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(71) Applicant: **Konica Minolta, Inc.**
Tokyo 100-7015 (JP)

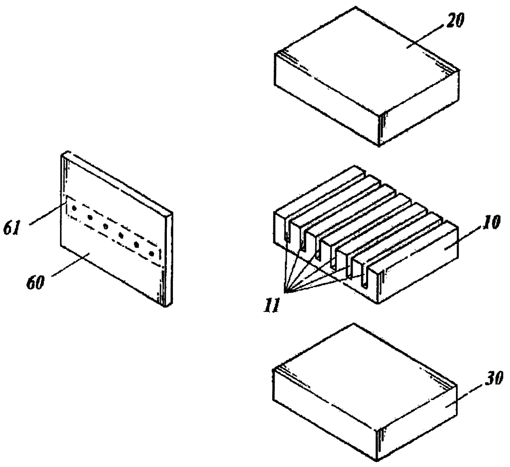
(72) Inventors:
- **YAMADA, Akihisa**
  Tokyo 100-7015 (JP)
- **WATANABE, Toshiki**
  Tokyo 100-7015 (JP)
- **MAKITA, Masahiro**
  Tokyo 100-7015 (JP)
- **HIRANO, Tadashi**
  Tokyo 100-7015 (JP)
- **KURAMOCHI, Shouhei**
  Tokyo 100-7015 (JP)

(74) Representative: **Henkel, Breuer & Partner**
Patentanwälte
Maximiliansplatz 21
80333 München (DE)

(54) INKJET HEAD MANUFACTURING METHOD AND INKJET HEAD

(57) Provided are an inkjet head manufacturing method capable of limiting cost increases while easily maintaining high positional precision of nozzle arrangement, and an inkjet head. The method comprises a first layering process and a first bonding process. The first layering process: layers, via a first adhesive layer, on one surface of a channel member, which is configured from a single member and has a shape in which grooves that will become the ink channels are formed on the one surface and no grooves are formed on the surface on the opposite side, a cover member that is configured from a single member with a different linear expansion coefficient from the channel member; and layers, via a second adhesive layer on the opposite surface, a first thermal deformation-limiting member, which is configured from a single member with a different linear expansion coefficient from the channel member and which limits the thermal deformation that occurs due to the difference in linear expansion coefficients of the channel member and the cover member. The first bonding process heats and cures the first and second adhesive layers simultaneously and bonds the cover member, the channel member, and the first thermal deformation-limiting member.

FIG. 1A



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Description

Technical Field

[0001] The present invention relates to a manufacturing method for an inkjet head, and an inkjet head.

Background Art

[0002] Conventionally, an inkjet printer has an inkjet head having a plurality of nozzles arrayed, and forms an image by controlling the timing at which the ink is discharged from these nozzles in parallel. The inkjet head is provided with an ink flow path (channel) in accordance with each nozzle, and by a predetermined driving operation of deforming this ink flow path at least partly, pressure is applied to the ink in a pressure chamber to let the nozzle discharge the ink.

[0003] As a manufacturing method for this inkjet head, a method is given in which a plurality of grooves is provided for a substrate (channel substrate) that can be deformed by voltage application by using a piezoelectric member such as lead zirconate titanate (PZT), a cover member (lid member) and a base member (bottom member) of a nonpiezoelectric member are stacked on and bonded to an upper surface and a lower surface of these grooves, respectively, thereby covering the grooves with the lid; thus, the ink flow path is formed. For bonding the cover member and the base member, a thermosetting adhesive is often used. Thus, by using the nonpiezoelectric member as the cover member and the base member, the cost reduction can be achieved.

[0004] However, when the inkjet head is manufactured by this method, the material of the channel member and the material of the cover member and the base member are different from each other, resulting in that the expansion coefficient, especially the linear expansion coefficient, is different. As a result, the inkjet may be bent due to the temperature rise in the ink discharge operation. This leads to a problem that in this inkjet head, the nozzle is displaced from a desired position. In view of this, Patent Literature 1 has disclosed the technique that suppresses the warp by adjusting the difference in temperature characteristic between the cover member, the channel member and the base member in a manner that the cover member provided with the rib is used and the rib is partly cut. Moreover, in regard to the technique related to the invention of the present application, Patent Literature 2 has disclosed the technique in which a nozzle unit having a plurality of nozzles arrayed to be bonded to one surface of a flow path member of an inkjet head (channel substrate) and an actuator unit that applies pressure to the ink in each flow path of the flow path member to be bonded to the other surface thereof are subjected to pressure bonding at the same time to assure the bonding.

Citation List

Patent Literatures

[0005]

Patent Literature 1: JP 2007-069475 A
Patent Literature 2: JP 2007-245394 A

Summary of Invention

Technical Problem

[0006] The inkjet head chip in which, with respect to the channel member with one surface provided with the groove serving as the ink flow path and the other surface not provided with the groove, the cover member with the different material is bonded to only the surface provided with the groove has a problem that, in the conventional method, the warp cannot be suppressed and the position accuracy of the nozzle array easily deteriorates.

[0007] An object of the present invention is to provide a manufacturing method for an inkjet head, and an inkjet head, which can maintain the position accuracy of the nozzle array to be high easily while suppressing the increase in cost.

Solution to Problem

[0008] In order to achieve the above object, according to the present invention, an invention of claim 1 is a manufacturing method for an inkjet head that discharges ink out of an ink channel through a nozzle, comprising: a first stacking step of stacking, through a first adhesive layer on one surface of a channel member with a shape having a groove serving as an ink channel formed on the one surface and not having the groove on the opposite surface, a cover member formed of a single member with a different linear expansion coefficient from the channel member, and stacking, through a second adhesive layer on the opposite surface, a first thermal deformation suppression member that is formed of a single member with a different linear expansion coefficient from the channel member and that suppresses thermal deformation caused by the difference in linear expansion coefficient between the channel member and the cover member; and a first bonding step of bonding the cover member, the channel member, and the first thermal deformation suppression member by thermally curing the first adhesive layer and the second adhesive layer at the same time.

[0009] An invention of claim 2 is the manufacturing method for an inkjet head according to claim 1, wherein the linear expansion coefficient of the cover member and the linear expansion coefficient of the first thermal deformation suppression member are both larger than that of the channel member.

[0010] An invention of claim 3 is the manufacturing method for an inkjet head according to claim 1, wherein the linear expansion coefficient of the cover member and the linear expansion coefficient of the first thermal deformation suppression member are both smaller than that of the channel member.

[0011] An invention of claim 4 is the manufacturing method for an inkjet head according to claim 2 or 3, wherein the linear expansion coefficient of the first thermal deformation suppression member is the same as the linear expansion coefficient of the cover member.

[0012] An invention of claim 5 is the manufacturing method for an inkjet head according to any one of claims 1 to 4, wherein the first thermal deformation suppression member has the same shape as the cover member.

[0013] An invention of claim 6 is the manufacturing method for an inkjet head according to any one of claims 1 to 5, wherein the cover member is provided with a penetration pore that communicates with the ink channel and supplies ink to the ink channel, and the first thermal deformation suppression member is provided with a dummy penetration pore that does not communicate with the ink channel.

[0014] An invention of claim 7 is the manufacturing method for an inkjet head according to any one of claims 1 to 6, further comprising, after the first stacking step, a nozzle bonding step of bonding a nozzle formation member provided with the nozzle to one end face at which the ink channel is open in a multilayer body including the cover member, the channel member, and the first thermal deformation suppression member.

[0015] An invention of claim 8 is the manufacturing method for an inkjet head according to claim 7, wherein the nozzle bonding step includes a step of attaching the nozzle formation member to the multilayer body using an adhesive including a thermosetting adhesive.

[0016] An invention of claim 9 is the manufacturing method for an inkjet head according to any one of claims 1 to 6, wherein the nozzle is provided for the cover member.

[0017] An invention of claim 10 is the manufacturing method for an inkjet head according to any one of claims 6 to 8, further comprising after the first bonding step: a second stacking step of stacking, through a third adhesive layer on a surface of the cover member that is opposite to a surface thereof bonded to the channel member, an ink supply member that is formed of a single member and that is provided with a recess serving as an ink supply path for supplying ink supplied from outside to the ink channel through the penetration pore, and stacking, through a fourth adhesive layer on a surface of the first thermal deformation suppression member that is opposite to a surface thereof bonded to the channel member, a second thermal deformation suppression member that is formed of a single member with the same linear expansion coefficient as the ink supply member and that is provided with a dummy recess which does not contribute to the ink supply to the ink channel; and a second bonding step of bonding the cover member and the ink supply member to each other and the first thermal deformation suppression member and the second thermal deformation suppression member to each other by thermally curing the third adhesive layer and the fourth adhesive layer at the same time.

[0018] An invention of claim 11 is an inkjet head for discharging ink out of an ink channel through a nozzle, the inkjet head comprising: a channel member that is formed of a single member and has a shape having a groove serving as an ink channel formed on one surface and not having the groove on the opposite surface; a cover member that is formed of a single member with a different linear expansion coefficient from the channel member and bonded to the one surface of the channel member; and a first thermal deformation suppression member that is formed of a single member with a different linear expansion coefficient from the channel member and bonded to the opposite surface of the channel member to suppress thermal deformation caused by a difference in linear expansion coefficient between the channel member and the cover member.

[0019] An invention of claim 12 is the inkjet head according to claim 11, wherein the linear expansion coefficient of the cover member and the linear expansion coefficient of the first thermal deformation suppression member are both larger than that of the channel member.

[0020] An invention of claim 13 is the inkjet head according to claim 11, wherein the linear expansion coefficient of the cover member and the linear expansion coefficient of the first thermal deformation suppression member are both smaller than that of the channel member.

[0021] An invention of claim 14 is the inkjet head according to claim 12 or 13, wherein the linear expansion coefficient of the first thermal deformation suppression member is the same as the linear expansion coefficient of the cover member.

[0022] An invention of claim 15 is the inkjet head according to any one of claims 11 to 14 , wherein the first thermal deformation suppression member has the same shape as the cover member.

[0023] An invention of claim 16 is the inkjet head according to any one of claims 11 to 15, wherein the cover member is provided with a penetration pore that communicates with the ink channel and supplies ink to the ink channel, and the first thermal deformation suppression member is provided with a dummy penetration pore that does not communicate with the ink channel.

[0024] An invention of claim 17 is the inkjet head according to any one of claims 11 to 16, wherein a nozzle formation member provided with the nozzle is bonded to one end face at which the ink channel is open in a multilayer body including the channel member, the cover member, and the first thermal deformation suppression member.

[0025] An invention of claim 18 is the inkjet head according to claim 17, wherein the nozzle formation member is attached to the multilayer body using an adhesive including a thermosetting adhesive.

[0026] An invention of claim 19 is the inkjet head according to any one of claims 11 to 16, wherein the nozzle is provided for the cover member.

[0027] An invention of claim 20 is the inkjet head according to any one of claims 16 to 18, further comprising: an ink supply member that is formed of a single member, that is provided with a recess serving as an ink supply path for supplying ink supplied from outside to the ink channel through the penetration pore, and that is bonded to the surface of the cover member that is opposite to the surface thereof bonded to the channel member; and a second thermal deformation suppression member that is formed of a single member with the same linear expansion coefficient as the ink supply member, that is provided with a dummy recess which does not contribute to the ink supply to the ink channel, and that is bonded to a surface of the first thermal deformation suppression member opposite to a surface thereof bonded to the channel member.

