blade portion 91 may be made thinner as it goes closer to the inner peripheral side of the disc-shaped base metal 9 and thicker as it goes to the outer peripheral side of the disc-shaped base metal 9, and the surface thereof is made in a stepped shape from the inner peripheral side to the outer peripheral side as illustrated in Fig. 19.

[0126] In this case, too, a gap is generated between the both cutting surfaces 10b, 10b by the annular blade portion 91 on the both surfaces and the annular blade portion 91, and the cutting chips 10a remain in this gap. Since the cutting chips 10a remain in the gap, they do not further cut the cutting surfaces 10b, 10b but are discharged favorably. Therefore, the both cutting surfaces 10b, 10b formed by the annular blade portion 91 on the both surfaces are made flat surfaces accurately in parallel with each other.

[Reference Signs List]

[0127]

- 1: head chip
- 1a: front surface (nozzle-plate bonding surface)
1b: rear surface (wiring substrate bonding surface)
- 5 2: nozzle plate
- 2a: nozzle
- 10 3: wiring substrate
- 31: opening
32: wiring electrode
- 15 4: electrode lead-out member
- 4a: front end surface
4b, 4c: side surface
41: second lead-out electrode
- 20 5: common flow passage member
- 51: common flow passage
52: rear wall
53: through hole
- 25 6: FPC
7: dicing sheet
8: rotating shaft
- 30 81: flange
82: flange
83: nut
- 35 9: disc-shaped base metal
- 9a: inner-peripheral side portion
9b: center hole
91: annular blade portion
91a: peripheral-surface blade portion
- 40 10: ceramic substrate
- 11: substrate
12a, 12b: piezoelectric element substrate
13: channel
13a: taper surface
14: driving wall
15: electrode
- 50 16: cover substrate
16a: upper surface
17: first lead-out electrode
- 20: laminated substrate
- 55 21: cutting-chip discharge groove
- A: dicing blade

C: cutting portion
 N: liquid injection nozzle
 P: pitch
 d: distance between groove and cutting portion closest to groove

Claims

1. A method for producing a head chip comprising:

cutting or cutting-off of a ceramic substrate (10) constituting a head chip (1) in an inkjet head (H) by using a dicing blade (A), wherein the dicing blade (A) has an annular blade portion (91) made of an abrasive grain layer formed over an entire circumference on both surfaces on peripheral edge sides of a disc-shaped base metal (9); an inner-peripheral side portion (9a) of the disc-shaped base metal (9), on which the annular blade portion (91) is not formed, is thinner than a peripheral-edge side portion including the annular blade portion (91); and a width (a) of the annular blade portion (91) in a radial direction is smaller than a cutting depth (b) of the ceramic substrate (10) to be cut or to be cut off.

2. The method for producing a head chip according to claim 1, wherein in cutting of the ceramic substrate (10),

the ceramic substrate (10) is bonded onto a dicing sheet (7) made of a resin and fixed, and the dicing blade (A) is advanced to the ceramic substrate (10) from a side opposite to the dicing sheet (7) and cuts off the ceramic substrate (10) and cuts a part of the dicing sheet (7); and a cutting depth (c) to the dicing sheet (7) is smaller than the width (a) of the annular blade portion (91) in the radial direction.

3. The method for producing a head chip according to claim 1 or 2 wherein

on the dicing blade (A), a peripheral-surface blade portion (91a) made of an abrasive grain layer is formed on a peripheral side surface of the disc-shaped base metal (9).

4. The method for producing a head chip according to claim 3, wherein

the peripheral-surface blade portion (91a) is formed flatly along the peripheral side surface of the disc-shaped base metal (9).

5. The method for producing a head chip according to any one of claims 1 to 4, wherein

the dicing blade (A) is used by sandwiching and fixing the disc-shaped base metal (9) by a pair of flanges (81, 82); and an arithmetic average roughness (Ra) of a surface of a sandwiched portion of the disc-shaped base metal (9) by the flanges (81, 82) is not smaller than an arithmetic average roughness on a surface of the annular blade portion (91).

