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(54) **MICROINJECTOR HAVING DRIVE CIRCUIT AND METHOD FOR MAKING THE SAME**

(57) The present invention discloses a microinjector having drive circuit and method for making the same. The microinjector utilizes bubble as virtual valve to eject fluid medium, including manifold, multiple fluid chambers, multiple pairs of the first bubble generating member and the second bubble generating member, multiple nozzles and drive circuit, wherein, the drive circuit controls multiple pairs of the first bubble generating member

and the second bubble generating member simultaneously to eject the fluid which in the corresponding fluid chamber from the corresponding nozzle, thereby attaining the effect for ejecting fluid; in addition, due to integrating the drive circuit with the bubble generating members in the same substrate, not only reduced the number of making steps, but also obtained the structure of less number of circuit unit and interconnecting lines.

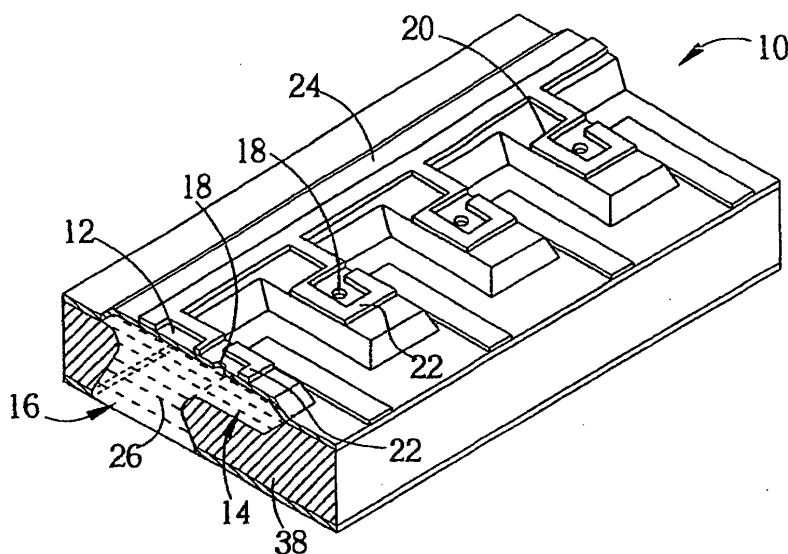


Fig. 1

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention relates to a microinjector head and its manufacturing method, and more particularly, to an integrally formed microinjector head with driving circuit, and a manufacturing method thereof.

2. Description of the Prior Art

[0002] At present, droplet injectors are widely applied in inkjet printers. Droplet injectors also have many other applications in different fields such as fuel injection systems, cell sorting, drug delivery systems, direct print lithography and micro jet propulsion systems. The common aim of the above applications is to provide a droplet injector that is reliable, of low-cost, and provides high-quality droplets with a high frequency and a high spatial resolution.

[0003] However not all apparatuses can successfully inject uniform droplets. In currently known and used droplet injection systems, one system using thermally driven bubbles to inject droplets is proved to be a successful system because of its comparatively simple architecture and lower cost.

[0004] U. S. Pat. No. 6,102,530-"Apparatus and method for using bubbles as virtual valve in microinjector to eject fluid" mentions a droplet injection apparatus with virtual valves as shown in Fig. 1. In fig.1, heaters 20, 22 are located around orifices 18. A first bubble is generated at a position on a fluid chamber 14 close to orifices upon heating, the first bubble acts like a virtual valve and is capable of reducing a cross talk effect with the adjacent chambers. A second bubble is then generated and approaches the first bubble to push the fluid, causing a droplet to be ejected from the orifice 18. Finally, the second bubble fuses with the first bubble and successfully reduces the production of satellite droplets.

[0005] U. S. Pat. No. 5,122,812-"Thermal inkjet print head having driver circuit thereon and method for making the same" mentions a structure of an inkjet print head with driving circuit as shown in Fig. 2. Heating devices and driving circuit are integrated on a same substrate. However there are still many steps in the process. And according to the structure, a barrier layer 130 of 20 ~ 30 μm in thickness must be formed and an orifice plate is adhered on the barrier layer 130. This adhesion procedure limits the spatial resolution due to unavoidable assembly tolerance. In addition, the adhesion procedure is not compatible with general IC processes. When microinjector arrays are integrated with driving circuit to reduce layout and are tightly packed, such incompatibility problems become more obvious and lead to more complicated manufacturing processes and thus higher costs.

SUMMARY OF THE INVENTION

[0006] It is therefore a primary objective of the claimed invention to provide a microinjector head with driving circuit to control a plurality of first and second bubble-generating devices simultaneously to eject fluid in a plurality of chambers from orifices. A secondary objective of the claimed invention is to provide a manufacturing method for making a microinjector head with driving circuit in fewer steps and with less number of circuit devices and linking circuits as compared with the conventional microinjector head.

[0007] According to the claimed invention, the microinjector head with driving circuit to eject fluid uses a bubble as a virtual valve. The microinjector head comprises a plurality of fluid chambers, a manifold, a plurality of orifices, and a plurality of pairs of bubble generators, each pair of bubble generators comprising a first bubble generating device and a second bubble generating device, and a driving circuit.

[0008] Wherein the manifold is communicated with the fluid chambers and the plurality of orifices are communicated with the fluid chamber.

[0009] The first and second bubble generating device are located near a corresponding orifice and above the corresponding chamber, the first bubble-generating device generates a first bubble that is used as a virtual valve, thereafter, the second bubble-generating device generates a second bubble to cause fluid in the chamber to eject out from the orifice when the chamber is filled with fluid.