Advantageous Effects of Invention

[0028] The present invention provides the effect that the inkjet head can be manufactured while the position accuracy of the nozzle array is easily maintained to be high and the cost increase is suppressed.

Brief Description of Drawings

[0029]

Fig. 1A is an exploded view illustrating a structure of an inkjet head according to a first embodiment of the present invention.
Fig. 1B is a diagram illustrating the structure of the inkjet head according to the first embodiment of the present invention.
Fig. 2A is a diagram for describing a manufacturing method for the inkjet head according to the first embodiment.
Fig. 2B is a diagram for describing the manufacturing method for the inkjet head according to the first embodiment.
Fig. 2C is a diagram for describing the manufacturing method for the inkjet head according to the first embodiment.
Fig. 2D is a diagram for describing the manufacturing method for the inkjet head according to the first embodiment.
Fig. 3A is a perspective view illustrating a structure of an inkjet head according to a first modified example.
Fig. 3B is a sectional view illustrating the structure of the inkjet head according to the first modified example.
Fig. 4A is a diagram for describing a manufacturing method for the inkjet head according to the first modified example.
Fig. 4B is a diagram for describing the manufacturing method for the inkjet head according to the first modified example.
Fig. 4C is a diagram for describing the manufacturing method for the inkjet head according to the first modified example.
Fig. 4D is a diagram for describing the manufacturing method for the inkjet head according to the first modified example.
Fig. 5A is a diagram for describing a structure of and a manufacturing method for an inkjet head according to a second modified example.
Fig. 5B is a diagram for describing the structure of and the manufacturing method for the inkjet head according to the second modified example.
Fig. 5C is a diagram for describing the structure of and the manufacturing method for the inkjet head according to the second modified example.
Fig. 5D is a diagram for describing the structure of and the manufacturing method for the inkjet head according to the second modified example.
Fig. 6A is a diagram for describing a structure of and a manufacturing method for an inkjet head according to a third modified example.
Fig. 6B is a sectional view for describing the structure of the inkjet head according to the third modified example.
Fig. 6C is a diagram for describing the structure of and the manufacturing method for the inkjet head according to the third modified example.
Fig. 6D is a diagram for describing the structure of and the manufacturing method for the inkjet head according to the third modified example.
Fig. 7A is a diagram illustrating a structure of an inkjet head according to a second embodiment.
Fig. 7B is a diagram illustrating the structure of the inkjet head according to the second embodiment.
Fig. 7C is a diagram illustrating the structure of the inkjet head according to the second embodiment.
Fig. 8 is a diagram for describing a method of evaluating the nozzle array.
Fig. 9 is a table representing the results of evaluating the nozzle array.

Description of Embodiments

[0030] Embodiments of the present invention will be hereinafter described with reference to the drawings.

[First Embodiment]

[0031] Fig. 1A and Fig. 1B are diagrams illustrating a structure of an inkjet head 100 according to a first embodiment.

[0032] Fig. 1A is an exploded view illustrating the structures of the inkjet head 100, and Fig. 1B is a diagram illustrating the state in which the above structures of the inkjet head 100 are combined.

[0033] The inkjet head 100 includes a channel member 10, a cover member 20, an assistant member 30 (first thermal deformation suppression member), a nozzle plate 60 (nozzle formation member), and the like with a plate-like shape.

[0034] In the inkjet head 100 according to this embodiment, the channel member 10 is a plate-shaped member with its length and width larger than the thickness, and one surface of the channel member 10, i.e., one of front and rear surfaces of the plate is provided with a plurality of grooves 11 serving as ink channels in parallel. Here, for the explanation, the channel member 10 with six grooves is illustrated as an example but the numerals including the length (short-side direction of the plate plane), the width (long-side direction of the plate plane), the depth (thickness direction) and width of each groove 11, the space from the adjacent groove, and the like are defined in accordance with the necessary number of grooves (for example, 256 grooves), the discharge amount of ink, the discharge speed, the resolution, and the like. In this inkjet head 100, the grooves 11 are provided to extend in the length direction on the plate plane of the channel member 10. Bonding the cover member 20 on the surface provided with the grooves 11 causes each of the grooves 11 to serve as a hole-shaped ink flow path 11a (pressure chamber). The channel member 10 is formed of a piezoelectric member (for example, lead zirconate titanate), and in the inkjet head 100 of this embodiment, electrodes are formed on opposite side walls of the ink flow path 11a and by applying voltage between the electrodes having the wall surface between the adjacent ink flow paths 11a held therebetween, the shape of each ink flow path 11a can be changed. The assistant member 30 is bonded to the surface of the channel member 10 opposite to the surface thereof that has the cover member 20 bonded thereto. A nozzle plate 60 is bonded to one side surface of the multilayer body in which the cover member 20, the channel member 10, and the assistant member 30 are stacked.

[0035] The cover member 20 is a ceramic substrate in this embodiment and is not particularly limited; for example, a single member of zirconia (ZrO_2), a silica/alumina compound (SiO_2/Al_2O_3), silicon nitride (Si_3N_4), and the like is selected to be used.

[0036] The nozzle plate 60 is formed of, for example, silicon, and is bonded to one of side surfaces of the multilayer body provided with an open end of the ink flow path 11a. The nozzle plate 60 is provided with nozzle opening portions 61 in accordance with opening positions of the ink flow paths 11a provided in the width direction. In other words, the plural nozzle opening portions 61 are arrayed in the width direction (longitudinal direction) of the inkjet head 100. In the inkjet head 100 of this embodiment, the ink is supplied to each ink flow path 11a from the other open end at which the nozzle plate 60 is not bonded, and the ink is compressed and pressurized along with the deformation of the ink flow paths 11a (pressure chambers) to be discharged out of the nozzle opening portions 61.

[0037] In the inkjet head 100 of this embodiment, one material is selected based on the criterion below and used for the assistant member 30. If the linear expansion coefficient of the cover member 20 is larger than the linear expansion coefficient of the channel member 10, the material with a larger linear expansion coefficient than that of the channel member 10 is selected for the assistant member 30; if the linear expansion coefficient of the cover member 20 is smaller than the linear expansion coefficient of the channel member 10, the material with a smaller linear expansion coefficient than that of the channel member 10 is selected for the assistant member 30.

[0038] Under this condition, the material can be selected so that the linear expansion coefficient of the assistant member 30 can be substantially the same as the linear expansion coefficient of the cover member 20. Further, the material of the assistant member 30 may be the same as the material of the cover member 20.

[0039] In the inkjet head 100 of this embodiment, the assistant member 30 has the same shape as the cover member 20.

[0040] In the inkjet head 100, this assistant member 30 does not contribute to any of the deformation of the pressure chamber or the wires for the voltage supply, the formation of the ink flow path, or the supply of the ink but functions as a thermal deformation suppression member that suppresses the warp caused by the difference in linear expansion coefficient between the channel member 10 and the cover member 20.

[0041] Next, a manufacturing method for the inkjet head 100 according to the first embodiment will be described. Figs. 2A to 2D are diagrams for describing the manufacturing method for the inkjet head 100 according to the first embodiment.

[0042] In the manufacture of the inkjet head 100 of this embodiment, first, the channel member 10 provided with the grooves 11, the cover member 20, and the assistant member 30 are prepared and at normal temperature, an adhesive 15 (first adhesive layer) is applied to a bonding surface between the cover member 20 and the channel member 10 and an adhesive 25 (second adhesive layer) is applied to a bonding surface between the channel member 10 and the assistant member 30 (Step 1, Fig. 2A). The adhesives 15 and 25 used in the manufacture of the inkjet head 100 of this embodiment are both thermosetting adhesives. Next, a multilayer body in which the assistant member 30, the channel member 10, and the cover member 20 are stacked in this order is formed (Step 2, Fig. 2B). Then, the multilayer body is heated integrally to cure the adhesives 15 and 25 at the same time and the assistant member 30 and the cover member 20 are bonded by adhesive layers 15a and 25a to the channel member 10 (Step 3, Fig. 2C). Subsequently, after an adhesive 35 is applied to a bonding surface between the nozzle plate 60 and the side surface portion of the multilayer body at which the members are bonded at normal temperature, the opening portion of the ink flow path 11a and the nozzle opening portion 61 are brought into contact with each other while their positions are aligned. The adhesive 35 used in the manufacture of the inkjet head 100 of this embodiment is also the thermosetting adhesive. Finally, this multilayer body and the nozzle plate 60 are heated to cure the adhesive 35, thereby bonding the nozzle plate 60 to the multilayer body through an adhesive layer 35a (Step 4, Fig. 2D) ; thus, the inkjet head 100 is formed. Of the manufacturing steps above, (Step 1) and (Step 2) constitute a first stacking step and and (Step 3) constitutes a first bonding step. Moreover, (Step 4) constitutes a nozzle bonding step.

[0043] In the inkjet head 100 of the first embodiment as above, of the channel member 10 with one surface provided with the grooves 11 and the opposite surface not provided with the grooves, the surface opposite to the surface bonded to the cover member 20 that covers the grooves 11 to form the ink flow paths 11a (pressure chambers) is bonded to the assistant member 30 that does not contribute to the deformation of the wire and the pressure chamber, the formation of the ink flow path, or the supply of the ink, whereby the function as the thermal deformation suppression member is achieved. In other words, the large warp caused by the bonding of the cover member 20 and the channel member 10 only is suppressed by the assistant member 30 provided on the opposite side; therefore, even in the occurrence of the temperature change when the inkjet head 100 is used, the nozzle array with smaller warp and high accuracy as the entire inkjet head 100 can be obtained.

[0044] Further, when the nozzle plate 60 is thermally attached to the side surface of the multilayer body including the channel member 10, the cover member 20, and the assistant member 30 using the thermosetting adhesive, the warp in the entire multilayer body can be suppressed and in the inkjet head 100 manufactured finally, the deterioration in accuracy of the nozzle array due to the distortion of the nozzle plate 60 can be prevented.

[0045] Since the cover member 20, the channel member 10, and the assistant member 30 are stacked at normal temperature with the adhesives 15 and 25 interposed therebetween and then heated to be attached at the same time, the large warp does not occur at the bonding of the multilayer body.

[0046] The assistant member 30 employs a single member that is selected so that the magnitude relation of the linear expansion coefficient between the cover member 20 and the channel member 10 becomes equal to the magnitude relation of the linear expansion coefficient between the assistant member 30 and the channel member 10; thus, the direction of the warp that is caused depending on the magnitude relation of the linear expansion coefficient with the channel member 10 when the thermosetting adhesive is thermally cured becomes symmetric relative to the channel member 10 to offset the warp as a whole.

[0047] Moreover, since it is not necessary to use the expensive piezoelectric member, which is the same as the channel member 10, for the cover member 20, the accuracy of the nozzle array position can be maintained or improved while the cost increase is suppressed.

[0048] Further, since the warp of the inkjet head 100 as a whole is suppressed, an inexpensive member can be selected to be used for each of the cover member 20 and the assistant member 30.

[0049] Since the large warp is not caused even when the thermosetting adhesive with high stability and certainty is used, the inkjet head 100 with high accuracy and high durability can be obtained.

[0050] On this occasion, the linear expansion coefficient of the channel member 10 may be either larger or smaller than the linear expansion coefficient of the cover member 20 and the assistant member 30 but by setting the linear expansion coefficient to increase the durability based on the strength of the adhesive, the size or the Young's modulus of the cover member 20 and the assistant member 30, and the like, the long-term use with high accuracy can be achieved.