6. The method for producing a head chip according to any one of claims 1 to 5, wherein

the dicing blade (A) is used by sandwiching and fixing the disc-shaped base metal (9) by a pair of flanges (81, 82); and a maximum static frictional force moment between the surface of the sandwiched portion of the disc-shaped base metal (9) by the flanges (81, 82) is not smaller than (a) dynamic frictional force moment between the surface of the annular blade portion (91) and the ceramic substrate (10).

7. The method for producing a head chip according to any one of claims 1 to 6, wherein

the annular blade portion (91) is thinner as it goes to the inner peripheral side of the disc-shaped base metal (9) and thicker as it goes to the outer peripheral side of the disc-shaped base metal (9), and its surface is an inclined surface from the inner peripheral side to the outer peripheral side.

8. The method for producing a head chip according to any one of claims 1 to 6, wherein

the annular blade portion (91) is thinner as it goes to the inner peripheral side of the disc-shaped base metal (9) and thicker as it goes to the outer peripheral side of the disc-shaped base metal (9), and its surface has a stepped shape from the inner peripheral side to the outer peripheral side.

9. The method for producing a head chip according to any one of claims 1 to 8, wherein

cutting of the ceramic substrate (10) comprises forming of a plurality of grooves constituting a plurality of channels

(13) in the ceramic substrate (10) and forming of a plurality of the juxtaposed channels (13) and a driving partition wall (14) separating the channels (13) from each other.

5 10. The method for producing a head chip according to any one of claims 1 to 9, wherein cutting-off of the ceramic substrate (10) comprises cutting-off of the ceramic substrate (10) so as to form at least either one of a nozzle-plate bonding surface 1a to which a nozzle plate (2) on which a plurality of nozzles (2a) is formed is bonded and a wiring-substrate bonding surface (1b) to which a wiring substrate (3) on which a wiring pattern for feeding electricity to the partition wall (14) separating the plurality of channels (13) from each other is formed is bonded.

10 11. The method for producing a head chip according to claim 10, wherein in cutting-off of the ceramic substrate (10), in the ceramic substrate (10) before the cutting, grooves constituting a plurality of channels (13) are formed, and an electrode (15) for feeding electricity to a piezoelectric element for generating a capacity change in the channel (13) is formed.

15 12. The method for producing a head chip according to claim 10 or 11, wherein in cutting-off of the ceramic substrate (10), on the ceramic substrate (10) before the cutting, a plurality of cutting-chip discharge grooves (21) is formed.

20 13. A method of producing an inkjet head comprising:

bonding a nozzle plate (2) on which a plurality of nozzles (2a) is formed to a head chip (1) driven by the partition wall (14) on which a plurality of channels (13) is formed by being juxtaposed and separating the channels (13) from each other by corresponding the nozzle (2a) to the channel (13); and

25 bonding of a wiring substrate (3) on which a wiring pattern for feeding electricity to the partition wall (14) is formed to the head chip (1), wherein

at least either one of a nozzle-plate bonding surface (1a) to which a nozzle plate (2) of the ceramic substrate (10) constituting the head chip (1) is bonded and a wiring-substrate bonding surface (1b) to which the wiring substrate (3) is bonded is formed by cutting-off using the dicing blade (A) according to any one of claims 1 to 8.