[0010] The driving circuit comprises a plurality of functional devices disposed on a same substrate as the plurality pairs of first and second bubble generating devices. The driving circuit is used to independently send a driving signal to a single bubble generator, and to drive the plurality pairs of the bubble generators, whereby functions to simultaneously control the plurality pairs of the bubble generators.

[0011] According to the claimed invention, it is provided a method for manufacturing the microinjector with a driving circuit comprising the steps of providing a substrate; forming a driving circuit which includes a plurality of functional devices on the substrate; then either forming a sacrificial layer on the substrate without coving the driving circuit or using the uppermost layer of the dielectric layer upon forming the driving circuit as the sacrificial layer; sequentially, forming a low-stress material layer on the sacrificial layer; then, etching the substrate and the sacrificial layer to form a manifold and a plurality of fluid chambers wherein the manifold is communicated with the fluid chambers so as to supply the fluid to the fluid chambers.

[0012] Then, a plurality of pairs of first and second bubble generating device are formed on the low-stress material layer while communicating with the driving circuit. Finally, a plurality of orifices are formed between the corresponding first and second bubble generating

device, and communicated with the fluid chambers to eject the fluid, whereby an integrally formed microinjector with a driving circuit is finished.

[0013] These and other objects and the advantages of the present invention will no doubt become obvious to those of ordinary skill in the art after having read the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1 is a structural diagram of a prior art droplet injection apparatus with virtual valves.

Fig. 2 is a structural dissection diagram of a prior art microinjector head with driving circuit;

Fig. 3 to Fig. 9 are structural and schematic diagrams of procedures to manufacture the microinjector head with driving circuit and structural diagrams of the microinjector head, wherein Fig. 9 is a structural and schematic diagram of the microinjector head with driving circuit of the present invention; and

Fig. 10 to Fig. 12 are structural and schematic diagrams of a second embodiment of procedures to manufacture the microinjector head with driving circuit and structural diagrams of the microinjector head.

Brief Description of the Reference Numerals

[0015]

10	array
12	microinjector
14	fluid chamber
16	manifold
18	orifice
20	first heater
22	second heater
24	common electrode
26	fluid
38	substrate
40	sacrificial layer
42	low-stress layer
44	conductive layer
45,46	low temperature oxide layer
50	second part
51	dielectric layer
52	first part
101	thin oxide layer
102	silicone nitride layer
105	polysilicon gate

106	source
107	drain
130	shield layer
140	orifice plate

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0016] The present invention offers an improvement over the prior art. Therefore, references to items shown in Fig. 1 and Fig. 2 will be made in the following description. As shown in Fig. 1 which shows an array 10 of microinjector 12, the array 10 comprises a plurality of microinjectors 12 adjacent each other. Each of the microinjectors includes a fluid chamber 14, a manifold 16, an orifice 18, a first heater 20, and a second heater 22. The first heater 20 and the second heater 22 are connected in series to a common electrode 24.

[0017] The first heater 20 and the second heater 22 is operated, so that the first heater 20 generates a first bubble which functions like a valve, for separating the fluid chamber 14 and the orifice 18, and the second heater 22 then generates a second bubble which is used to push the fluid 26, cause the fluid to be ejected from the orifice 18, thereby achieve the function of ejecting fluid 26.

[0018] The fluid chamber 14 is filled with fluid 26 which includes but not limited to ink, gasoline, oil, chemicals, biomedical solution, water and the like, and the kind of the fluid is selected depending on the special application.

[0019] However, in the present invention, in order to simultaneously control a plurality of pairs of the first and second heater 20 and 22, it is necessary to incorporate a driving circuit into the microinjector head.

[0020] As shown in Figs. 3 to Fig. 5, making a microinjector array 10 with driving circuit on a substrate 38 such as a silicon wafer comprises forming a thin oxide layer 101 on the substrate 38, then forming a silicon nitride (SiN_x) layer 102 on the thin oxide layer (as shown in Fig. 3), etching the silicon nitride layer 102 (as shown in Fig. 4) after exposing and developing a silicon nitride layer 102, , and then using local oxidation to oxidize unprotected regions of the thin oxide layer 101 to form a field oxide layer. Until now, a dielectric layer 51 (as shown in Fig. 5) which comprised a first part 52 and a second part 50 is formed. The first part 52 is a part of the thin oxide layer 101 covered by silicon nitride layer 102. The second part 50 is the field oxide layer formed by local oxidation. This field oxide layer can be etched in the following procedures to form fluid chambers 14. Then the silicon nitride layer 102 is removed. Blanket boron ion implantation of the first part 52 and the second part 50 (as shown in Fig. 5) adjusts the threshold voltage of the driving circuit. A polysilicon gate 105 is formed on the first part 52 and a phosphorus ion implantation of the polysilicon gate 105 is performed to reduce resistance of the polysilicon gate 105. Implanting arsenic ions

in the substrate 38 forms a source 106 and a drain 107 close to the gate 105. Therefore, a plurality of functional devices are formed on the substrate 38 (as shown in Fig. 6).

[0021] Please refer to Fig. 7. A low stress layer 42, such as SiN_x , is deposited on the second part 50 as an upper layer of chambers 14.

[0022] Please refer to Fig. 8. An etching solution KOH is used to etch a back side of the substrate 38 to form a manifold 16 as a main channel for fluid supply, and then the second part 50 is removed by the etching solution HF. Another etching using KOH is performed under precisely controlling the etching period to increase the depths of the fluid chambers 14. So the chambers 14 and the manifold 16 are connected and are capable of being filled with fluid. Extra care must be undertaken during this etching step because the convex corners of the chambers 14 are also attacked and rounded.

