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(71) Applicant:
Microjet Technology Co., Ltd
Hsin Chu (TW)

(72) Inventors:
- **Mou, Tse-chi,**
  1F, No. 28. R&D Rd Sec 2
  Taiwan (CN)
- **Yang, Arnold Chang-Mou,**
  1F,No. 28. R&D Rd Sec 2
  Taiwan (CN)
- **Chuang, Bill Yuan-Chung,**
  1F,No. 28. R&D Rd Sec 2
  Taiwan (CN)
- **Chou, Chin-Yi,**
  1F,No. 28. R&D Rd Sec 2
  Taiwan (CN)
- **Ho, Jing-Yuang,**
  1F,No. 28. R&D Rd Sec 2
  Taiwan (CN)

(74) Representative: **Perkins, Sarah**
Stevens, Hewlett & Perkins
Halton House
20/23 Holborn
London EC1N 2JD (GB)

(54) Method and device for manufacturing ink jet printhead

(57) A method and a device for the manufacturing of an ink jet printhead are provided. The ink jet printhead includes a plurality of ink-containing holes (3) for containing therein an ink, a nozzle plate (4) having thereon a plurality of nozzles (41) corresponding to the plurality of ink-containing holes (3) for ejecting therethrough the ink, and a chip (1) for controlling the ejection of the ink. The device includes a base (71), a flute (72) provided on the base, and a vacuum apparatus (73). The method includes steps of (a) forming a photo-sensitive layer on the chip, (b) forming the plurality of ink-containing holes on the photo-sensitive layer, (c) placing the nozzle plate on the photo-sensitive layer, and (d) heating the photo-sensitive layer to bond the chip and the nozzle plate.

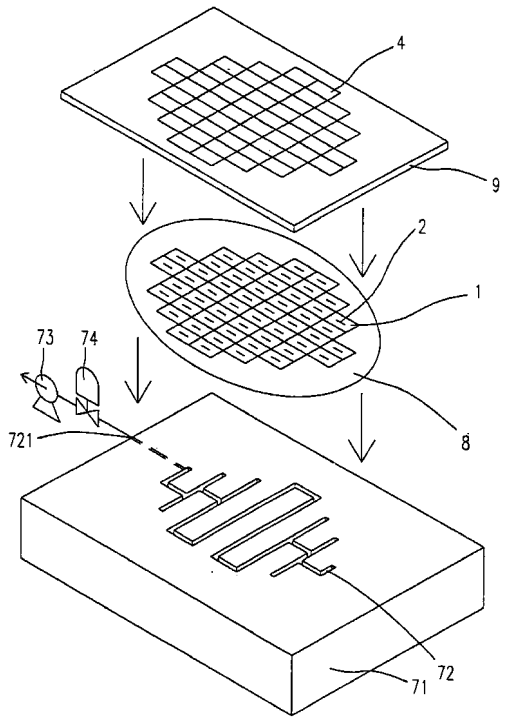

Fig. 6

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Description

FIELD OF THE INVENTION

[0001] The present invention is related to a method for manufacturing an ink jet printhead, and more particularly to a device for manufacturing an ink jet printhead.

BACKGROUND OF THE INVENTION

[0002] Ink jet printers play an important role in printing field. Although they are put into application before laser jet printers, the use of laser jet printers does not supersede ink jet printers because of their increasingly high resolution and potential in color printing. The ink jet printhead is the most important part in an ink jet printer because it is crucial to printing performance and quality.

[0003] Please refer to Fig. 1 which is a schematic diagram showing a typical ink jet printhead. The main part of the printhead is a chip 1 including circuits which are used for receiving signals generated from the computer through the software program operation, and controlling the ink-ejecting operation in accordance with the received signals. In the center of the chip 1 is a through hole 2 for restoring the ink 21. There are many ink-containing holes 3 provided around through hole 2. The plurality of ink-containing holes 3 are communicated with the through hole 2 so ink 21 contained in through hole 2 can flow into the ink-containing holes 3. A nozzle plate 4 having many nozzles 41 thereon covers ink-containing holes 3 wherein the plurality of nozzles 41 respectively correspond to the plurality of ink-containing holes 3.

[0004] Please refer to Fig. 2 which is a sectional diagram showing an ink-containing hole and its peripheral structure. The ink-containing hole 3 is formed by photolithographing a photoresist 31. The chip 1 has a heating element. When a printing instruction is given, the circuits of chip 1 control the heating- element to heat ink 21 restrained in ink-containing hole 3, and then ink 21 will be ejected through the nozzle 41 of the nozzle plate 4. Thus, it can be seen that the nozzle 41 must be small enough so that the amount of ejected ink 21 can be controlled well and high resolution of the ink jet printer can be anticipated.

[0005] Please refer to Figs. 3(a)-(d) which are schematic diagrams showing a conventional process for manufacturing an ink jet printhead. Fig. 3(a) shows the first step of forming a photoresist 31 on the chip 1 followed by the next step of forming a plurality of ink-containing holes 3 on the chip 1 by photolithographing the photoresist 31 as shown in Fig. 3(b). Then, a hard baking step is executed in order to reduce the solvent in the photoresist 31. For bonding the nozzle plate 4 and the chip 1, the adhesive 5 is coated right above the photoresist 31 as shown in Fig. 3(c). Fig. 3(d) shows that the nozzle plate 4 is placed on the adhesive 5. It must be noted that the plurality of nozzles 41 are in vertical alignment with the plurality of ink-containing holes 3 respectively so the ink can be ejected smoothly through the nozzle 41. At last, the chip 1 accompanied with the nozzle plate 4 is transferred to a heating chamber to be heated to bond the chip 1 and the nozzle plate 4 together firmly. It is difficult to operate this prior method because such a tiny element requires an extremely small amount of adhesive 5. The small amount of adhesive is not easily controllable. Too much adhesive chokes the small nozzle and the ink can not be ejected. On the other hand, too less adhesive can not bond the chip and the nozzle plate properly so the nozzle plate will fall down or the ink will leak out. Moreover, the adhesive-coating instrument is very expensive, but the rejection rate is as high as fifty percents. It really wastes too much production cost.