Fig. 1

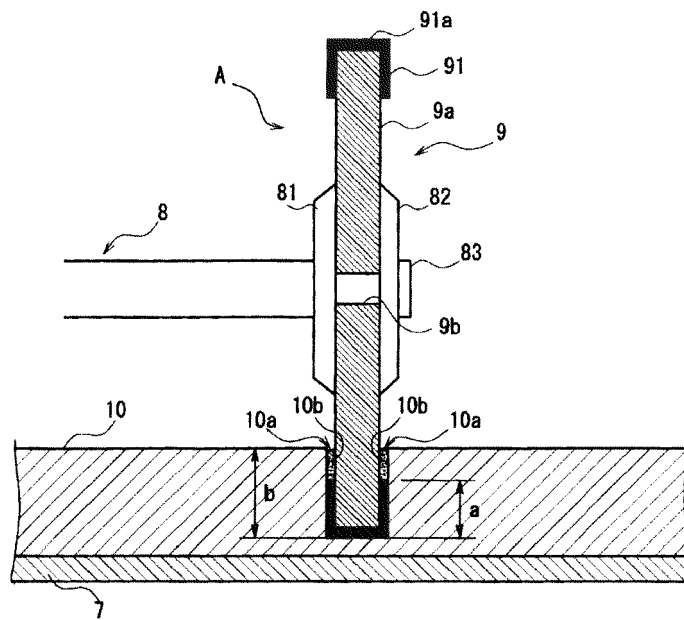


Fig. 2

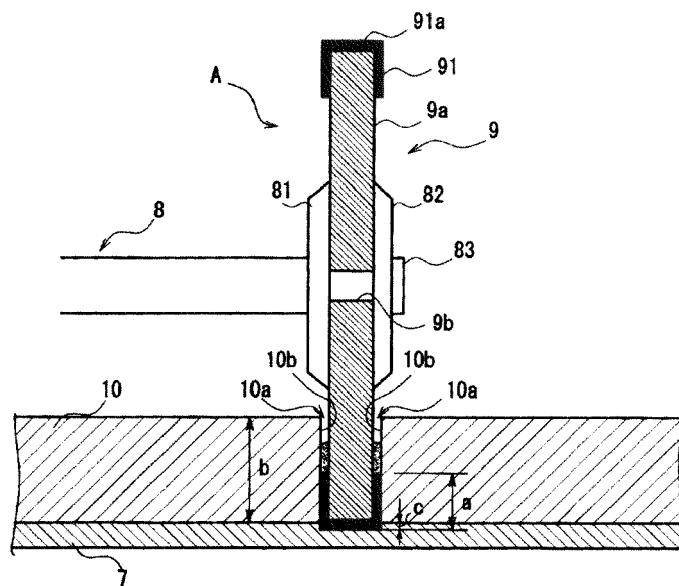


Fig. 3



Fig. 4

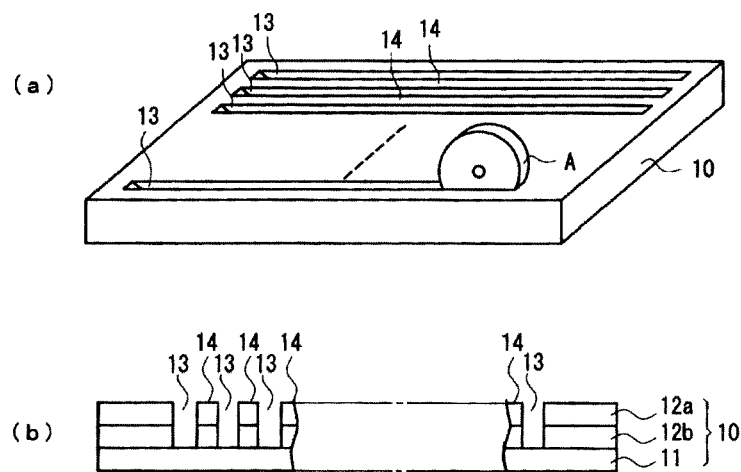


Fig. 5