[0023] Heaters, including first heaters 20 and second heaters 22 are deposited and patterned. Preferably, the first heaters 20 and the second heaters 22 may be made of an alloy of tantalum and aluminum. However, other materials or alloys, such as platinum or HfB_2 , may also be employed to achieve the same effect. To protect the first heaters 20 and the second heaters 22 and isolate the plural functional devices, a low temperature oxide layer 45 is deposited as a protection layer on the whole substrate 38 which includes the gate 105, the source 106, the drain 107, and the second part 50.

[0024] A conductive layer 44 is formed on the first heaters 20 and the second heaters 22 to connect the first heaters 20, the second heaters 22, and the functional devices of the driving circuit. The driving circuit can transmit independently driving signals to a single heater (the first heaters 20 and the second heaters 22) and drive a plurality of pairs of heaters (the first heaters 20 and the second heaters 22), whereby less circuit elements and circuit lines are required to achieve the same function. For example, in the preferred embodiment, the first heaters 20 and the second heaters 22 are connected in series. The driving circuit controls the plurality bubble generators in matrix manner. For example, a column bubble generators is powered simultaneously, and another row is inputted transmission signals (or information), to independently control a single first heater 20 and second heater 22. The conductive layer 44 may preferably be made of an alloy of aluminum-silicon-copper. The conductive layer 44 may also be made of aluminum, copper, gold, tungsten, or other materials. Afterwards, a low temperature oxide layer 46 is deposited as a protection layer on the conductive layer 44.

[0025] Please refer to Fig. 9. An orifice 18 is formed between the first heater 20 and the second heater 22. If a line width of $3\text{ }\mu\text{m}$ is allowed in photolithography, the diameter of the orifice 18 can be as small as $2\text{ }\mu\text{m}$, and the pitch between the orifice 18 and an adjacent orifice 18 can be as small as $15\text{ }\mu\text{m}$. Until now, an integrally formed microinjector array with driving circuit is formed.

Not only the driving circuit and heaters are integrated on the same substrate 38, but also an integral microinjector head structure is formed without the need of adhesion of an orifice plate.

[0026] The following is a description of another embodiment of the present invention. Compared with the first embodiment, the difference lies in the process of directly etching the second part 50 of Fig. 6 to form the fluid chamber 14 in the above mentioned embodiment as shown in Figs. 7, 8, and 9. This embodiment first etches a part of the second part 50 and forms a sacrificial layer 40 on the etched position, then performs the subsequent processes. Please refer to Fig. 10. Fig. 10 continues the process of Fig. 6. A part of the second part 50 of Fig. 6 is etched locally, and an oxide layer 40 is deposited on a part of the substrate 38 uncovered by the driving circuit so as to become a sacrificial layer 40 of the fluid chamber 14. A low stress layer 42' is then deposited as a top layer of the chamber 14.

[0027] Please refer to Fig. 11 and Fig. 12, which are similar in their processes to those of Fig. 8 and Fig. 9. As shown in Fig. 11, the substrate 38 and the sacrificial layer 40 are etched from the back side to form the manifold 16 and the chambers 14. The first heater 20, the second heater 22 and the protective low temperature oxide layer 45 are then deposited. A conductive layer 44 is formed to conduct the first heater 20, the second heater 22, and the driving circuit, and a low temperature oxide layer 46 is deposited on the conductive layer 44 as a protective layer. Finally, as shown in Fig. 12, photolithography is utilized to form an orifice 18 between the first heater 20 and the second heater 22. Then an integrally formed microinjector array with driving circuit is formed.

[0028] The order of the above processes can be changed according to real situations while still manufacturing a micro droplet injector head with appropriate driving circuit.

40 The Effect of the Present Invention

[0029] The microinjector and the method thereof according to the present invention function as follows:

- 45 1. The present invention provides an improved micro-droplet injector structure which can be applied in various fields such as ink jet printer;
- 50 2. The present invention provides an integrally formed micro-droplet injector in which the driving circuit and heaters are integrated on the same substrate, and the need of orifice plate is eliminated;
- 55 3. The number of steps is reduced, and the manufacturing process can be simplified;
4. The number of the connection wiring is reduced due to an integral structure, thus the manufacturing

cost can be lowered while achieving the same control function.

[0030] Those skilled in the art will readily observe that numerous modifications and alterations of the present invention may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of appended claims.

Claims

1. A microinjector head with driving circuit using bubble as virtual valve to eject fluid, the microinjector head comprising:

a plurality of fluid chambers;
 a manifold communicated with the fluid chambers for providing fluid to the chambers;
 a plurality of orifices communicated with the corresponding chambers;
 a plurality of pairs of bubble generators, each pair of which includes a first bubble generating device and a second bubble generating device which are provided near the corresponding orifice and above the corresponding chamber, and wherein when the corresponding fluid chamber is filled with the fluid, the first bubble generating device generates a first bubble as a virtual valve in the fluid chamber, thereafter the second bubble generating device generates a second bubble so as to cause fluid in the chamber to eject out from the orifice; and
 a driving circuit comprising a plurality of functional devices disposed on a same substrate as the plurality pairs of bubble generators, for independently sending driving signals to a single bubble generator and for driving the plurality pairs of bubble generator.