[0051] Moreover, since using the same member for the cover member 20 and the assistant member 30 can make those members have substantially the same warp characteristic, the warp of the bonded multilayer body as a whole can be further suppressed.

[0052] In addition, since making the cover member 20 and the assistant member 30 have the same shape can make those members have substantially the same warp size, the force that causes the warp is applied uniformly to the both sides of the channel member 10, so that the warp of the bonded multilayer body as a whole can be further suppressed.

[First modified example]

[0053] Fig. 3A and Fig. 3B illustrate a structure of an inkjet head 100a according to a first modified example.

[0054] The inkjet head 100a according to the first modified example is the same as the inkjet head 100 according to the first embodiment except the shape of a cover member 20a and the presence or absence of an ink supply port 21a, and the detailed description to the same portion is omitted.

[0055] Fig. 3A is a diagram in which the structures of the inkjet head 100a are bonded. The cover member 20a included in the inkjet head 100a has a shape whose length is different from that of the assistant member 30 and the channel member 10 (length in the ink flow path direction in the channel member 10). This cover member 20a is provided with the ink supply port 21a (penetration pore).

[0056] Fig. 3B is a sectional view taken along a section A-A including one of the ink flow paths 11a in Fig. 3A. This sectional view also shows an ink supply member 40 (manifold) in addition to the structures of Fig. 3A, thereby enabling the easy understanding of the flow of the ink. The ink supply member 40 is formed of, for example, a single member of resin or the like, and bonded to a surface of the cover member 20a that is opposite to the surface thereof bonded to the channel member 10. In this inkjet head 100a, the ink is supplied from an ink chamber recess 41, which is provided for the ink supply member 40 to serve as the ink supply path, to each ink flow path 11a through the ink supply port 21a, and discharged out of the nozzle opening portion 61.

[0057] Figs. 4A to 4D illustrate a manufacturing method for the inkjet head 100a according to the first modified example. First, the uncured adhesives 15 and 25 are applied to the bonding surface between the cover member 20a and the channel member 10 and the bonding surface between the channel member 10 and the assistant member 30, respectively at normal temperature (Fig. 4A) and the members are stacked sequentially to form a multilayer body (Fig. 4B). Next, the whole body is heated to attach the cover member 20a and the assistant member 30 to the channel member 10 at the same time through the adhesive layers 15a and 25a obtained by curing the adhesives 15 and 25. After the adhesive 35 is applied to one end face of the side surfaces of the multilayer body, at which the ink flow paths 11a are open, (Fig. 4C), the nozzle plate 60 is pasted while the position of the ink flow path 11a and the position of the nozzle opening portion 61 are aligned and the adhesive 35 is thermally cured. Thus, the multilayer body and the nozzle plate 60 are bonded to each other through the adhesive layer 35a (Fig. 4D).

[0058] As described above, the inkjet head 100a according to the first modified example employs the cover member 20a and the assistant member 30 with a different size. In the inkjet head, the shape is sometimes asymmetric in point of the size, the function, or the design due to the problem in the arrangement of the ink supply member 40 ; even in this case, the warp as the whole can be reduced by the use of the assistant member 30. Moreover, by setting another shape or material to be asymmetry to offset one asymmetry, the warp as the whole can be suppressed more efficiently and the inkjet head with the accurate nozzle array can be obtained.

[Second modified example]

[0059] Figs. 5A to 5D illustrate a manufacturing method for an inkjet head 100b according to a second modified example.

[0060] The inkjet head 100b according to the second modified example is the same as the inkjet head 100a according to the first modified example except that both a cover member 20b and an assistant member 30b are different in size from the channel member 10 and that any member is provided with a plurality of penetration holes (penetration pores). The same structure is denoted by the same symbol and the detailed description thereto is omitted.

[0061] As illustrated in Fig. 5A, the cover member 20b is provided with ink supply ports 21b for supplying ink individually to the grooves 11 of the channel member 10. On the other hand, the assistant member 30b is also provided with penetration holes 31b. The number, the arrangement, and the shape of the penetration holes 31b are not limited in particular; however, it is more desirable that the influence of the warp by the ink supply ports 21b provided for the cover member 20b when the temperature of the inkjet head 100b is changed can be effectively offset, for example, in the form of providing the penetration holes 31b symmetrically to the channel member 10. In the inkjet head 100b of this embodiment, the penetration holes 31b are provided at the same positions as the ink supply ports 21b of the cover member 20b in the assistant member 30b with the same shape as the cover member 20b.

[0062] In the manufacture of the inkjet head 100b according to the second modified example, first, the adhesives 15 and 25 are applied to the bonding surface between the cover member 20b and the assistant member 30b and the bonding surface between the channel member 10 and the assistant member 30b, respectively at normal temperature (Fig. 5A). Next, these are stacked sequentially to form a multilayer body (Fig. 5B). After that, the adhesives 15 and 25 are thermally cured at the same time to bond the cover member 20b and the assistant member 30b to the channel member 10 with the adhesive layers 15a and 25a interposed therebetween. Then, the adhesive 35 is applied to one end of the side surfaces of the multilayer body, at which the ink flow paths 11a are open, at normal temperature, and the nozzle plate 60 is pasted (Fig. 5C). Then, by thermally curing the adhesive 35, the nozzle plate 60 and the multilayer body are bonded to each other through the adhesive layer 35a (Fig. 5D). Through the above procedure, the inkjet head 100b is formed.

[0063] In this inkjet head 100b, in a manner similar to the inkjet head 100a of the first modified example, the ink is supplied to each ink flow path 11a from the ink supply member 40, which is not shown, provided outside the cover member 20b through the ink supply ports 21b only, and then discharged out of the nozzle plate 60. The penetration holes 31b provided for the assistant member 30b are blocked so as not to communicate with the ink flow paths 11a by the bottom surface of the channel member 10 and serve as the dummy penetration holes that do not contribute to the ink supply.

[0064] As described above, in the inkjet head 100b of the second modified example, the dummy penetration holes 31b that do not contribute to the ink supply are provided for the assistant member 30b and the cover member 20b and the assistant member 30b have substantially the same expansion and contraction characteristics in the heat treatment. Therefore, the warp of the multilayer body when the inkjet head 100b is heated can be further suppressed. Therefore, the nozzle line can be disposed at high accuracy in the attachment of the nozzle plate 60 or the operation of the inkjet head 100b.

[Third modified example]

[0065] Figs. 6A to 6D illustrate a structure of and a manufacturing method for an inkjet head 100c according to a third modified example.

[0066] In the inkjet head 100c according to the third modified example, the shape of the grooves 11 provided for the channel member 10 of the inkjet head 100a of the first modified example is changed and the size of the assistant member 30 is the same as that of the cover member 20a, and moreover a dummy member 50 (second thermal deformation suppression member) is provided. In regard to the other points, the inkjet head 100c of the third modified example is the same as the inkjet head 100a of the first modified example, and the same component is denoted by the same symbol and the detailed description thereto is omitted.

[0067] As shown by the exploded view of Fig. 6A, grooves 11c are open at only one side surface of the plate-shaped channel member 10c, and are each formed so that an ink flow path 11d (see the sectional view of Fig. 6B) formed by having the upper surface of the groove 11c covered with the cover member 20a communicates with the ink supply port 21a.

[0068] Moreover, as shown by the sectional view of Fig. 6B, the dummy member 50 is bonded to a surface of the assistant member 30c that is opposite to a surface thereof to which the channel member 10c is bonded. This dummy member 50 is provided with a recess 51 (dummy recess), and this recess 51 is disposed to face the channel member 10c. The dummy member 50 is, however, to cancel the characteristic of the deformation caused by the temperature change of the ink supply member 40 and this recess 51 does not contribute to the supply of the ink to each portion. The dummy member 50 is not particularly limited but in the third modified example, is formed of the same material and with the same size as the ink supply member 40, and has the shape symmetrical to the channel member 10c. In other words, the shape of the recess 51 is not particularly limited but in the third modified example, is formed of the same material and with the same size as the ink chamber recess 41.

[0069] The inkjet head 100c of the third modified example is manufactured as below. In other words, as shown in Fig. 6C, an adhesive 45 (third adhesive layer) is applied to a bonding surface between the ink supply member 40 and the cover member 20a, the channel member 10c, the assistant member 30c, and the nozzle plate 60 which are already bonded through the procedure similar to that of the first modified example, and moreover an adhesive 55 (fourth adhesive layer) is applied to a bonding surface with the dummy member 50 (Step 5). Here, in the inkjet head 100c of the third modified example, the thermosetting adhesive is used for the adhesives 45 and 55. Then, the members are stacked so that the ink chamber recess 41 and the recess 51 face the bonding surface side. After that, the whole is heated integrally to bond the ink supply member 40 and the dummy member 50 through adhesive layers 45a and 55a, which are obtained by thermally curing the adhesives 45 and 55 at the same time. Thus, the inkjet head 100c shown in Fig. 6D is formed (Step 6). Step 5 above constitutes a second stacking step and Step 6 constitutes a second bonding step.

[0070] In this manner, the inkjet head 100c of the third modified example includes the assistant member 30c that offsets the warp of the cover member 20a and the dummy member 50 that offsets the warp of the ink supply member 40; thus, in the manufacture and in the use, the nozzle array position can be maintained accurately and the warp that occurs in the use of the inkjet head 100c can be suppressed low.

[Second embodiment]

[0071] Next, an inkjet head 100d according to a second embodiment will be described.

[0072] Fig. 7A and Fig. 7B are diagrams for describing a structure of and a manufacturing method for the inkjet head 100d according to the second embodiment. As shown by the exploded view of Fig. 7A, in the inkjet head 100d according to the second embodiment, a nozzle opening portion 21d (nozzles) for discharging ink is provided for the cover member 20d at positions corresponding to the grooves 11 of the channel member 10, and serves as the nozzle plate. In other words, in this inkjet head 100d, the ink is discharged in a direction perpendicular to the direction where the ink flow paths 11a extend and the nozzle plate 60 is not provided for the side surface portion of the multilayer body. The other structure is similar to that of the inkjet head 100 of the first embodiment and the detailed description thereto is omitted by denoting the same portion with same reference symbol.

[0073] Next, the manufacturing method for the inkjet head 100d according to the second embodiment will be described. In the manufacture of the inkjet head 100d, as shown in Fig. 7B, first, the cover member 20d, the channel member 10, and the assistant member 30 are stacked with the adhesives 15 and 25 interposed therebetween at normal temperature, thereby forming a multilayer body. Then, through adhesive layers 15a and 25a obtained by thermally curing the adhesives 15 and 25 at the same time, the cover member 20d and the assistant member 30 are bonded to the channel member 10 as shown in Fig. 7C. Note that one end of the ink flow path 11a open at the side surface of the bonded multilayer body is bonded to the ink supply member, which is not shown, to serve as the ink supply port, while the other end thereof is blocked.

[0074] As described above, the inkjet head 100d according to the second embodiment has a nozzle opening portion 21d in the cover member 20d, and the assistant member 30 is bonded to the surface of the channel member 10 opposite to the surface thereof to which the cover member 20d is bonded, and the material of the cover member 20d and the assistant member 30 is selected within the range where the magnitude relation of the linear expansion coefficient is determined so that the direction of the warp of the cover member 20d and the direction of the warp of the assistant member 30 become symmetric along the channel member 10. Therefore, even though the temperature rises in the operation of the inkjet head 100d, the large warp of the cover member 20d can be suppressed and the highly accurate nozzle array can be maintained.