[0006] Before the chip and the nozzle plate are moved to the heating chamber, the fixing step is also important because a careless fixing will cause a relative displacement between the chip and the nozzle plate. When the semiconductor manufacturing process is progressed into the sub-micron field, such a careless mistake is not allowable because it results in failure of the element. Sometimes, a simple clip is used for fixing the chip and the nozzle plate, but the force exerted by the clip can not be controlled. Usually, a press gripper is used in fixing wafers. Please refer to Fig. 4 which is a schematic diagram of a conventional fixing facility. The nozzle plate 4 is placed on the chip 1 and is fixed by a press gripper 6. The press gripper 6 includes a bottom 61, contact mediums 62, a cylinder 63, and an air-supplying pipe 64. The air-supplying pipe 64 supplies a controlled amount of air into the cylinder 63, and the upper contact medium 62 presses down to fix the nozzle plate 4 on the chip 1. This kind of fixing device can control the exerted force on the nozzle plate 4 by controlling the flow rate of the supplied air. Different forces are exerted n view of different strengths of the chip 1 and the nozzle plate 4. But, it is possible that the introduced force on the nozzle plate 4 is not a normal force. It will thus cause a relative displacement between the chip 1 and the nozzle plate 4. Besides, if the exerted forces on the two sides of the nozzle plate 4 are not balanced, these elements still can not be fixed well due to the resulting inclination of these elements.

SUMMARY OF THE INVENTION

[0007] An objective of the present invention is to provide a method for manufacturing an ink jet printhead with high yield rate.

[0008] Another objective of the present invention is to provide a device for manufacturing an ink jet printhead with high yield rate.

[0009] In accordance with the objective of the present invention, a method for manufacturing an ink jet printhead which includes a plurality of ink-containing holes for containing therein an ink, a nozzle plate having

thereon a plurality of nozzles corresponding to the plurality of ink-containing holes for ejecting therethrough the ink, and a chip for controlling the ejection of the ink, includes steps of (a) forming a photo-sensitive layer on the chip, (b) forming the plurality of ink-containing holes on the photo-sensitive layer, (c) placing the nozzle plate on the photo-sensitive layer, and (d) heating the photo-sensitive layer to bond the chip and the nozzle plate.

[0010] In accordance with another aspect of the present invention, the photo-sensitive layer is certainly a photoresist.

[0011] In accordance with another aspect of the present invention, the photoresist is a dry photoresist. The thickness of the formed photoresist is preferably from 50 μm to 1000 μm.

[0012] In accordance with another aspect of the present invention, the photoresist is a wet photoresist. The thickness of the formed photoresist is preferably from 0.1 μm to 50 μm.

[0013] In accordance with another aspect of the present invention, the plurality of ink-containing holes are formed by photolithography.

[0014] In accordance with another aspect of the present invention, the photo-sensitive layer is heated by a hot plate under a heat temperature from 100 °C to 250 °C for a heat period form 1 minute to 10 hours.

[0015] In accordance with another aspect of the present invention, the heating step (d) farther includes a step of (d1) exerting a pressure from 0.01 kg/cm^2 to 1 kg/cm^2 on the nozzle plate to prompt the step (d) of bonding the chip and the nozzle plate.

[0016] In accordance with another aspect of the present invention, the plurality of nozzles are respectively in vertical alignment with the corresponded ink-containing holes.

[0017] In accordance with another aspect of the present invention, the step (c) further includes a step of (c1) fixing the nozzle plate on the chip.

[0018] In accordance with another aspect of the present invention, the nozzle plate is fixed on the chip by a clip.

[0019] In accordance with another aspect of the present invention, the fixing step (c1) farther includes steps of (c11) placing the nozzle plate and the chip on a base wherein a through hole in the chip is right above a flute on the base, and (c12) vacuumizing the flute for fixing the nozzle plate by a sucking force.

[0020] In accordance with another aspect of the present invention, an vacuumized pressure in the flute is preferably less than a surrounding pressure from 50 mmHg to 200 mmHg.

[0021] In accordance with another aspect of the present invention, the nozzle plate is a metal plate such as a nickel plate.

[0022] In accordance with the objective of the present invention, a method for manufacturing an ink jet printhead which includes a plurality of ink-containing holes for containing therein an ink, a nozzle plate having thereon a plurality of nozzles for ejecting therethrough the ink, and a chip for controlling the ejection of the ink, includes steps of (a) placing the chip on a base wherein a through hole in the chip is right above a flute on the base, (b) coating an adhesive on the chip, (c) placing the nozzle plate on the chip, (d) vacuumizing the flute for fixing the nozzle plate by a sucking force, and (e) heating the adhesive to bond the chip and the nozzle plate.

[0023] In accordance with another aspect of the present invention, the base further includes a plurality of independent flutes which have different vacuumized pressures.

[0024] In accordance with another aspect of the present invention, the method includes, after the step (e), a step of (f) de-vacuumizing the flute for removing the sucking force.