2. The microinjector head with driving circuit of claim 1 wherein the functional device is a transistor.

3. The microinjector head with driving circuit of claim 2 wherein the transistor is a metal oxide semiconductor field effect transistor (MOSFET).

4. The microinjector head with driving circuit of claim 1 wherein the first bubble generating device comprises a first heater and the second bubble generating device comprises a second heater.

5. The microinjector head with driving circuit of claim 4 wherein the first bubble generating device and the second bubble generating device further comprise a conductive layer.

6. The microinjector head with driving circuit of claim 5 wherein the material of the conductive layer is any one selected from the group consisting of aluminum, gold, copper, tungsten, and alloys of aluminum-silicon-copper.

7. The microinjector head with driving circuit of claim 4 wherein the material of the first and second heaters is any one selected from the group consisting of alloys of tantalum and aluminum, platinum, and HfB_2 .

8. A method for making a microinjector head with driving circuit, said microinjector head using bubble as a virtual valve to eject fluid, comprising the steps of:

providing a substrate;
 forming a dielectric layer having a first part and a second part on the substrate;
 forming a driving circuit containing a plurality of functional devices on the first part of the dielectric layer;
 forming a low-stress material layer on the second part of the dielectric layer;
 etching the substrate and the dielectric layers to form a manifold and a plurality of fluid chambers, the manifold and the fluid chambers being communicated to supply fluid to the chambers;
 forming a plurality of pairs of bubble generators on the low-stress material layer, each pair of the bubble generator comprising a first bubble generating device and a second bubble generating device, and being connected to the driving circuit; and
 forming an orifice located between the corresponding first bubble generating device and second bubble generating device, and communicated the corresponding chamber to eject the fluid.

9. The method of claim 8 for making a microinjector head with driving circuit wherein the step of forming the dielectric layer comprises the steps of:

forming a thin oxide layer on the substrate;
 forming a silicon nitride layer on the thin oxide layer;
 oxidizing regions of the thin oxide layer uncovered by the silicon oxide layer by means of local oxidation to form a field oxide, wherein the thin oxide layer covered by the silicon nitride layer is the first part of the dielectric layer, and the field oxide is the second part of the dielectric layer; and
 removing the silicon nitride layer.

10. The method of claim 8 for making a microinjector head with driving circuit wherein the step of forming

the driving circuit comprises the steps of:

implanting boron ions into the dielectric layer;
forming a polysilicon gate on the first part of the
dielectric layer; and
implanting arsenic ions into the substrate for
forming a source and a drain close to the gate.

11. The method of claim 8 for making a microinjector head with driving circuit wherein the driving circuit is used to independently send the signals to a single bubble generator, and drive the plurality pairs of bubble generators.

12. The method of claim 8 for making a microinjector head with driving circuit wherein the functional device is transistor.

13. The method of claim 12 for making a microinjector head with driving circuit wherein said transistor is metal oxide semiconductor field effect transistor (MOSFET)

14. The method of claim 8 for making a microinjector head with driving circuit wherein the step of etching the substrate and the dielectric layer to form the manifold and the chambers comprises the step of:

etching the substrate from back side to form the manifold;
removing the second part of the dielectric layer;
and
etching the substrate from back side again to form the chambers.

15. The method of claim 8 for making a microinjector head with driving circuit wherein the step of forming the first bubble-generating device and the second bubble-generating device comprises the steps of:

forming a resistance layer on the low-stress material layer to form a first heater and a second heater; and
forming a conductive layer on the resistance layer, the conductive layer and the resistance layer being connected.

16. The method of claim 15 for making a microinjector head with driving circuit wherein the conductive layer is any one selected from the group consisting of aluminum, gold, copper, tungsten, and alloys of aluminum-silicon-copper.

17. The method of claim 15 for making a microinjector head with driving circuit wherein the material of the first and second heaters is any one selected from the group consisting of alloys of tantalum and aluminum, platinum, and HfB_2 .

18. The method of claim 15 for making a microinjector head with driving circuit, wherein between the step of forming said resistance layer and the step of forming said conductive layer, further comprising a step of forming a first oxide layer on the resistance layer, so as to protect the first and second heaters.

19. The method of claim 8 for making a microinjector head with driving circuit, further comprising the step of forming a second oxide layer on the first bubble generating devices and the second bubble generating devices, so as to protect the first bubble generating devices and the second bubble generating devices.

20. A method for making a microinjector head with driving circuit, said microinjector head using bubble as virtual valve to eject fluid, the method comprising the steps of:

providing a substrate;
forming a dielectric layer having a first part and a second part on the substrate;
forming a driving circuit having a plurality of functional devices on the first part of the dielectric layer;
etching a portion of the second part of the dielectric layer, and forming a sacrificial layer on the etched portion of the second part of the dielectric layer;
forming a low-stress material layer on the sacrificial layer;
etching a portion of the substrate and the sacrificial layer which includes no driving circuit, for forming a manifold and a plurality of fluid chambers, the manifold being communicated with the chambers for providing fluid to the chambers;
forming a plurality pairs of bubble generator on the low-stress material layer, each pair of the bubble generator being communicated with the driving circuit and comprising a first bubble generating device and a second bubble generating device; and
forming a plurality of orifices each of which being located between the corresponding first bubble generating device and second bubble generating device, and communicated with the corresponding fluid chambers for ejecting the fluid.