[0075] Moreover, since the cover member 20d and the assistant member 30 are attached to the channel member 10 with the thermosetting adhesives 15 and 25 at the same time, the highly accurate nozzle array with smaller warp as a whole in the manufacture of the inkjet head 100d can be obtained.

[0076] Note that the present invention is not limited to the above embodiment but various changes are possible. For example, in the above embodiment, the warp is suppressed by the symmetry that is achieved by making the shape or material of the cover member 20 and the assistant member 30 equal. Further, in consideration of the point that the channel member 10 itself has the asymmetric shape of having the grooves 11 only on one surface side of the plate, the shape or the material of the cover member 20 and the assistant member 30 may be minutely adjusted so as to complement this influence.

[0077] In addition, in the above embodiment, the warp is suppressed by making the magnitude relation of the linear expansion coefficient between the cover member 20 and the channel member 10 be equal to the magnitude relation of the linear expansion coefficient between the assistant member 30 and the channel member 10. However, the selection of the material that enables the member to function as the assistant member 30 is not limited to this criterion. For example, the material can be selected based on other parameters than the linear expansion coefficient; for example, by using, as the assistant member 30, the member that has small difference in linear expansion coefficient from the channel member 10 and that has large Young' s modulus and is bent uneasily, the warp caused by the difference in linear expansion coefficient between that member and the channel member 10 is suppressed to be low and moreover the force that resists the warping force caused by the difference in linear expansion coefficient between the cover member 20 and the channel member 10 is increased to prevent the warp as a whole from being increased.

[0078] Moreover, in the above embodiment, the adhesives 15 and 25 are thermally cured at the same temperature; however, the heating temperature for the adhesives may be different. For example, if the linear expansion coefficient of the cover member 20 is larger than that of the channel member 10 and the linear expansion coefficient of the assistant member 30 is smaller than that of the channel member 10, the thermal curing of the adhesives 15 and 25 may be controlled so that the temperature of the channel member 10 is lower than that of the assistant member 30 and the temperature of the cover member 20 is lower than that of the channel member 10, thereby suppressing the large warp. Alternatively, on the contrary, if the linear expansion coefficient of the cover member 20 is smaller than that of the channel member 10 and the linear expansion coefficient of the assistant member 30 is larger than that of the channel member 10, the thermal curing of the adhesives 15 and 25 may be controlled so that the temperature of the channel member 10 is lower than that of the cover member 20 and the temperature of the assistant member 30 is lower than that of the channel member 10, thereby suppressing the large warp. By the method as above, the warp in the manufacture of the inkjet head 100 can be suppressed as a whole, and the material selection width of the cover member 20 and the assistant member 30 can be further expanded. In addition, different adhesives 15 and 25 may be selected in accordance with such different thermal curing temperature. Similarly, the heating temperature for the adhesives 35 and 45 may be set differently or different adhesives may be selected therefor.

[0079] In the above embodiment, the members are bonded using the thermosetting adhesive; however, another adhesive may be used. Even in the case of using the adhesives that can be attached at normal temperature, the highly accurate nozzle array can be maintained while suppressing the warp according to the heat generation (temperature rise) in the use of the inkjet head 100. Moreover, even in the case of bonding by the thermal curing, the adhesive may be not just the thermosetting adhesive but also the mixture of another kind of adhesive, such as UV curable adhesive.

[0080] In the above embodiment, the grooves 11 or the nozzle opening portions 61 are provided to arrange the nozzle line in the longitudinal direction of the channel member 10 as the plate-shaped member; however, the arrangement is not limited thereto. Further, the structure may be arranged as appropriate unless the structure that contributes to the ink supply, such as the groove or the hole, is provided on the surface opposite to the surface provided with the grooves 11.

[0081] In the above embodiment, the nozzles are arranged on one nozzle plate 60; however, even when each nozzle is provided at a terminal of each ink flow path 11a of the channel member 10, the accuracy of the nozzle array position can be maintained or improved similarly.

[0082] In the above embodiment, the electrodes are disposed along the side wall in the pressure chamber; however, the present invention is not limited thereto. For example, the electrodes may be arranged between the side wall between the pressure chambers and the cover member. Moreover, in regard to the details including the specific structure, shape, arrangement, numerals, and materials shown in the above embodiments, various changes can be made within the range not departing from the scope of the present invention.

Example 1

[0083] Hereinafter, the present invention will be described specifically with reference to examples; however, the present invention is not limited thereto.

[Manufacture of inkjet head]

(Example 1)

[0084] A plate of lead zirconate titanate (PZT) with a thickness of 0.9 mm, a width of 42 mm, and a length of 17 mm was used as the channel member of the inkjet head. The channel member is provided with 256 grooves each having a depth of 310 μm and a width of 80 μm in parallel with a distance (pitch) of 141 μm between the centers of the grooves. PZT has a linear expansion coefficient ([$\mu m \cdot m^{-1} \cdot K^{-1}$], hereinafter referred to as [$ppmK^{-1}$]) of 6.7 [$ppmK^{-1}$] based on 20°C.

[0085] Moreover, the cover member was formed of silicon nitride (with a linear expansion coefficient of 2.6 [$ppmK^{-1}$] based on 20°C) with a thickness of 0.8 mm, a width of 42 mm, and a length of 12 mm, and the assistant member (thermal deformation suppression member) was formed of a compound of aluminum nitride and boron nitride (AlN/BN, the linear expansion coefficient is 4.4 [$ppmK^{-1}$] based on 20°C) with a thickness of 0.8 mm, a width of 42 mm, and a length of 12 mm.

[0086] After the assistant member, the channel member, and the cover member were stacked in this order at normal temperature (20°C) with an epoxy resin layer interposed therebetween, the members were heated integrally to cure the epoxy resin layers at the same temperature and attached to each other. Then, a silicon nozzle plate with a thickness of 0.2 mm, a width of 42 mm, and a length of 2.5 mm was brought into contact with the side surface of the multilayer body with epoxy resin interposed therebetween, and heat was applied again to cure the epoxy resin for attachment. Thus, the inkjet head according to Example 1 was manufactured.

(Example 2)

[0087] An inkjet head according to Example 2 was manufactured in a manner similar to the inkjet head according to Example 1 except that the cover member was formed of zirconia (with a linear expansion coefficient of 10.5 [$ppmK^{-1}$]) and the assistant member was formed of a silica/alumina compound (SiO_2/Al_2O_3, with a linear expansion coefficient of 8.5 [$ppmK^{-1}$]).

(Example 3)

[0088] An inkjet head according to Example 3 was manufactured in a manner similar to the inkjet head according to Example 1 except that the cover member and the assistant member were formed of AlN/BN.

(Comparative Example 1)

[0089] An inkjet head according to Comparative Example 1 was manufactured in a manner similar to the inkjet head according to Example 1 except that the cover member was formed of silicon nitride and the assistant member serving as the thermal deformation suppression member was not provided.

(Comparative Example 2)

[0090] An inkjet head according to Comparative Example 2 was manufactured in a manner similar to the inkjet head according to Comparative Example 1 except that the cover member was formed of zirconia.

(Comparative Example 3)

[0091] An inkjet head according to Comparative Example 3 was manufactured in a manner similar to the inkjet head according to Example 1 except that the cover member was formed of zirconia and the assistant member (formed of AlN/BN) was attached at the same position.

(Comparative Example 4)

[0092] An inkjet head according to Comparative Example 4 was manufactured in a manner similar to the inkjet head according to Comparative Example 3 except that the cover member was formed of silicon nitride and the assistant member was formed of zirconia.

[Evaluation of inkjet head]

[0093] The inkjet heads according to Examples 1 to 3 and Comparative Examples 1 to 4 manufactured as above were evaluated as below.

[Nozzle line straightness]

[0094] The maximum displacement width Δh (Fig. 8) of the position in the thickness direction of the nozzle line according to the 256 nozzle opening portions provided for the nozzle plate was measured. The evaluation results are shown in Fig. 9.

[0095] As shown in the evaluation results, if the assistant member is not provided (Comparative Examples 1, 2), the evaluation values of the nozzle line straightness are 16 μm and 20 μm, which do not depend on the magnitude relation of the linear expansion coefficient of the channel member and the cover member. On the other hand, if the assistant member (thermal deformation suppression member) is selected so that both the cover member and the assistant member have the linear expansion coefficient larger or smaller than that of the channel member (Examples 1, 2), the improvement is made to the value of approximately 1/5 as compared to Comparative Examples 1, 2.

[0096] If the cover member and the thermal deformation suppression member are formed of the same member (Example 3), the value is substantially the same as that of Examples 1 and 2 or improved a little.

[0097] On the other hand, if the magnitude relation of the linear expansion coefficient of the cover member is the opposite to the magnitude relation of the assistant member relative to the linear expansion coefficient of the channel member (Comparative Examples 3, 4), the improvement is not made at all as compared to the case of not using the assistant member (Comparative Examples 1, 2). Therefore, even if the grooves are provided only one surface of the channel member and the cover member is necessary only on one surface, the nozzle line straightness can be improved by selecting the thermal deformation suppression member whose magnitude relation in linear expansion coefficient with the channel member is the same as that of the cover member and attaching the thermal deformation suppression member to the surface opposite to the cover member at the same time as the cover member.

Industrial Applicability

[0098] The present invention can be applied to the manufacturing method for the inkjet head that discharges the ink and to the inkjet head.

Reference Signs List

[0099]

10	Channel member
10c	Channel member
11	Groove
11a	Ink flow path (pressure chamber)
11c	Groove
11d	Ink flow path
15	Adhesive
15a	Adhesive layer
20	Cover member
20a	Cover member
20b	Cover member
20d	Cover member
21a	Ink supply port
21b	Ink supply port
21d	Nozzle opening portion
25	Adhesive
25a	Adhesive layer
30	Assistant member
30b	Assistant member
30c	Assistant member
31b	Penetration hole
35	Adhesive
35a	Adhesive layer
40	Ink supply member
41	Ink chamber recess
45	Adhesive
45a	Adhesive layer
50	Dummy member
51	Recess
55	Adhesive
55a	Adhesive layer
60	Nozzle plate
61	Nozzle opening portion
100	Inkjet head
100a	Inkjet head
100b	Inkjet head
100c	Inkjet head
100d	Inkjet head

Claims

1. A manufacturing method for an inkjet head that discharges ink out of an ink channel through a nozzle, comprising:

a first stacking step of stacking, through a first adhesive layer on one surface of a channel member with a shape having a groove serving as an ink channel formed on the one surface and not having the groove on the opposite surface, a cover member formed of a single member with a different linear expansion coefficient from the channel member, and stacking, through a second adhesive layer on the opposite surface, a first thermal deformation suppression member that is formed of a single member with a different linear expansion coefficient from the channel member and that suppresses thermal deformation caused by the difference in linear expansion coefficient between the channel member and the cover member; and

a first bonding step of bonding the cover member, the channel member, and the first thermal deformation suppression member by thermally curing the first adhesive layer and the second adhesive layer at the same time.

2. The manufacturing method for an inkjet head according to claim 1, wherein the linear expansion coefficient of the cover member and the linear expansion coefficient of the first thermal deformation suppression member are both larger than that of the channel member.