[0025] In accordance with another objective of the present invention, a device for manufacturing an ink jet printhead which includes a nozzle plate for ejecting therethrough an ink, and a chip mounted below the nozzle plate for controlling the ejection of the ink and having therein a through hole, includes a base and a flute provided on the base having an opening communicating with the flute, and a vacuum apparatus communicating with the opening. The base is used for supporting thereon the chip wherein the through hole is right above the flute. The vacuum apparatus is used for vacuumizing the flute to fix the nozzle plate to the chip by a sucking force.

[0026] In accordance with another aspect of the present invention, the flute can be a straight flute or an annular flute.

[0027] In accordance with another aspect of the present invention, the vacuum apparatus is preferably a rotary vacuum pump.

[0028] In accordance with another aspect of the present invention, the device further includes a three-way valve mounted between the vacuum apparatus and the opening for controlling the sucking force. The valve communicates the flute with the vacuum apparatus for vacuumizing the flute to exert the sucking force in a first instance. And the valve communicates the flute with surroundings for de-vacuumizing the flute to remove the sucking force in a second instance.

[0029] The present invention may best be understood through the following description with reference to the accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

[0030]

Fig. 1 is a schematic diagram showing a typical ink jet printhead;

Fig. 2 is a sectional diagram showing an ink-containing hole and its peripheral structure;

Figs. 3(a)-(d) are schematic diagrams showing a

conventional process for manufacturing an ink jet printhead;

Fig. 4 is a schematic diagram of a conventional fixing medium.;

Figs. 5(a)-(c) are schematic diagrams showing a preferred embodiment of a method for manufacturing an ink jet printhead according to the present invention;

Fig. 6 is a schematic diagram showing another preferred embodiment of the printhead-manufacturing method according to the present invention; and

Fig. 7 is a schematic diagram showing a preferred embodiment of a fixing device according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0031] The present invention will now be described more specifically with reference to the following embodiments. It is to be noted that the following descriptions of preferred embodiments of this invention are presented herein for the purpose of illustration and description only; it is not intended to be exhaustive or to be limited to the precise form disclosed.

[0032] The present invention provides a method for manufacturing an ink jet printhead more rapidly. Please refer to Fig. 5 which is a schematic diagram showing a preferred embodiment of a method for manufacturing the ink jet printhead according to the present invention. At first, coat a photoresist 31 on the chip 1 as shown in Fig. 5(a). The photoresist 31 is made from a known photo-sensitive material and has no other limitations. The photoresist is typically classified into dry photoresist or wet photoresist according to the amount of solvent in the photoresist. The dry type is applicable to thicker photoresist with thickness from 50 μm to 1000 μm while the other type is applicable to thinner photoresist with thickness from 0.1 μm to 50 μm. The dry type is the most often used one because the thickness range is suitable for containing the ink. The coating step is executed by spin-coating because the obtained photoresist is especially smooth by this method.

[0033] Please refer to Fig. 5(b). The next step is to photolithograph the photoresist 31 to form the ink-containing hole 3. The steps including soft baking, exposure, and development are executed in sequence to form a plurality holes, so-called ink-containing holes 3, on the photoresist 31. According to the prior art, the next step should be hard-backing step for evaporating the solvent in the photoresist 31 in order to adhere the photoresist 31 to the chip 1 more firmly. But the photoresist 31 is not gluey after dried so another adhesive is needed for bonding the nozzle plate 4 to the chip 1. Please refer to Fig. 5(c), According to the present invention, the conventional hard baking step is suspended temporarily. Before the photoresist 31 is dried, place the nozzle plate 4 on the photoresist 31 wherein each nozzle 41 is in alignment with its corresponding ink-containing hole 3. Then, the hard baking step is resumed.

[0034] Hard baking step is used for reducing the amount of solvent in the photoresist 31. This step can make the photoresist 31 adhere to the chip 1 and the nozzle plate 4 properly. The photoresist 31 is heated by conduction. In other words, a hot plate is adopted. The heat temperature and heat period are determined according to the material of photoresist 31. Typically, the heat temperature is from 100 °C to 250 °C while the heat period is from 1 minute to 10 hours. Too low a heat temperature requires a longer period of time to evaporate the solvent. Too high a heat temperature causes a worse adhesion of the photoresist due to much tensile stress stored in it. It is difficult to fully evaporate the solvent in the photoresist if the heating period is too short. On the other hand, the photoresist becomes fragile if the heat period is too long. For the above reasons, the heat temperature and the heating period must be determined properly. Besides, an additional pressure from 0.01 kg/cm^2 to 1 kg/cm^2 can be exerted on the nozzle plate 4 to prompt the bonding of nozzle plate 4 and chip 1.

[0035] Certainly, the production efficiency can be increased by slightly modifying the present technology. Heretofore, because of the limit of the adhesive-coating step, the manufacturers can not manufacture many ink jet printheads at a particular period of time. They must bond the first nozzle plate on the first chip, then bond the second nozzle plate on the second chip, and so on. If a wafer has thereon one hundred chips, the bonding step must be repeated for one hundred times. It is impossible to coat an adhesive on all of the chips included in one wafer at first, and then place all the nozzle plates on the wafer because the adhesive-coating step is a time-consuming step. The coated adhesive will dry before all the nozzle plates are placed on the wafer. On the contrary, the method according to the present invention can manufacture many ink jet printheads at a time. A metal plate having hundreds of nozzle plates is placed on the photoresist above the wafer having hundreds of chips before the photoresist is dried. Then, the metal plate accompanied with the wafer is heated and all hundreds of nozzle plates and chips are bonded together. Apparently, this method can speed up the production efficiency.