21. The method of claim 20 for making a microinjector head with driving circuit wherein the step of forming the dielectric layer comprises the steps of:

forming a thin oxide layer on the substrate;
forming a silicon nitride layer on the thin oxide layer;

oxidizing the thin oxide layer not covered by the silicon nitride layer by means of local oxidation, for forming a field oxide layer, wherein the thin oxide layer covered by the silicon nitride layer is the first part of the dielectric layer, and the field oxide layer is the second part of the dielectric layer; and
removing the silicon nitride layer.

- 22.** The method of claim 20 for making a microinjector head with driving circuit wherein the step of forming the driving circuit comprises the steps of:

implanting boron ion into the dielectric layer;
forming a polysilicon gate on the first part of the dielectric layer; and
implanting arsenic ion into the substrate for forming a source and a drain close to the gate.

- 23.** The method of claim 20 for making a microinjector head with driving circuit wherein the driving circuit is used to independently send driving signals to a single bubble generator and for driving the plurality pairs of the bubble generator.

- 24.** The method of claim 20 for making a microinjector head with driving circuit wherein the functional device is a transistor.

- 25.** The method of claim 24 for making a microinjector head with driving circuit wherein the transistor is a metal oxide semiconductor field effect transistor (MOSFET).

- 26.** The method of claim 20 for making a microinjector head with driving circuit wherein the step of etching the substrate and the sacrificial layer to form the manifold and the chambers comprises the steps of:

etching the substrate from back side to form the manifold;
removing the sacrificial layer that does not cover the driving circuit; and
etching the substrate from back side again to form the chambers.

- 27.** The method of claim 20 for making a microinjector head with driving circuit wherein the step of forming the first bubble generating devices and the second bubble generating devices comprises the steps of:

forming a resistance layer on the low-stress material layer to form a first heater and a second heater; and
forming a conductive layer on the resistance layer, the conductive layer connected to the driving circuit.

- 28.** The method of claim 27 for making a microinjector head with driving circuit wherein the conductive layer is any one selected from the group consisting of aluminum, gold, copper, tungsten, and alloys of aluminum-silicon-copper.

- 29.** The method of claim 27 for making a microinjector head with driving circuit wherein the material of the first and second heaters is any one selected from the group consisting of alloys of tantalum and aluminum, platinum, and HfB_2 .

- 30.** The method of claim 27 for making a microinjector head with driving circuit wherein between the step of forming the resistance layer and the step of forming the conductive layer, further comprising a step of forming a first oxide layer on the resistance layer for protecting the first heater and the second heater.

- 31.** The method of claim 20 for making a microinjector head with driving circuit further comprises the steps of forming a second oxide layer on the first bubble generating devices and the second bubble generating devices for protecting the first bubble generating devices and the second bubble generating devices.