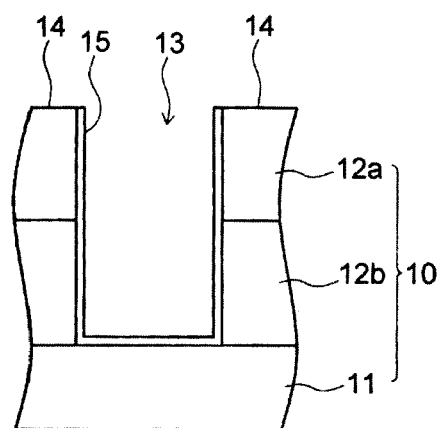


Fig. 6

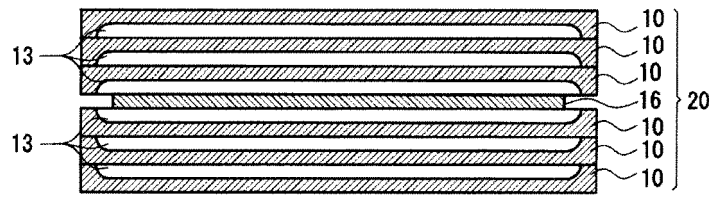


Fig. 7

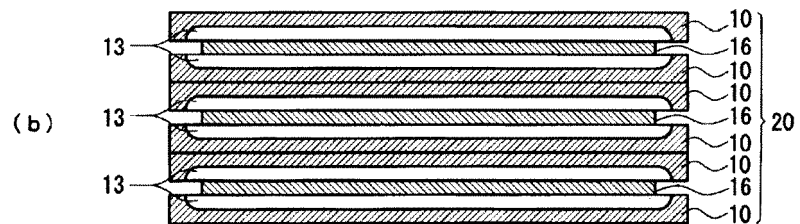
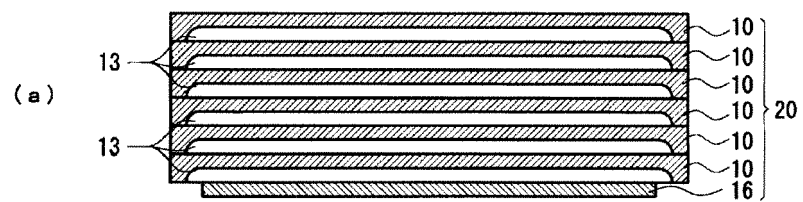