[0036] Compared with the prior art, the present invention eliminates the adhesive-coating step so that the process consumes less time. Moreover, the present invention can even bond hundreds of nozzle plates and chips at the same time so that the process consumes much less time. Besides, eliminating the adhesive-coating step also eliminates the troubles, such as choke of the nozzle, leakage of the ink, or falling of the nozzle plate, resulting from an improper amount of the adhesive occurred during the adhesive-coating step. The rejection rate will be reduced to zero if the nozzles of the nozzle plates are really in alignment of the ink-contain-

ing holes on the chips. The expensive adhesive-coating instrument is not needed any more so this method saves not only production time but also production cost.

[0037] The fixing device is also improved according to the present invention. If the nozzle plates are not fixed properly on the chips, the above-described efforts are in vain because there is a relative displacement between the nozzle plates and the chips before we heat the photoresist. Please refer to Fig. 6 which is a schematic diagram showing another preferred embodiment of the printhead-manufacturing method according to the present invention. The wafer 8 including many chips 1 is placing on the base 71 wherein the through holes 2 of the chips 1 are right above the flute 72 of the base 71. After the photoresist is coated on the chips 1, the metal plate 9 including many nozzle plates 4 is placed on the wafer 8 wherein the nozzles of the nozzle plates 4 are in vertical alignment with the ink-containing holes of the chips 1 as described in the prior preferred embodiment. Before heating the photoresist located between the metal plate 9 and the wafer 8, the metal plate 9 and the wafer 8 must be fixed firmly so there is no relative displacement between them when they are translated. The vacuum apparatus 73 communicating with the opening 721 of the base 71 vacuumizes the flute 72 and a sucking force is generated to fix the metal plate 9 to the wafer 8. The vacuum apparatus 73 is a rotary vacuum pump. A three-way valve 74 can be added to control the sucking force. If the sucking force is desired, the three-way valve 74 is caused to communicate the rotary vacuum pump 73 with the flute 72 and the rotary vacuum pump 73 vacuumizes the flute 72. After the heating step, the metal plate 9 and the wafer 8 are bonded together so the sucking force can be removed. Consequently, the three-way valve 74 communicates the flute 72 with the surroundings and the flute 72 is de-vacuumized so the sucking force is removed. When the rotary vacuum pump 73 works, the pressure difference between the flute 72 and the surroundings is from 50 mmHg ~ 200 mmHg. The greater the pressure difference is, the greater the sucking force is. The pressure difference is determined by the vacuuming power of the rotary vacuum pump 73 in accordance with the strength of the metal plate 9. It is noted that although a great pressure difference can fix the metal plate 9 more firmly, too great a pressure difference will cause damage to the metal plate 9.

[0038] Certainly, it is not necessary that all the through holes 2 are right above the flute 72. The generation of sucking force is not affected if some through holes 2 are not right above the flute 72.

[0039] Certainly, the fixing method is also practicable if there are a plurality of flutes on the base, or the flute is otherwise shaped. Please refer to Fig. 7 which is a schematic diagram showing a preferred embodiment of the fixing device according to the present invention. The flutes 72 are annular flutes. Each flute 72 corresponds to a rotary vacuum pump 73 and a three-way valve 74. Accordingly, the pressure differences between the flutes 72 and the surroundings may be different. For example, if the strength of the metal plate is not equable, the exerted sucking forces must be different at different points of the metal plate. Thus, proper sucking forces can be exerted at any point of the metal plate by respectively controlling the vacuuming powers of each rotary vacuum pump 73.

[0040] The present fixing method used for manufacturing the ink jet printhead is better than the prior art. The manufacturers need not worry about other forces which are not normal to the metal plate are introduced according to the prior art. The best advantage is that the force strength can be adjusted arbitrarily at any point. The manufacturers also need not worry that the metal plate is not fixed well or the metal plate is damaged because of improper exerted forces. Moreover, the sucking force is uniform for the whole metal plate according to the present invention while the sucking force is not uniform according to the prior art because strains are only generated at the points where the clips or the grippers are added. Such improper fixing will cause deformation of the metal plate and the wafer. Accordingly, the present method is more utilizable due to its easily controlled characteristics.

[0041] While the invention has been described in terms of what are presently considered to be the most practical and preferred embodiments, it is to be understood that the invention need not be limited to the disclosed embodiment. On the contrary, it is intended to cover various modifications and similar arrangements included within the spirit and scope of the appended claims which are to be accorded with the broadest interpretation so as to encompass all such modifications and similar structures.

Claims

1. A method for manufacturing an ink jet printhead, said ink jet printhead including a plurality of ink-containing holes for containing therein an ink, a nozzle plate having thereon a plurality of nozzles corresponding to said plurality of ink-containing holes for ejecting therethrough said ink, and a chip for controlling the ejection of said ink, comprising:

   (a) forming a photo-sensitive layer on said chip;
   (b) forming said plurality of ink-containing holes on said photo-sensitive layer;
   (c) placing said nozzle plate on said photo-sensitive layer; and
   (d) heating said photo-sensitive layer to bond said chip and said nozzle plate.

2. A method according to claim 1 wherein in said step (a), said photo-sensitive layer is a photoresist.

3. A method according to claim 2 wherein said pho-

toresist is a dry photoresist having a thickness from 50 μm to 1000 μm.

4. A method according to claim 2 wherein said photoresist is a wet photoresist having a thickness from 0.1 μm to 50 μm.

5. A method according to claim 2 wherein in said step (b), said plurality of ink-containing holes are formed by photolithography.

6. A method according to claim 1 wherein in said step (d), said photo-sensitive layer is heated by a hot plate under a heat temperature for a heat period.