3. The manufacturing method for an inkjet head according to claim 1, wherein the linear expansion coefficient of the cover member and the linear expansion coefficient of the first thermal deformation suppression member are both smaller than that of the channel member.

4. The manufacturing method for an inkjet head according to claim 2 or 3, wherein the linear expansion coefficient of the first thermal deformation suppression member is the same as the linear expansion coefficient of the cover member.

5. The manufacturing method for an inkjet head according to any one of claims 1 to 4, wherein the first thermal deformation suppression member has the same shape as the cover member.

6. The manufacturing method for an inkjet head according to any one of claims 1 to 5, wherein
the cover member is provided with a penetration pore that communicates with the ink channel and supplies ink to the ink channel, and
the first thermal deformation suppression member is provided with a dummy penetration pore that does not communicate with the ink channel.

7. The manufacturing method for an inkjet head according to any one of claims 1 to 6, further comprising, after the first stacking step, a nozzle bonding step of bonding a nozzle formation member provided with the nozzle to one end face at which the ink channel is open in a multilayer body including the cover member, the channel member, and the first thermal deformation suppression member.

8. The manufacturing method for an inkjet head according to claim 7, wherein the nozzle bonding step includes a step of attaching the nozzle formation member to the multilayer body using an adhesive including a thermosetting adhesive.

9. The manufacturing method for an inkjet head according to any one of claims 1 to 6, wherein the nozzle is provided for the cover member.

10. The manufacturing method for an inkjet head according to any one of claims 6 to 8, further comprising after the first bonding step:

a second stacking step of stacking, through a third adhesive layer on a surface of the cover member that is opposite to a surface thereof bonded to the channel member, an ink supply member that is formed of a single member and that is provided with a recess serving as an ink supply path for supplying ink supplied from outside to the ink channel through the penetration pore, and stacking, through a fourth adhesive layer on a surface of the first thermal deformation suppression member that is opposite to a surface thereof bonded to the channel member, a second thermal deformation suppression member that is formed of a single member with the same linear expansion coefficient as the ink supply member and that is provided with a dummy recess which does not contribute to the ink supply to the ink channel; and
a second bonding step of bonding the cover member and the ink supply member to each other and the first thermal deformation suppression member and the second thermal deformation suppression member to each other by thermally curing the third adhesive layer and the fourth adhesive layer at the same time.

11. An inkjet head for discharging ink out of an ink channel through a nozzle, the inkjet head comprising:

a channel member that is formed of a single member and has a shape having a groove serving as an ink channel formed on one surface and not having the groove on the opposite surface;
a cover member that is formed of a single member with a different linear expansion coefficient from the channel member and bonded to the one surface of the channel member; and
a first thermal deformation suppression member that is formed of a single member with a different linear expansion coefficient from the channel member and bonded to the opposite surface of the channel member to suppress thermal deformation caused by a difference in linear expansion coefficient between the channel member and the cover member.

12. The inkjet head according to claim 11, wherein the linear expansion coefficient of the cover member and the linear expansion coefficient of the first thermal deformation suppression member are both larger than that of the channel member.

13. The inkjet head according to claim 11, wherein the linear expansion coefficient of the cover member and the linear expansion coefficient of the first thermal deformation suppression member are both smaller than that of the channel member.

14. The inkjet head according to claim 12 or 13, wherein the linear expansion coefficient of the first thermal deformation suppression member is the same as the linear expansion coefficient of the cover member.

15. The inkjet head according to any one of claims 11 to 14, wherein the first thermal deformation suppression member has the same shape as the cover member.

16. The inkjet head according to any one of claims 11 to 15, wherein
the cover member is provided with a penetration pore that communicates with the ink channel and supplies ink to the ink channel, and
the first thermal deformation suppression member

is provided with a dummy penetration pore that does not communicate with the ink channel.

17. The inkjet head according to any one of claims 11 to 16, wherein a nozzle formation member provided with the nozzle is bonded to one end face at which the ink channel is open in a multilayer body including the channel member, the cover member, and the first thermal deformation suppression member.

18. The inkjet head according to claim 17, wherein the nozzle formation member is attached to the multilayer body using an adhesive including a thermosetting adhesive.

19. The inkjet head according to any one of claims 11 to 16, wherein the nozzle is provided for the cover member.

20. The inkjet head according to any one of claims 16 to 18, further comprising:

an ink supply member that is formed of a single member, that is provided with a recess serving as an ink supply path for supplying ink supplied from outside to the ink channel through the penetration pore, and that is bonded to the surface of the cover member that is opposite to the surface thereof bonded to the channel member; and a second thermal deformation suppression member that is formed of a single member with the same linear expansion coefficient as the ink supply member, that is provided with a dummy recess which does not contribute to the ink supply to the ink channel, and that is bonded to a surface of the first thermal deformation suppression member opposite to a surface thereof bonded to the channel member.