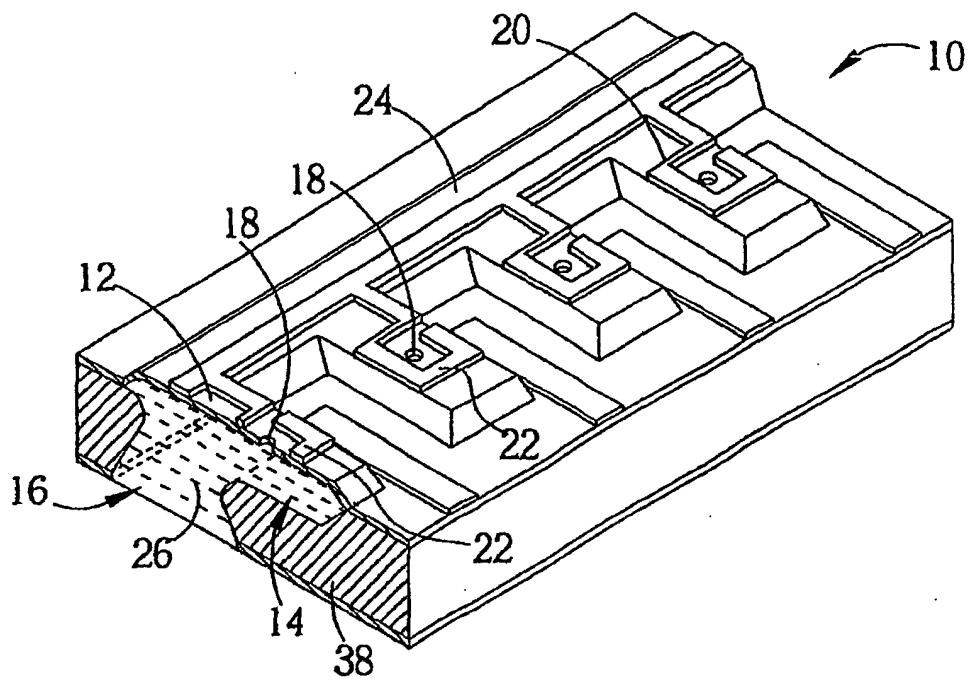


Fig. 1

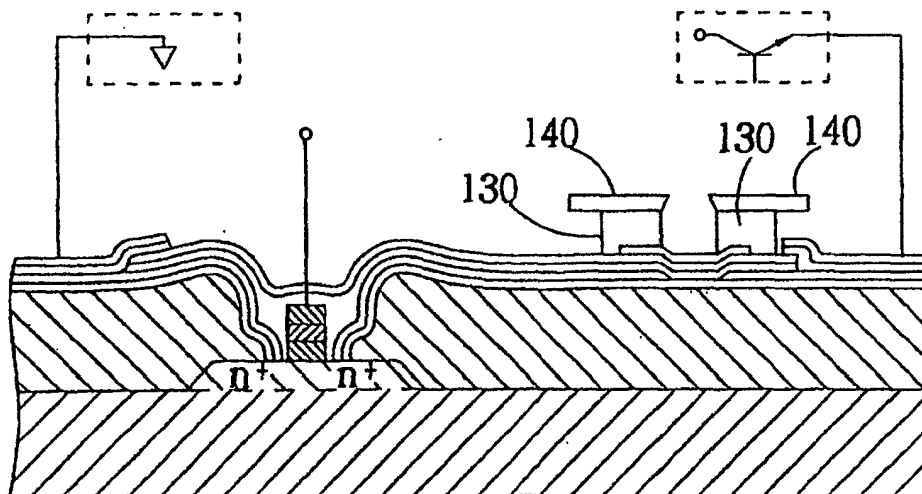


Fig. 2

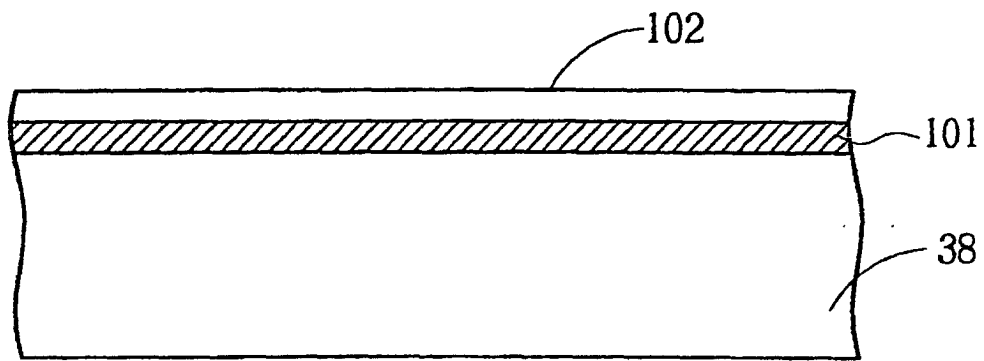


Fig. 3

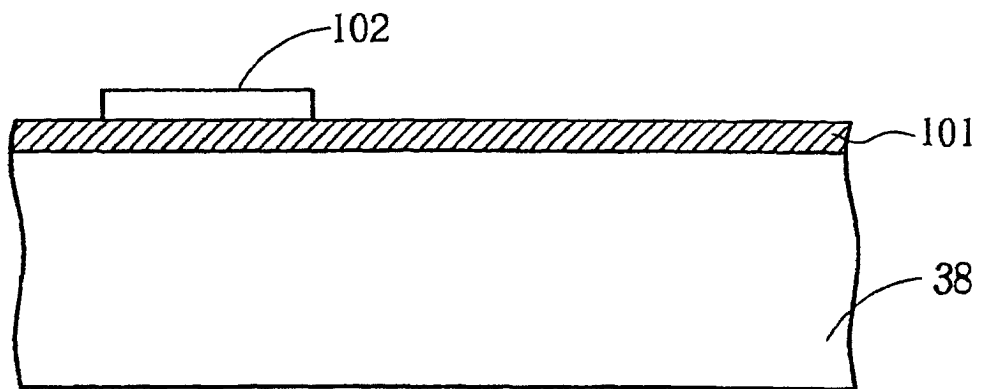