7. A method according to claim 6 wherein said heat temperature is from 100 °C to 250 °C.

8. A method according to claim 6 wherein said heat period is from 1 minute to 10 hours.

9. A method according to claim 1 wherein said step (d) further comprises a step of (d1) exerting a pressure on said nozzle plate to prompt said step (d) of bonding said chip and said nozzle plate.

10. A method according to claim 9 wherein said pressure is from 0.01 kg/cm^2 to 1 kg/cm^2.

11. A method according to claim 1 wherein in said step (c), said plurality of nozzles are respectively in vertical alignment with said corresponded ink-containing holes.

12. A method according to claim 1 wherein said step (c) further comprises a step of (c1) fixing said nozzle plate on said chip.

13. A method according to claim 12 wherein in said step (c1), said nozzle plate is fixed on said chip by a clip.

14. A method according to claim 12 wherein said step (c1) further comprises steps of:

(c11) placing said nozzle plate and said chip having therein a through hole on a base having thereon a flute, said through hole being right above said flute; and
(c12) vacuumizing said flute for fixing said nozzle plate by a sucking force.

15. A method according to claim 14 wherein in said step (c12), an vacuumized pressure in said flute is less than a surrounding pressure from 50 mmHg to 200 mmHg.

16. A method according to claim 1 wherein said nozzle plate is a metal plate.

17. A method according to claim 16 wherein said metal plate is a nickel plate.

18. A method for manufacturing an ink jet printhead, said ink jet printhead including a nozzle plate having thereon a plurality of nozzles for ejecting therethrough an ink, and a chip for controlling the ejection of said ink, comprising:

(a) placing said chip having therein a through hole on a base having thereon a flute, said through hole being right above said flute;
(b) coating an adhesive on said chip;
(c) placing said nozzle plate on said chip;
(d) vacuumizing said flute for fixing said nozzle plate by a sucking force; and
(e) heating said adhesive to bond said chip and said nozzle plate.

19. A method according to claim 18 wherein said base further includes a plurality of independent flutes.

20. A method according to claim 19 wherein said plurality of independent flutes have different vacuumized pressures.

21. A method according to claim 18 wherein after said step (e), said method further comprises a step of (f) de-vacuumizing said flute for removing said sucking force.

22. A device for manufacturing an ink jet printhead, said ink jet printhead including a nozzle plate for ejecting therethrough an ink, and a chip mounted below said nozzle plate for controlling the ejection of said ink and having therein a through hole, comprising:

a base supporting thereon said chip and a flute provided on said base having an opening communicating with said flute, said through hole being right above said flute; and
a vacuum apparatus communicating with said opening for vacuumizing said flute to fix said nozzle plate to said chip by a sucking force.

23. A device according to claim 22 wherein said flute is a straight flute.

24. A device according to claim 22 wherein said flute is an annular flute.

25. A device according to claim 22 wherein said vacuum apparatus is a rotary vacuum pump.

26. A device according to claim 22 wherein said device further comprises a three-way valve mounted

between said vacuum apparatus and said opening for controlling said sucking force, said valve communicating said flute with said vacuum apparatus for vacuumizing said flute to exert said sucking force in a first instance and communicating said flute with surroundings for de-vacuumizing said flute to remove said sucking force in a second instance.