FIG. 1A

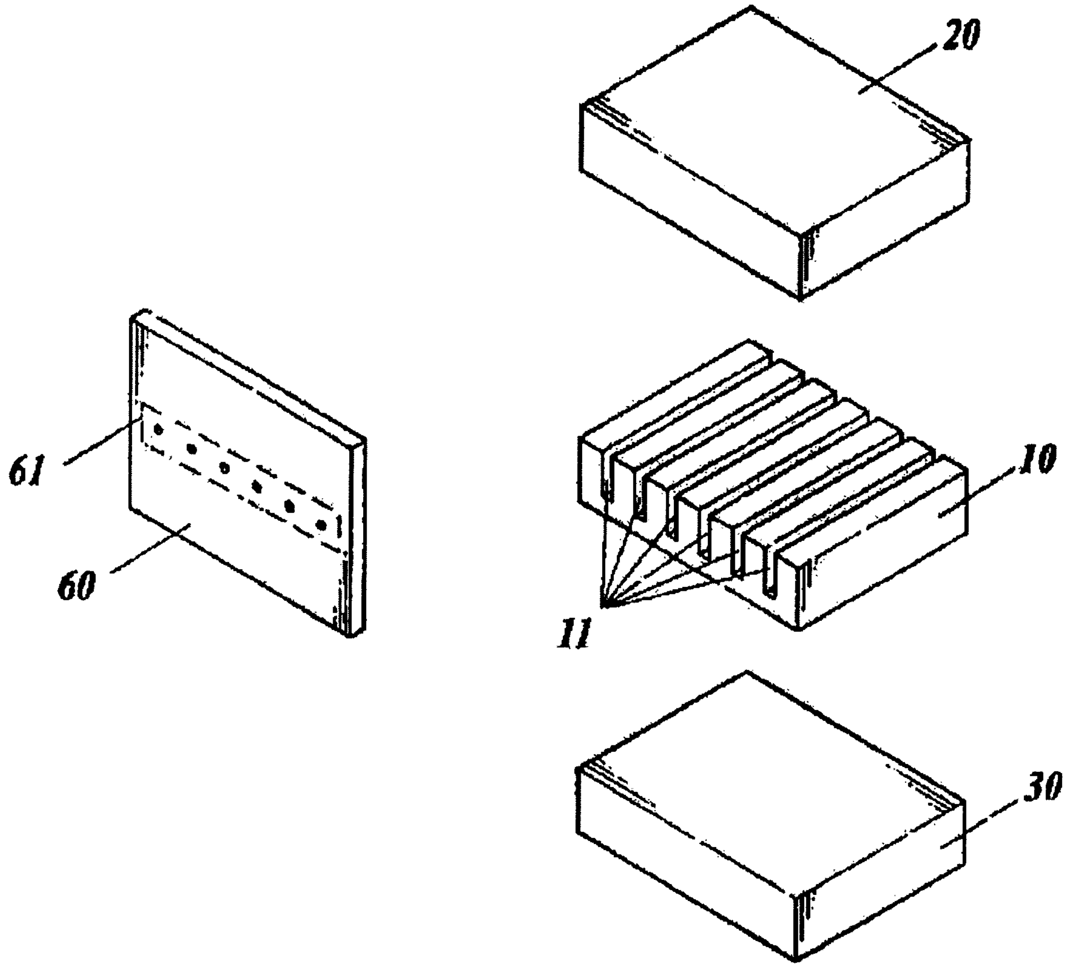

FIG. 1B

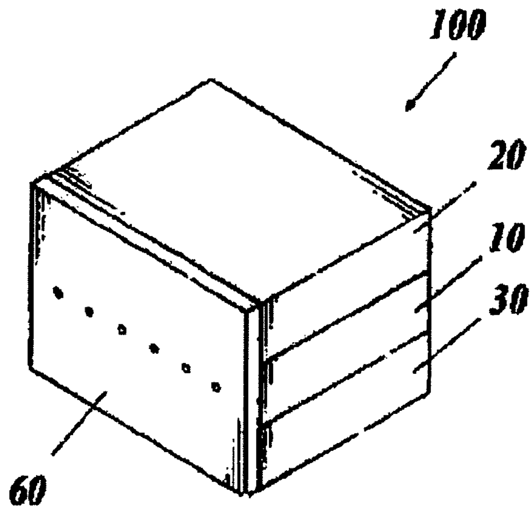

FIG. 2A

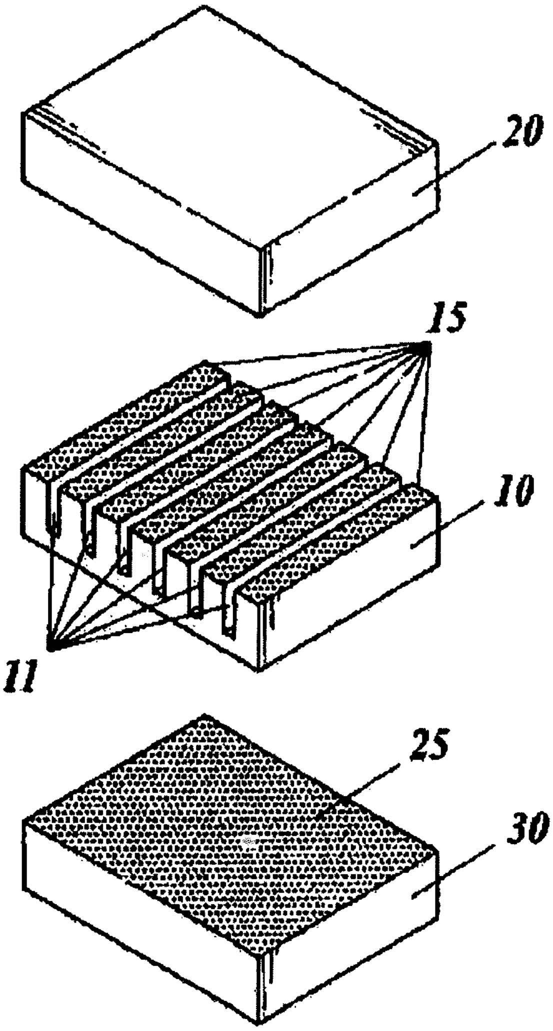

FIG. 2B

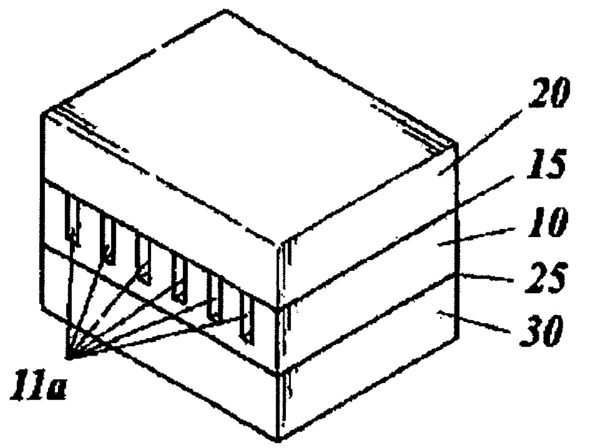

FIG. 2C

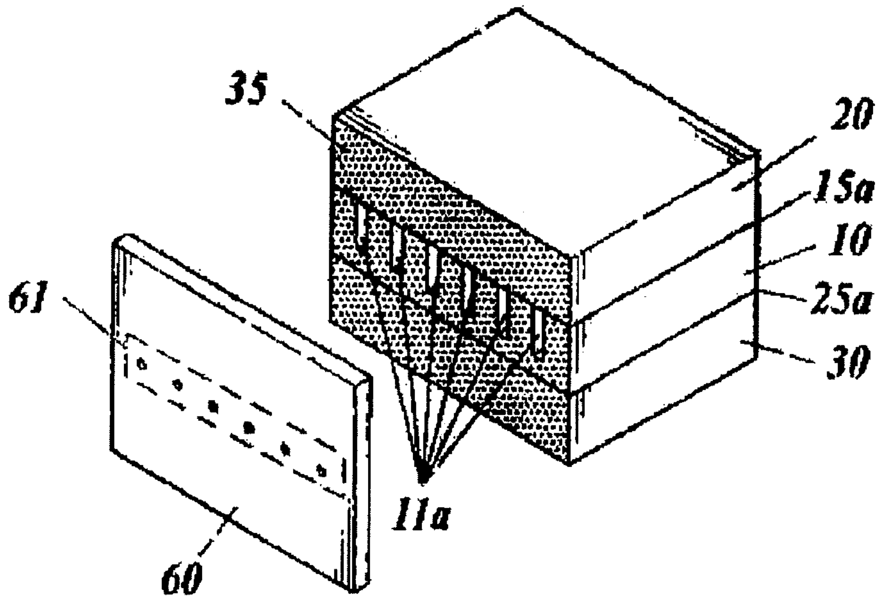

FIG. 2D

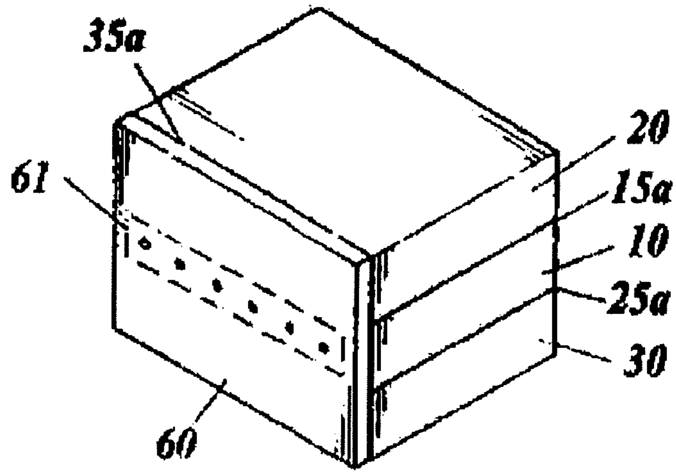

FIG. 3A

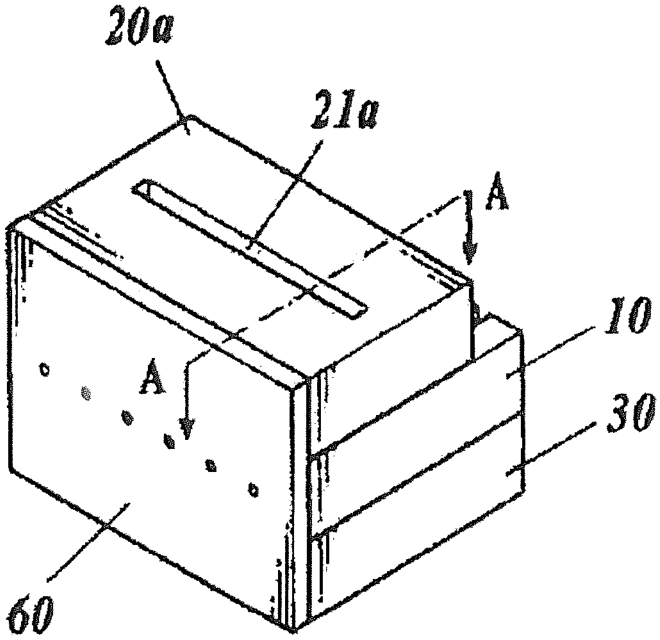

FIG. 3B

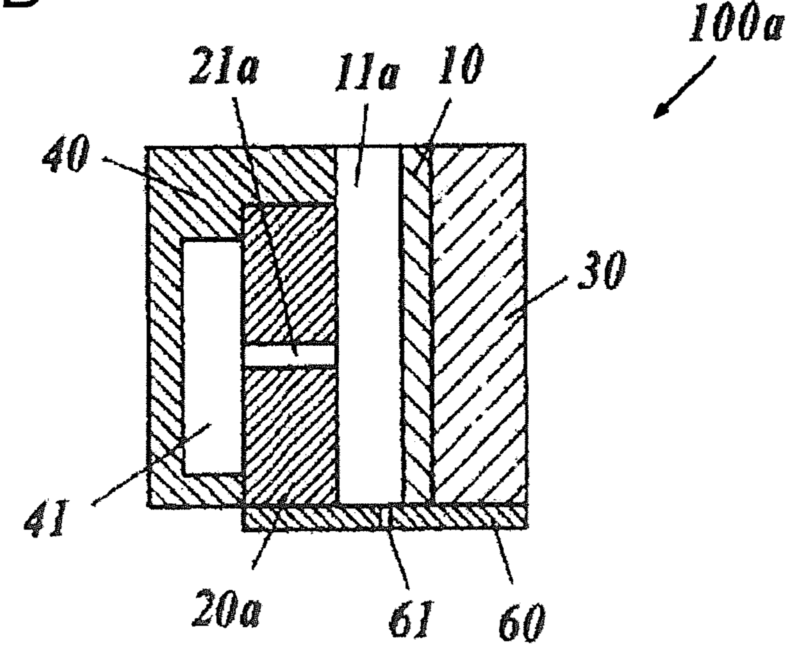

FIG. 4A

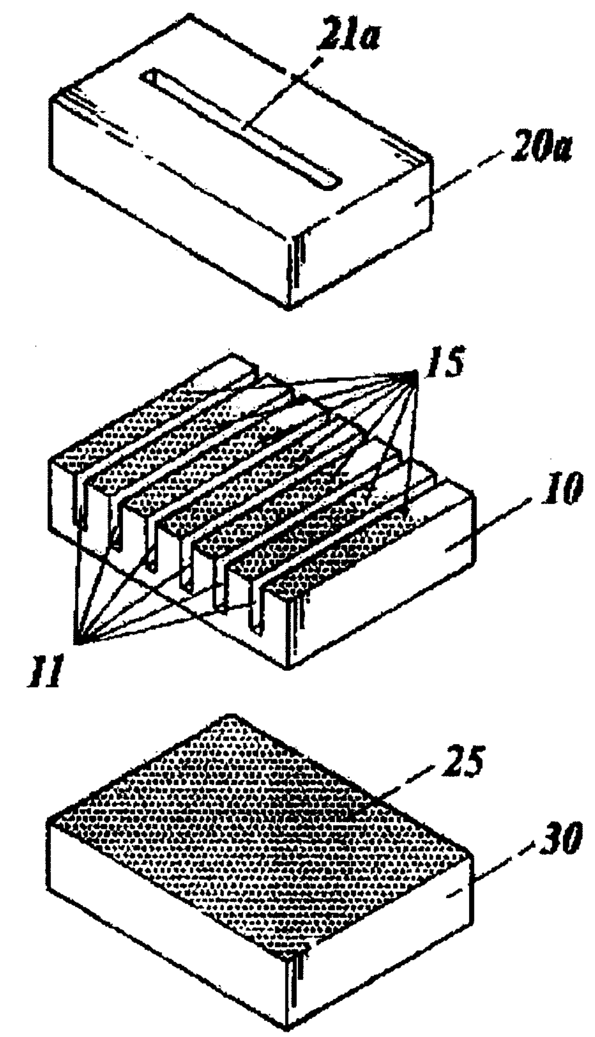

FIG. 4B

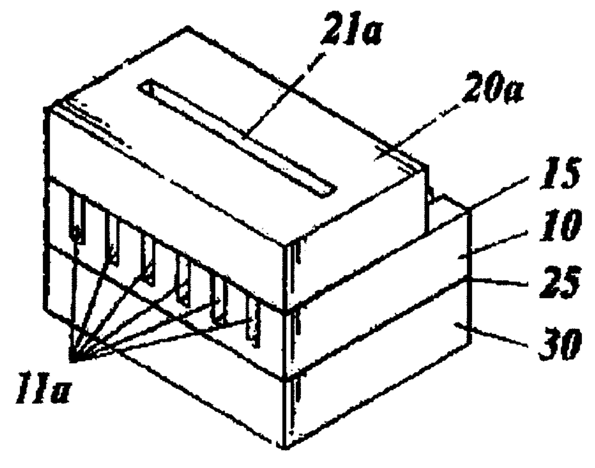

FIG. 4C

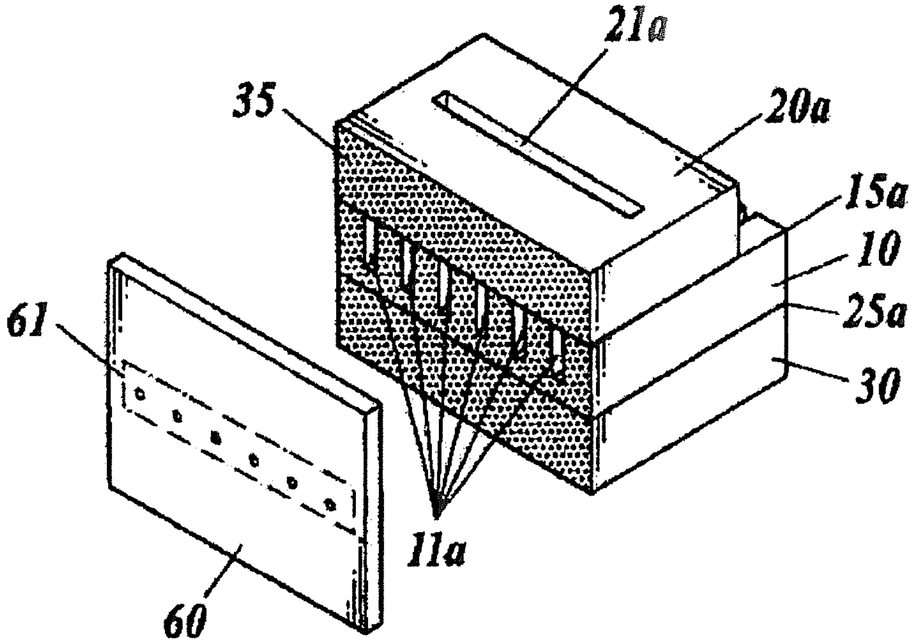