Fig. 8

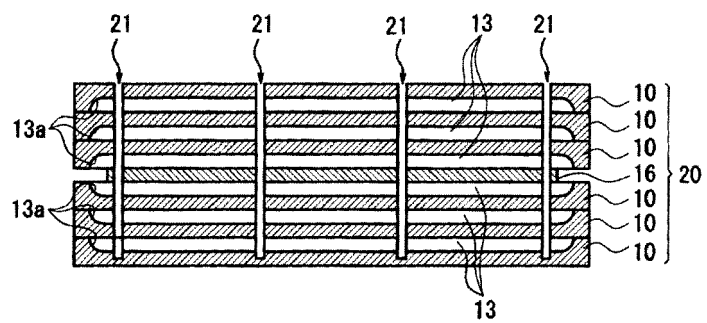


Fig. 9

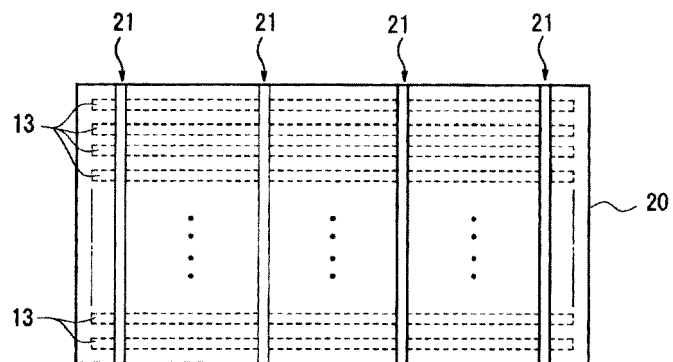


Fig. 10

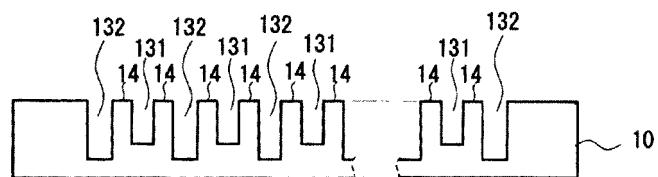


Fig. 11

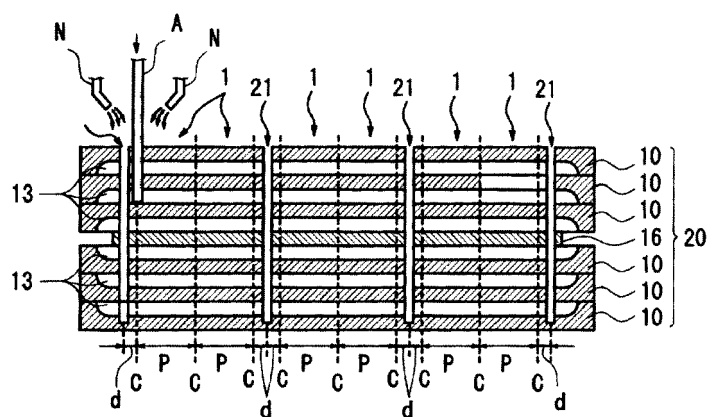


Fig. 12

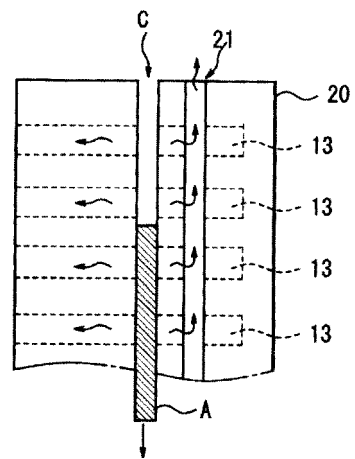


Fig. 13

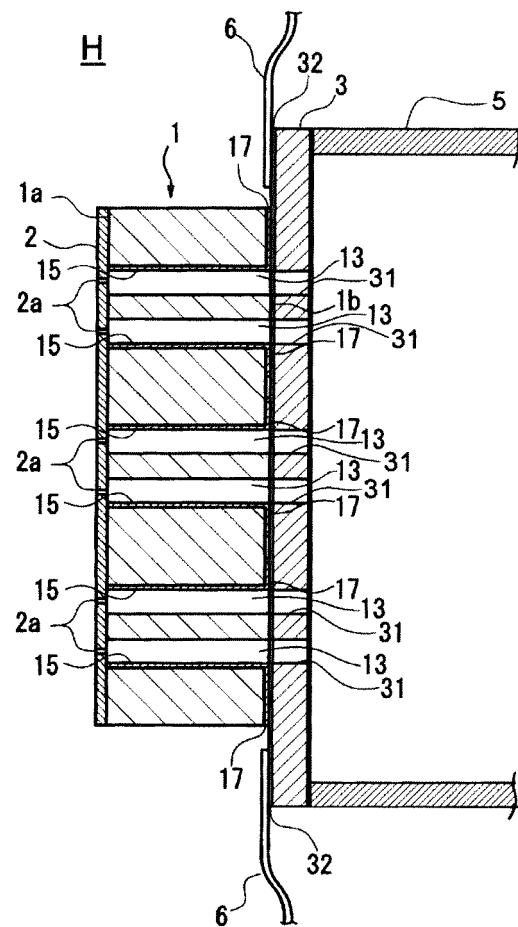