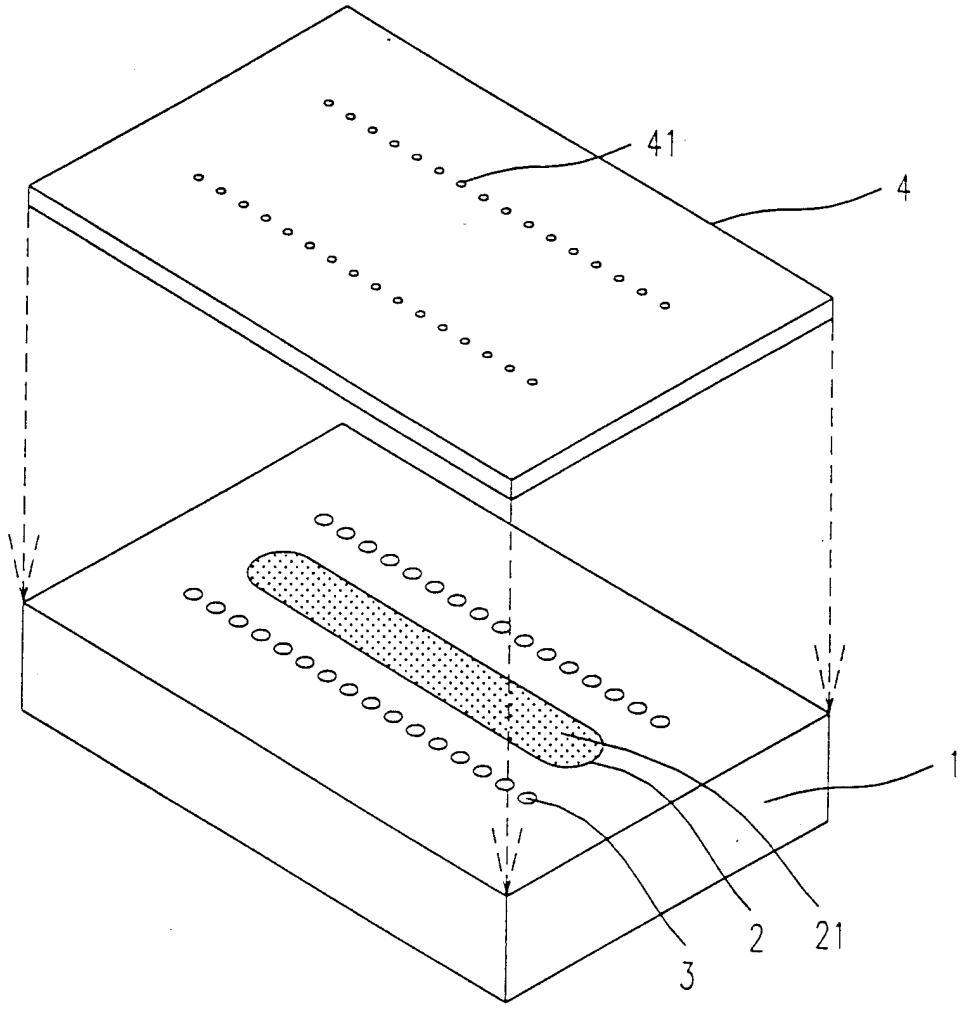

Fig. 1 (PRIOR ART)

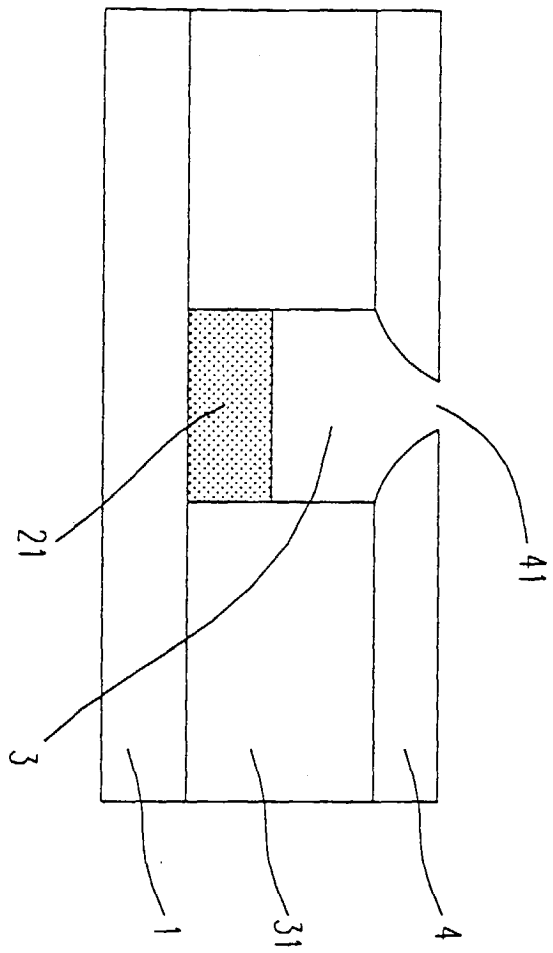

Fig. 2 (PRIOR ART)

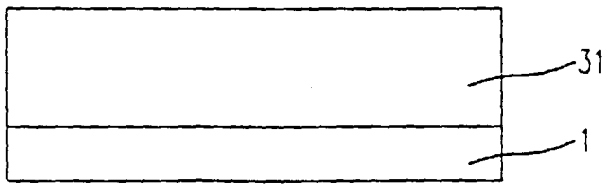

Fig. 3(a) (PRIOR ART)

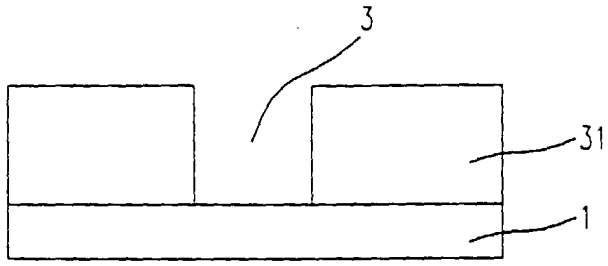

Fig. 3(b) (PRIOR ART)

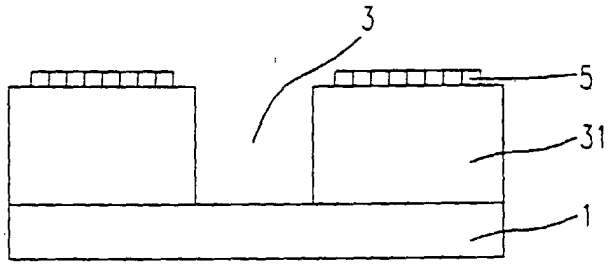

Fig. 3(c) (PRIOR ART)

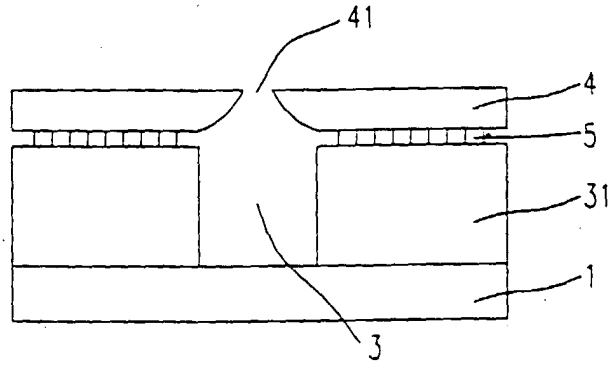

Fig. 3(d) (PRIOR ART)