FIG. 4D

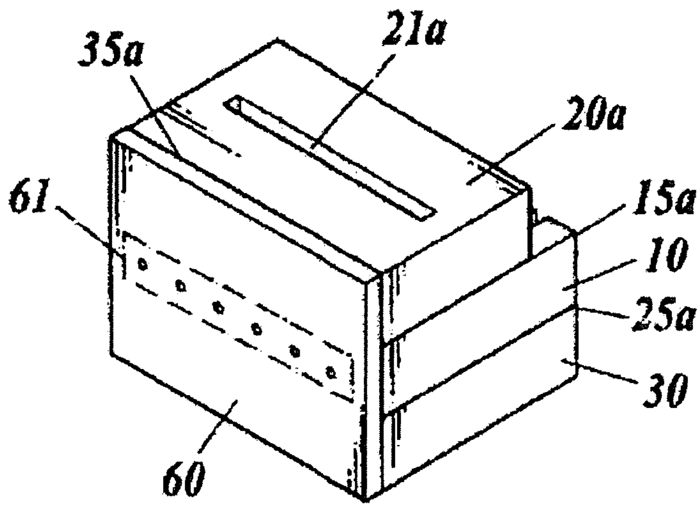

FIG. 5A

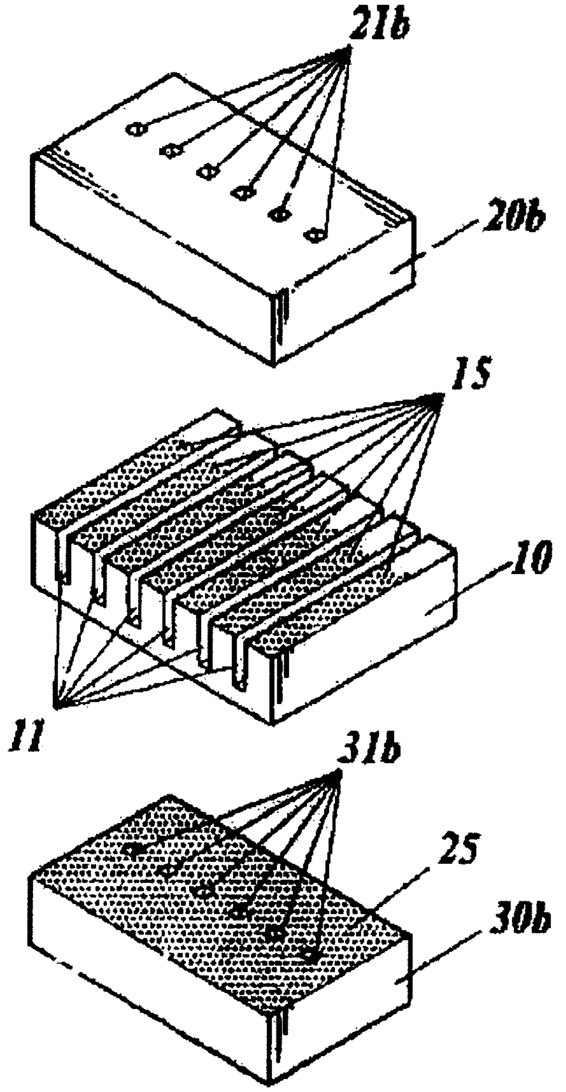

FIG. 5B

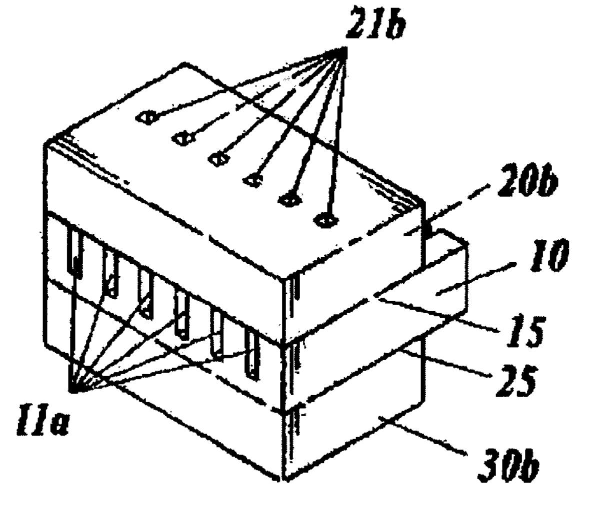

FIG. 5C

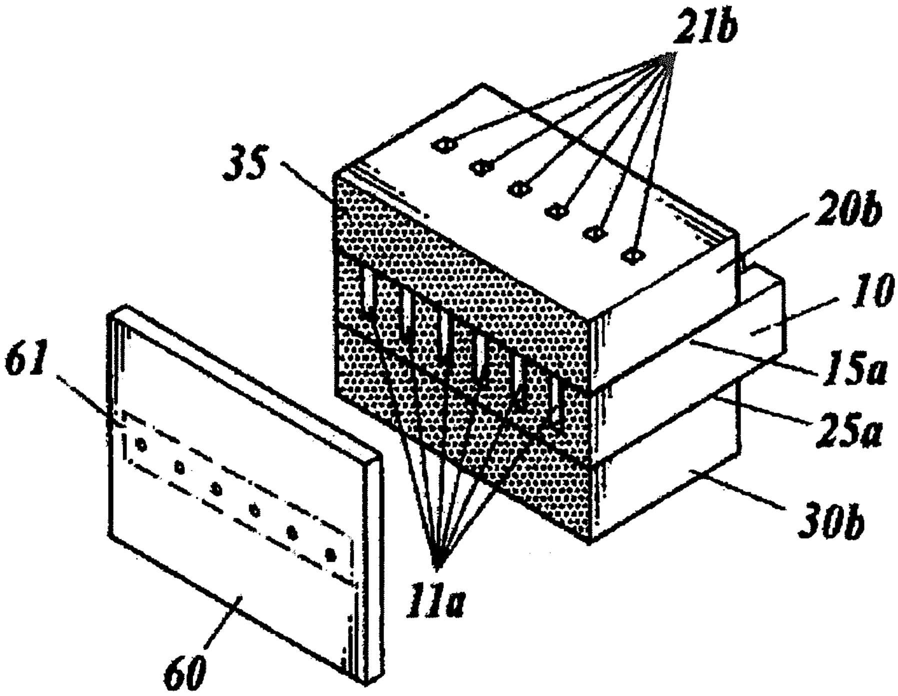
21b
35
20b
10
15a
25a
30b
61
11a
60

FIG. 5D

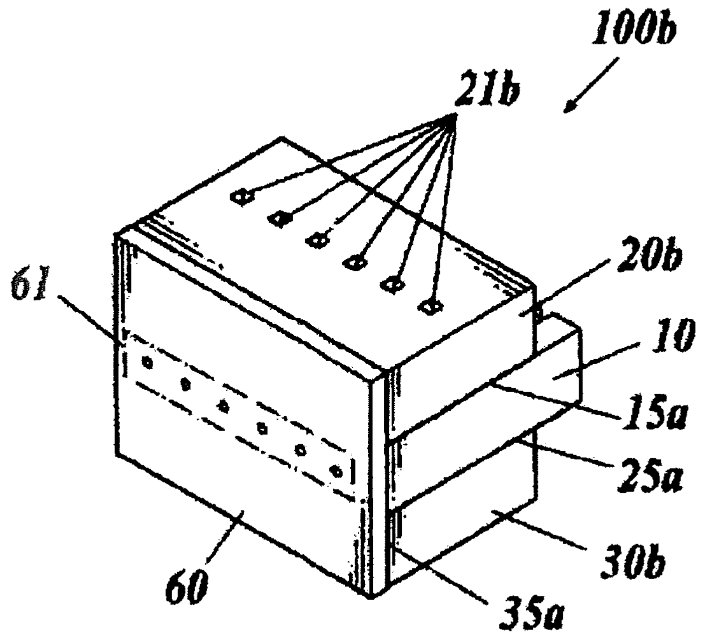
100b
21b
61
20b
10
15a
25a
30b
60
35a

FIG. 6A

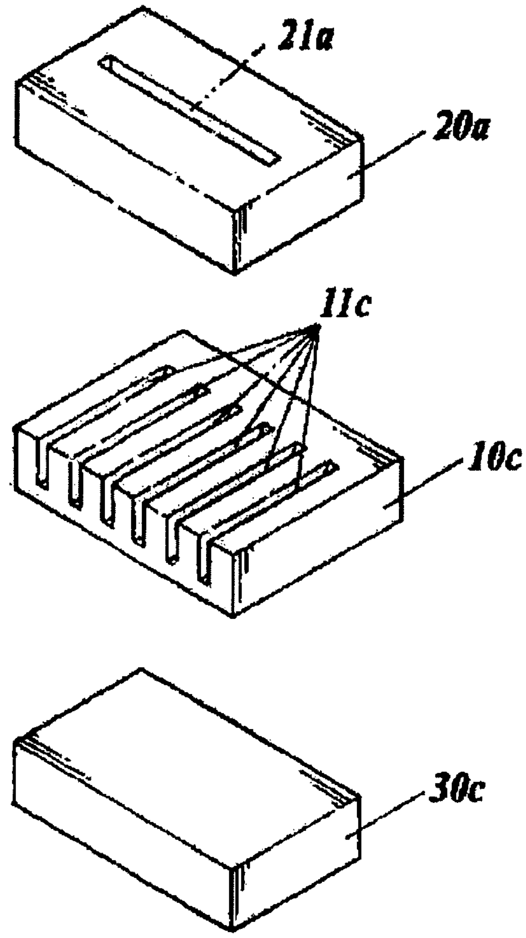

FIG. 6B

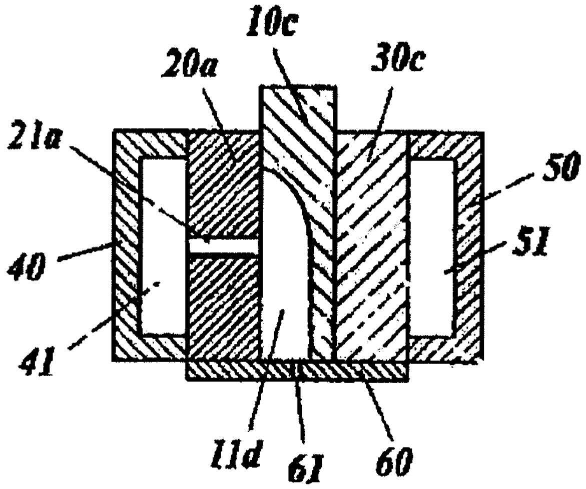

FIG. 6C

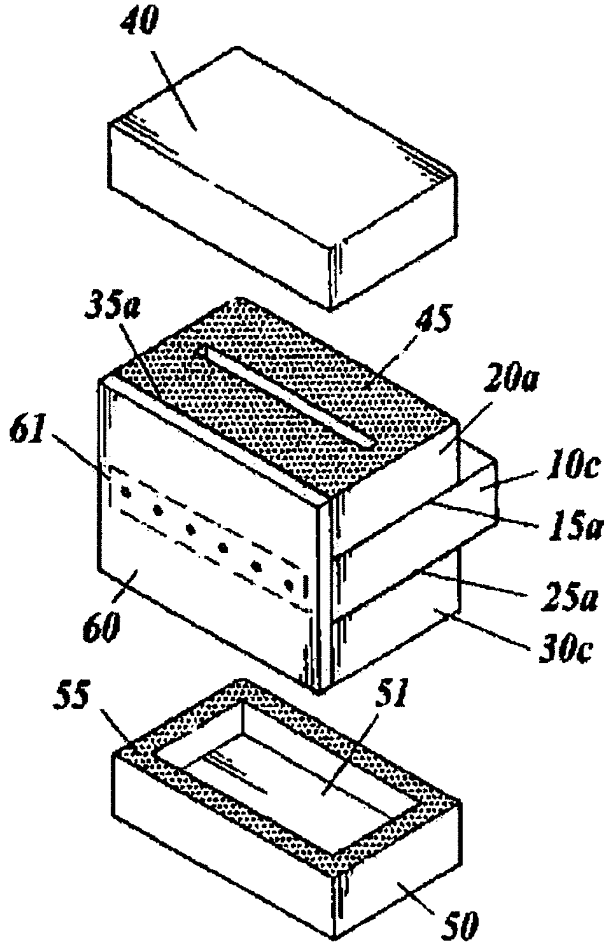
40
35a
45
20a
61
10c
15a
25a
60
30c
55
51
50