Fig. 4

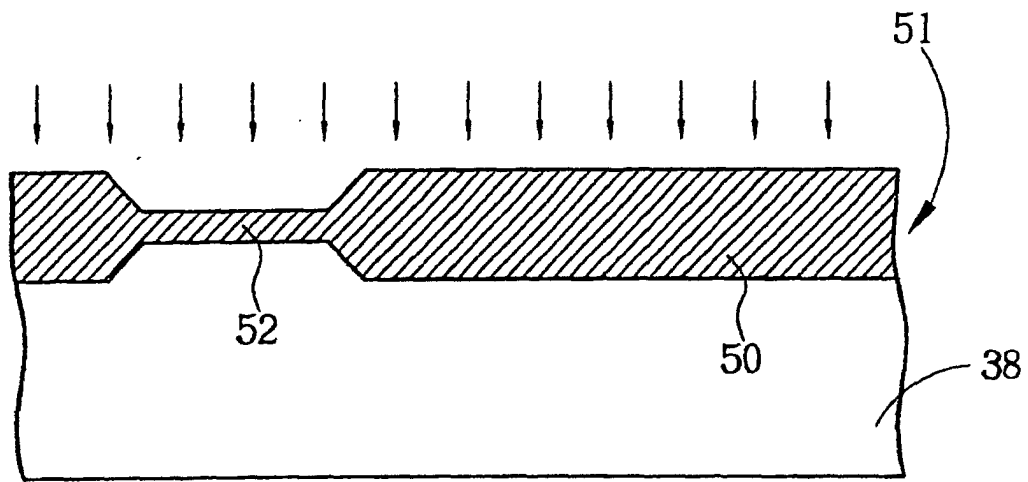


Fig. 5

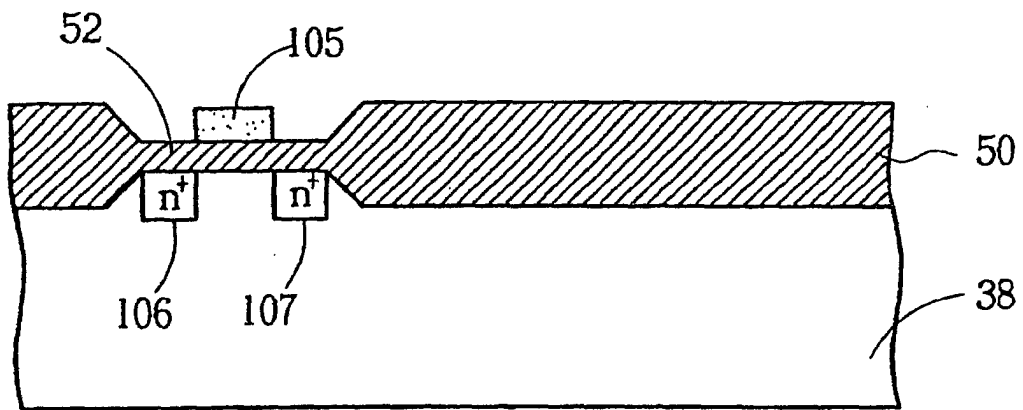


Fig. 6

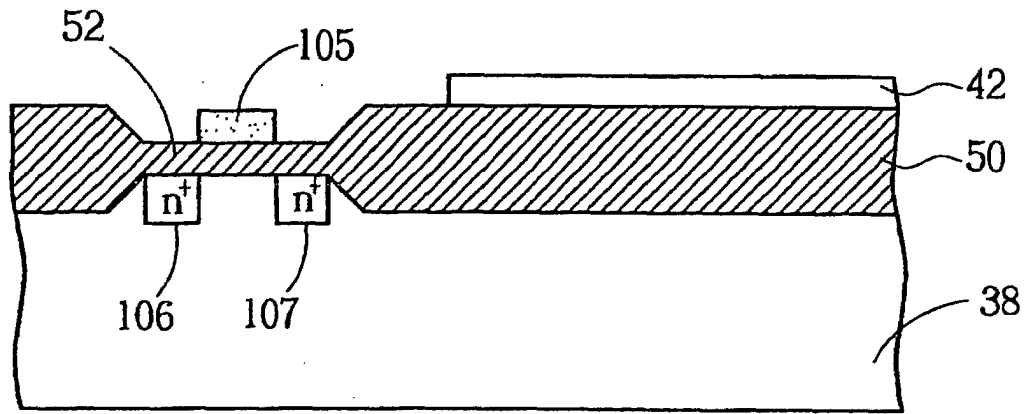


Fig. 7