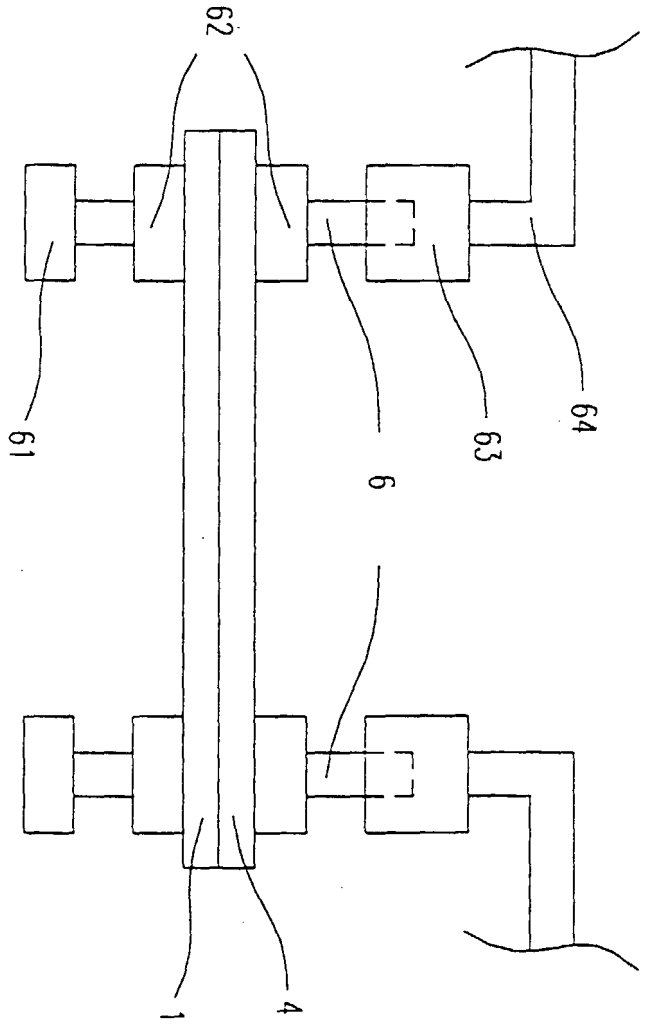

Fig. 4 (PRIOR ART)

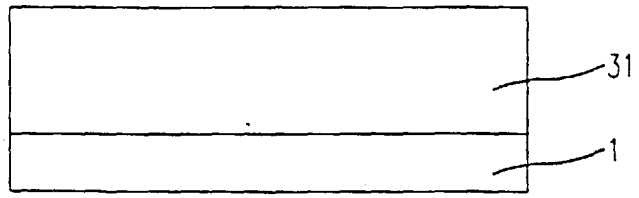

Fig. 5(a)

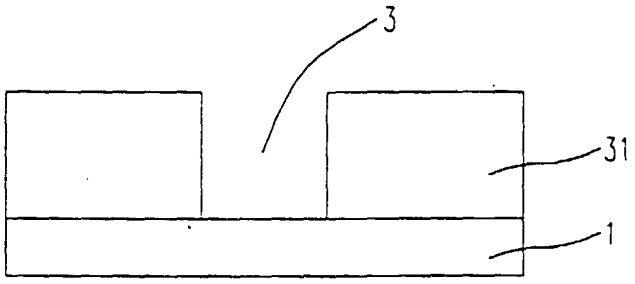

Fig. 5(b)

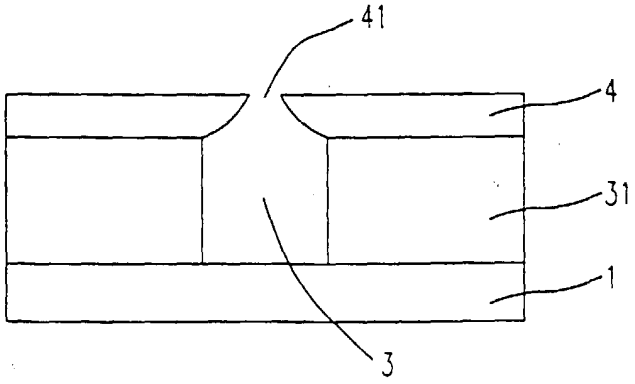

Fig. 5(c)