Fig. 14

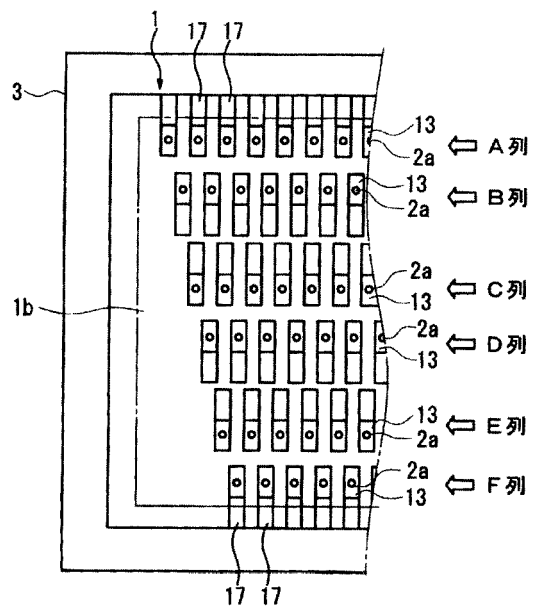


Fig. 15

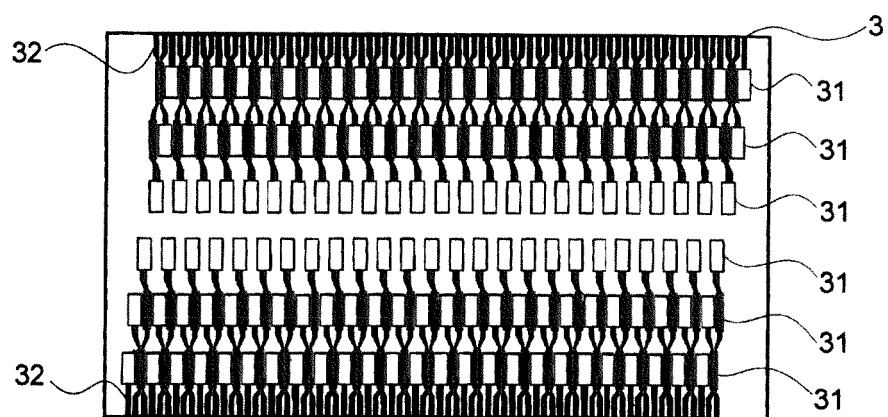


Fig. 16

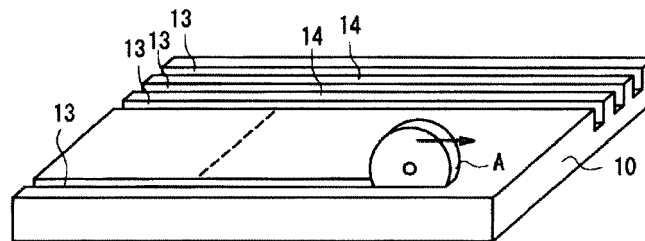


Fig. 17

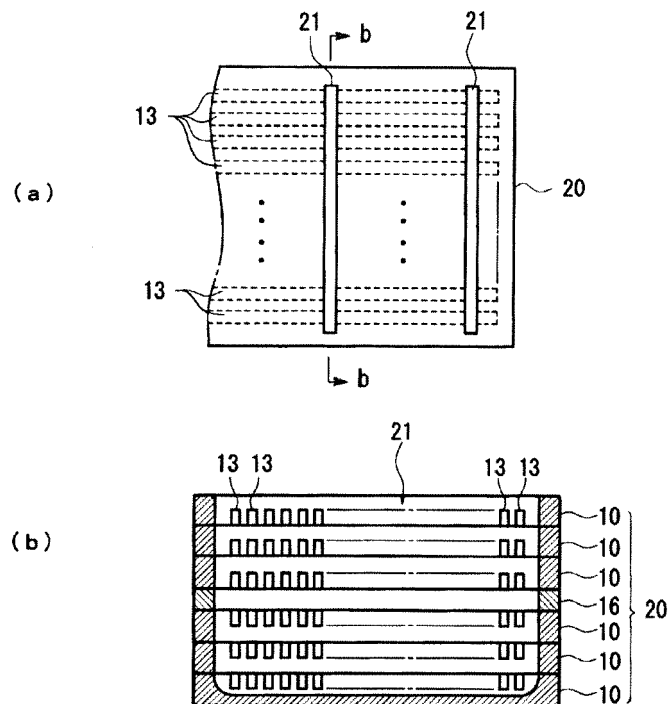


Fig. 18

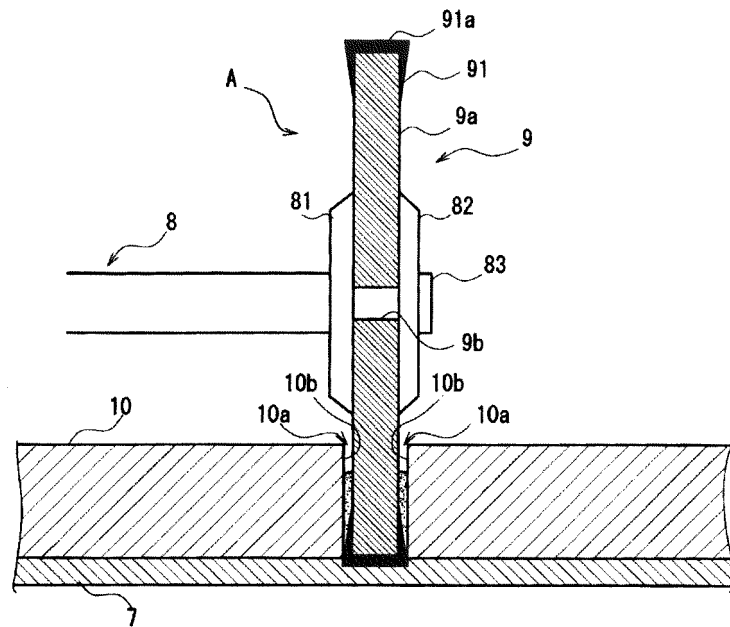


Fig. 19

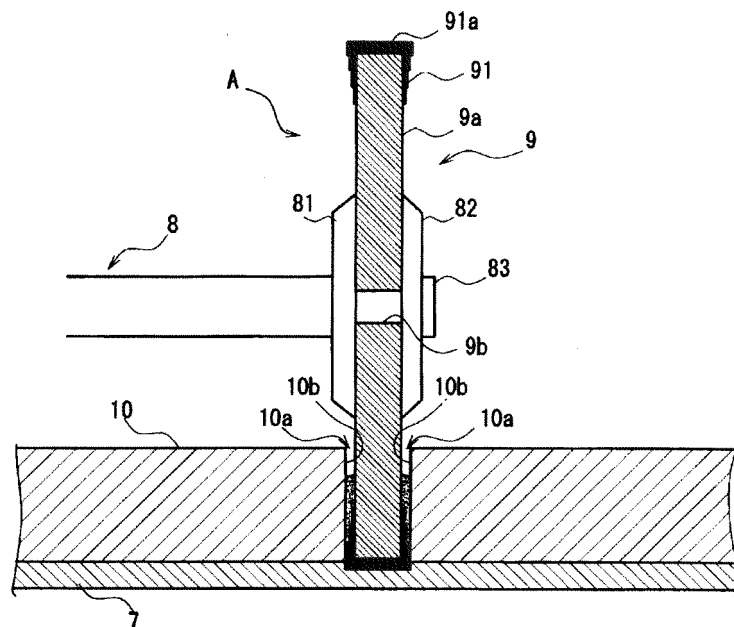