FIG. 6D

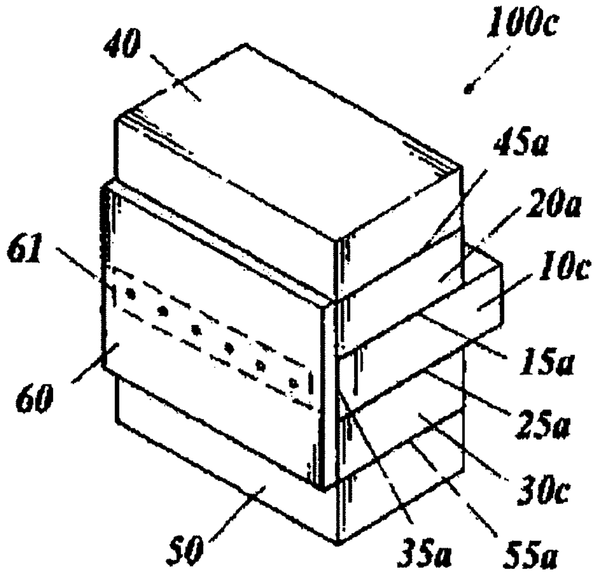
40
100c
45a
20a
61
10c
15a
60
25a
30c
50
35a
55a

FIG. 7A

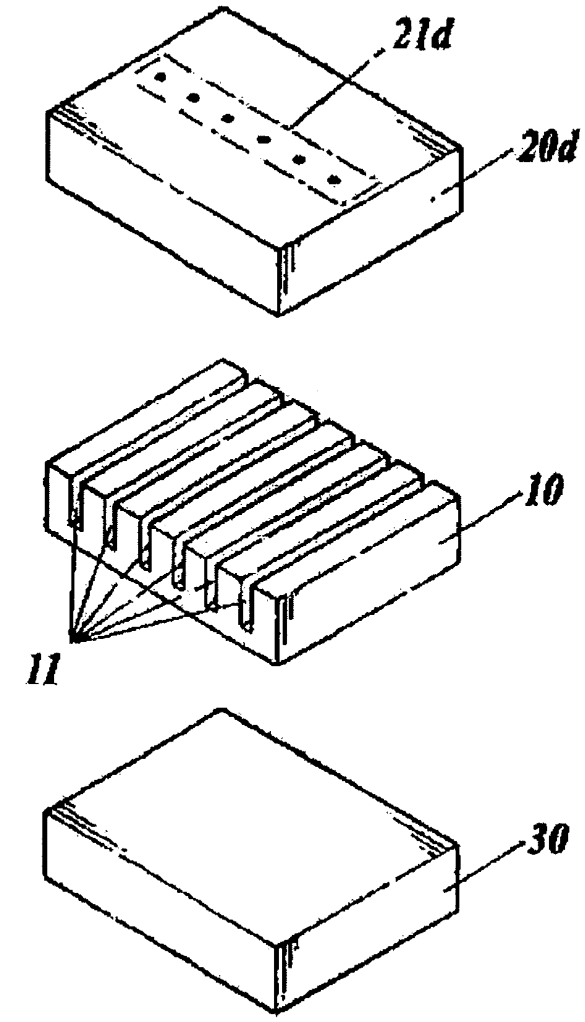

FIG. 7B

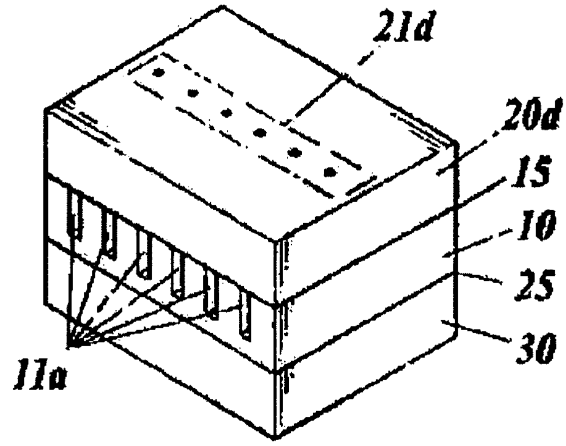

FIG. 7C

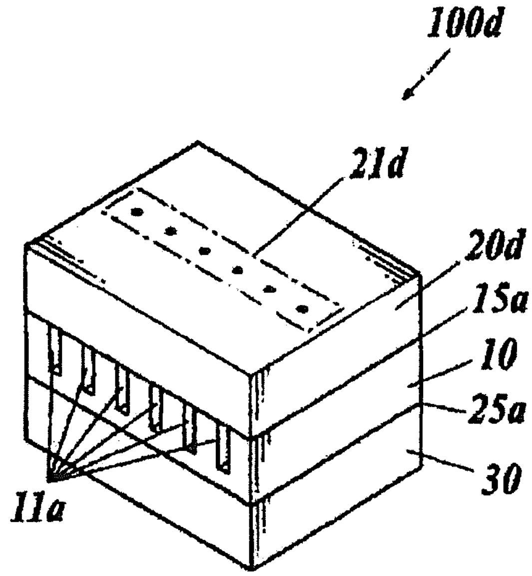

FIG. 8

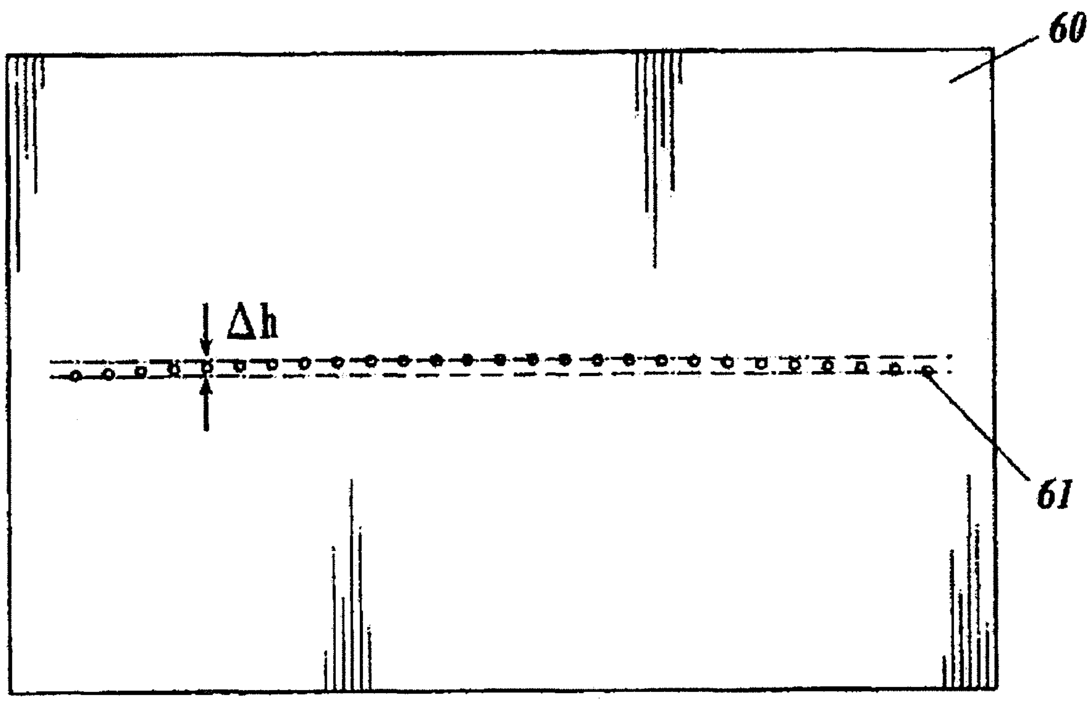

FIG. 9

COVER MEMBER	MATERIAL		Si_3N_4	ZrO_2	Si_3N_4	ZrO_2	AlN BN	ZrO_2	Si_3N_4
	LINEAR EXPANSION COEFFICIENT	ppm/K	2.6	10.5	2.6	10.5	4.4	10.5	2.6
CHANNEL MEMBER	MATERIAL		PZT	PZT	PZT	PZT	PZT	PZT	PZT
	LINEAR EXPANSION COEFFICIENT	ppm/K	6.7	6.7	6.7	6.7	6.7	6.7	6.7
THERMAL DEFORMATION SUPPRESSION MEMBER	MATERIAL		NONE	NONE	AlN BN	SiO_2 Al_2O_3	AlN BN	—	—
	LINEAR EXPANSION COEFFICIENT	ppm/K	—	—	4.4	8.5	4.4	—	—
ASSISTANT MEMBER	MATERIAL		NONE	NONE	—	—	—	AlN BN	ZrO_2
	LINEAR EXPANSION COEFFICIENT	ppm/K	—	—	—	—	—	4.4	10.5
NOZZLE LINE STRAIGHTNESS Δh		μm	16	20	4	3	2	22	18
			COMPARATIVE EXAMPLE 1	COMPARATIVE EXAMPLE 2	EXAMPLE 1	EXAMPLE 2	EXAMPLE 3	COMPARATIVE EXAMPLE 3	COMPARATIVE EXAMPLE 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/080618

A. CLASSIFICATION OF SUBJECT MATTER
B41J2/16(2006.01)i, *B41J2/045*(2006.01)i, *B41J2/055*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B41J2/16, B41J2/045, B41J2/055

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2014
Kokai Jitsuyo Shinan Koho	1971-2014	Toroku Jitsuyo Shinan Koho	1994-2014

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 10-157108 A (Tec Co., Ltd.), 16 June 1998 (16.06.1998), paragraphs [0010] to [0015]; fig. 1 to 5 (Family: none)	1-20
A	JP 10-157105 A (Tec Co., Ltd.), 16 June 1998 (16.06.1998), paragraphs [0011] to [0025]; fig. 1 to 4 (Family: none)	1-20
A	JP 10-128984 A (NEC Corp.), 19 May 1998 (19.05.1998), paragraphs [0011] to [0013]; fig. 1 to 3 (Family: none)	1-20

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

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Date of the actual completion of the international search	Date of mailing of the international search report
05 February, 2014 (05.02.14)	18 February, 2014 (18.02.14)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/080618

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2007-320187 A (Toshiba Tec Corp.), 13 December 2007 (13.12.2007), paragraphs [0029] to [0031]; fig. 6 (Family: none)	9,19
A	JP 2005-297310 A (Konica Minolta Holdings, Inc.), 27 October 2005 (27.10.2005), paragraphs [0034] to [0036]; fig. 1 (Family: none)	10,20

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2007069475 A **[0005]**
- JP 2007245394 A **[0005]**