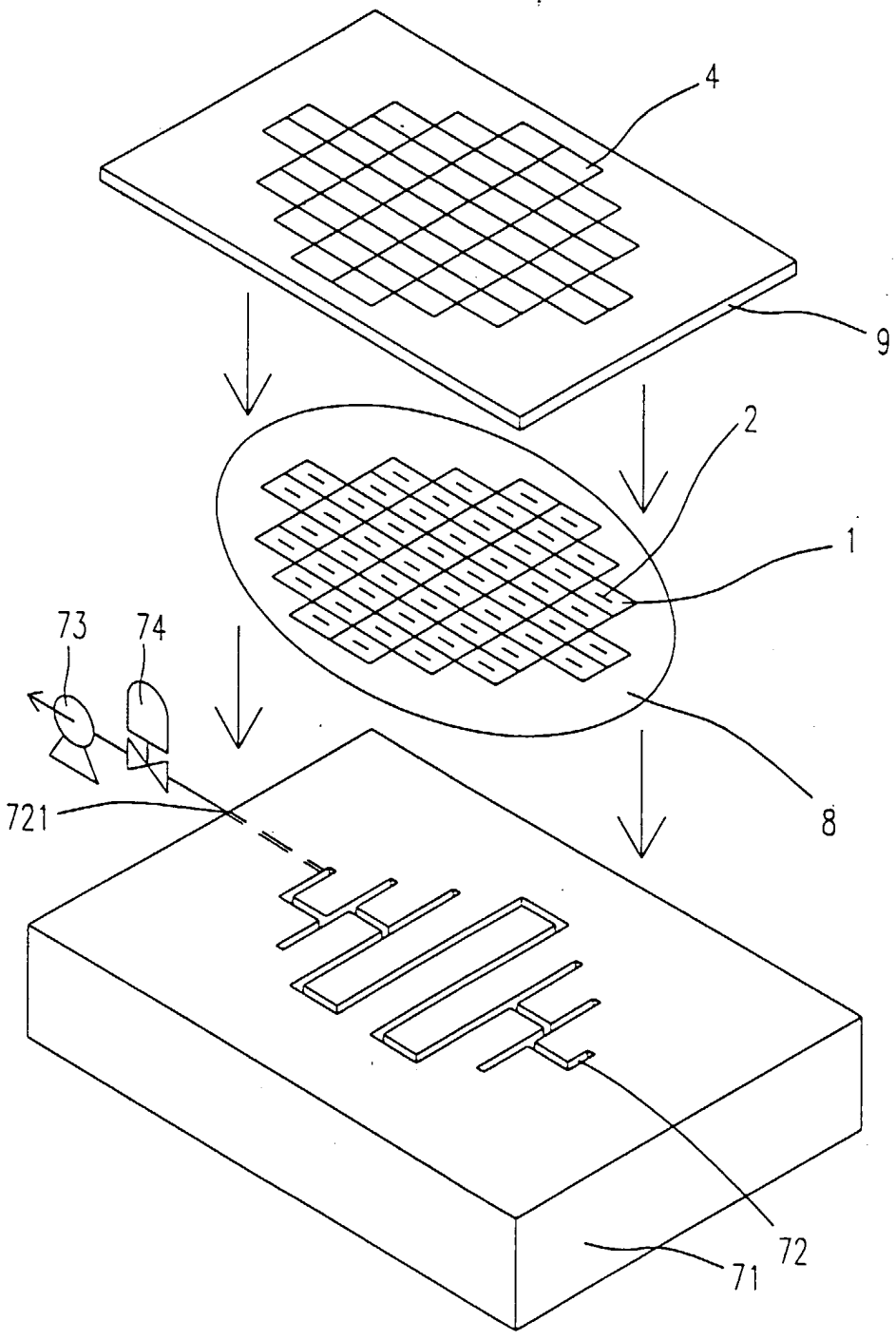

Fig. 6

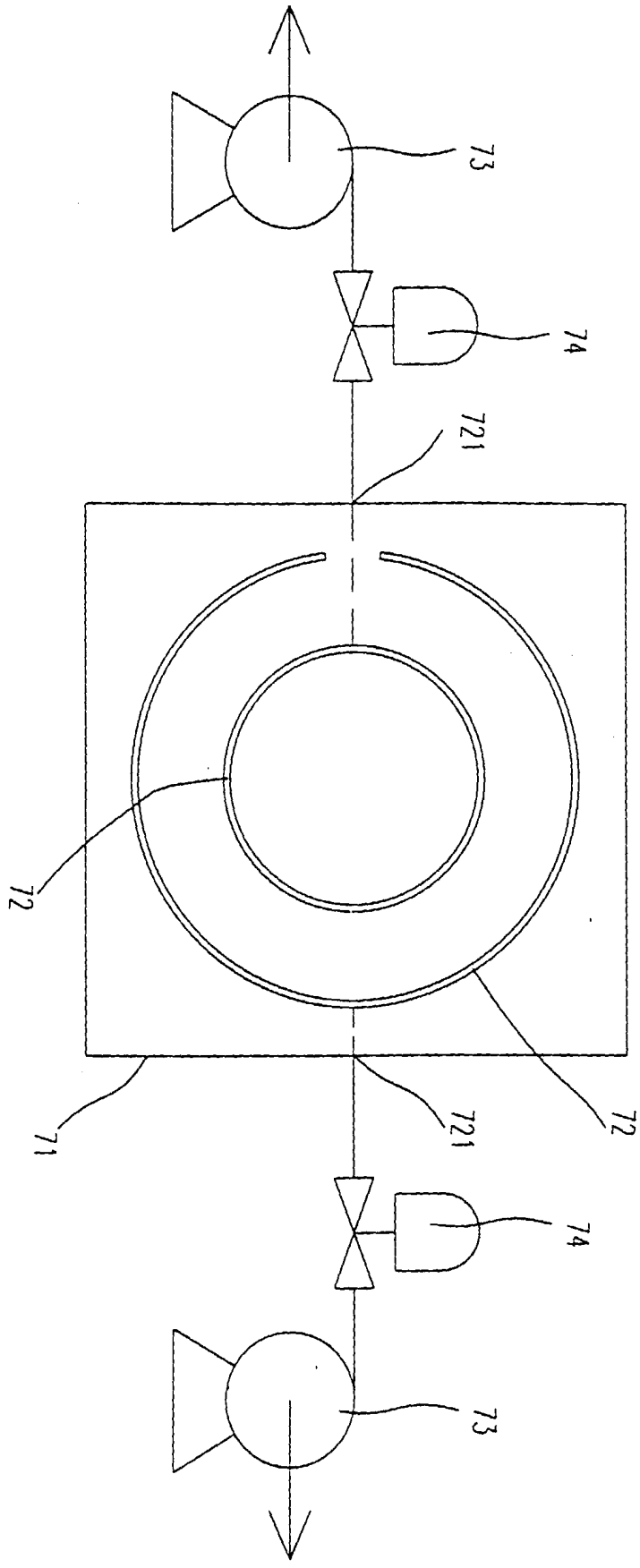

Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
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Place of search	Date of completion of the search	Examiner
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