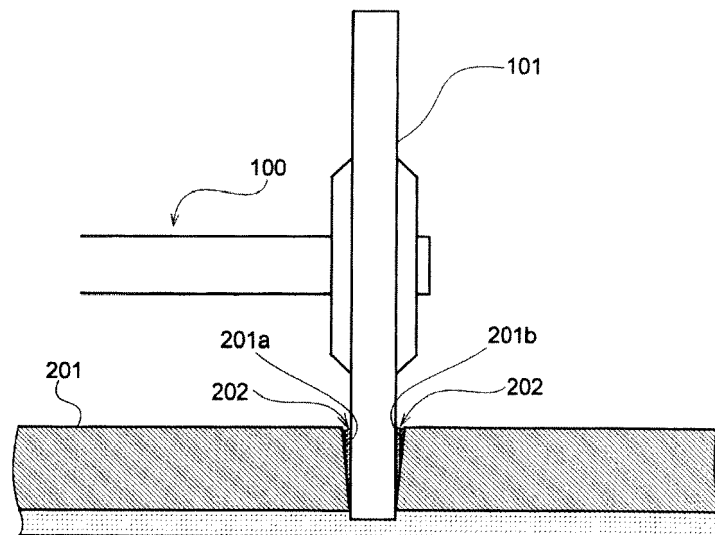


Fig. 20





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Place of search The Hague		Date of completion of the search 9 August 2018	Examiner Dewaele, Karl
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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