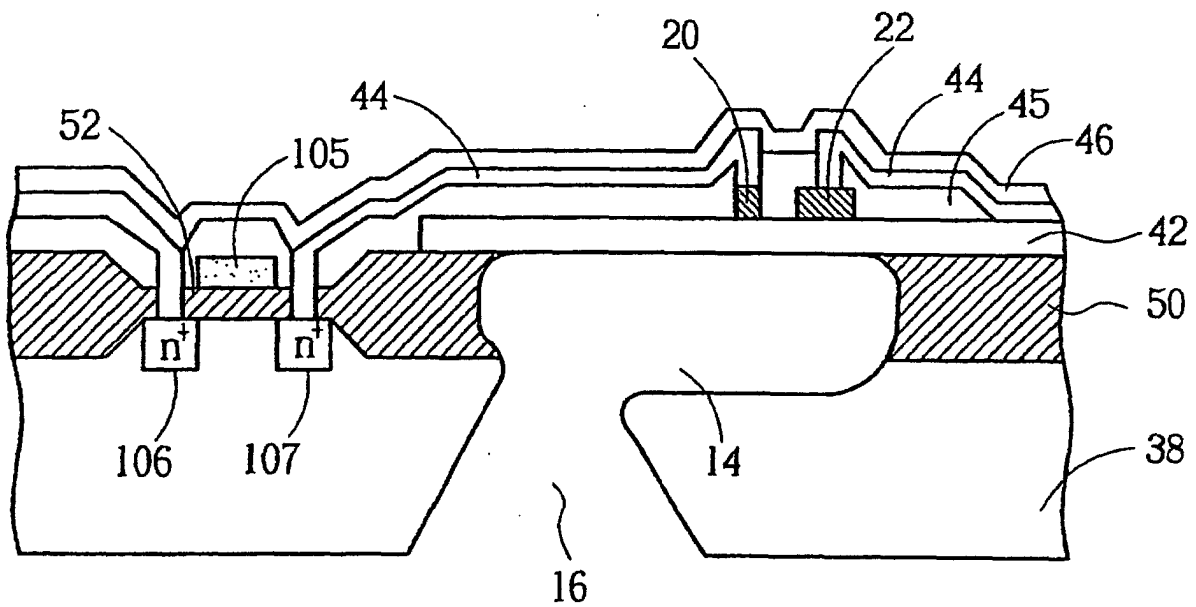


Fig. 8

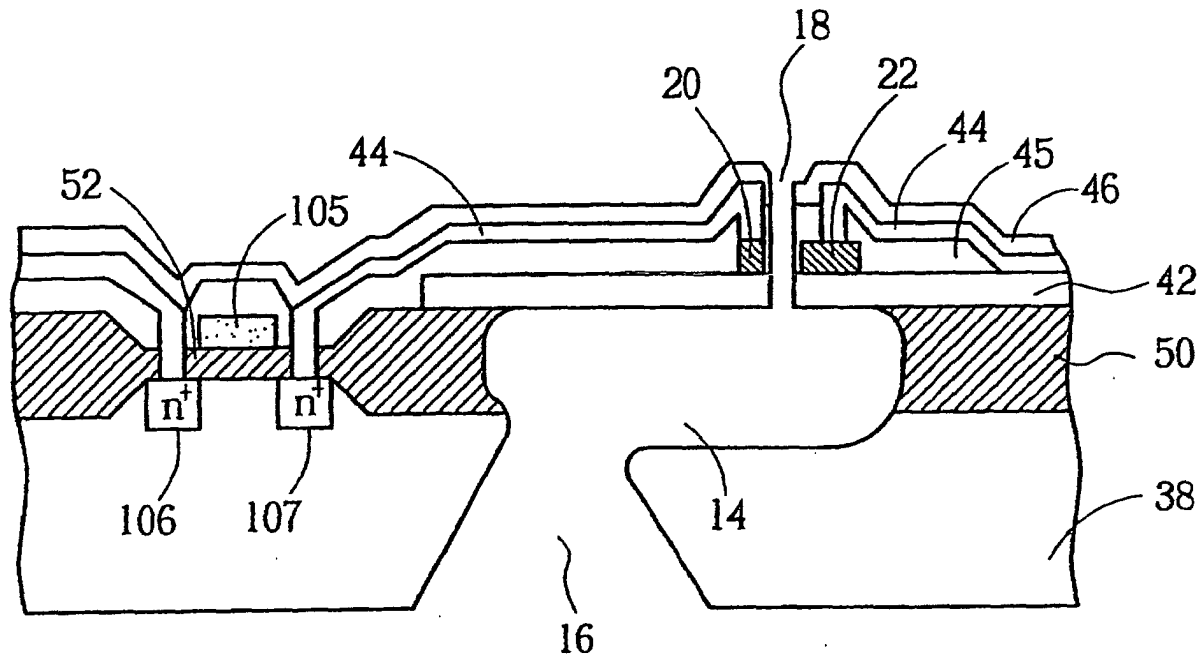


Fig. 9

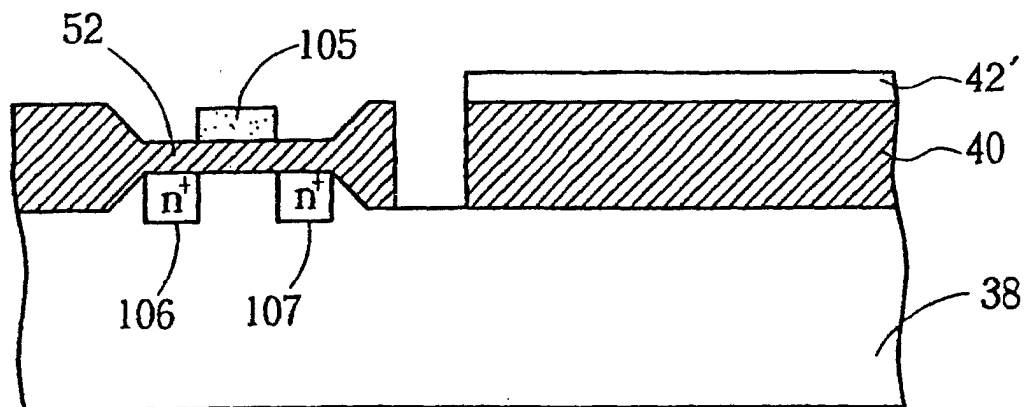


Fig. 10

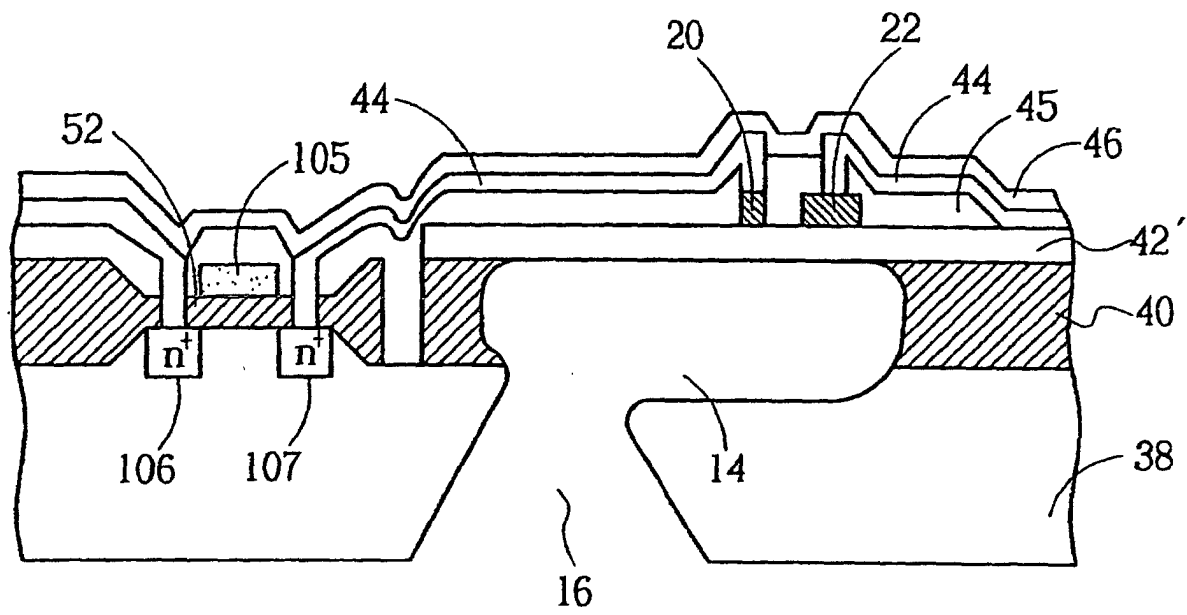


Fig. 11

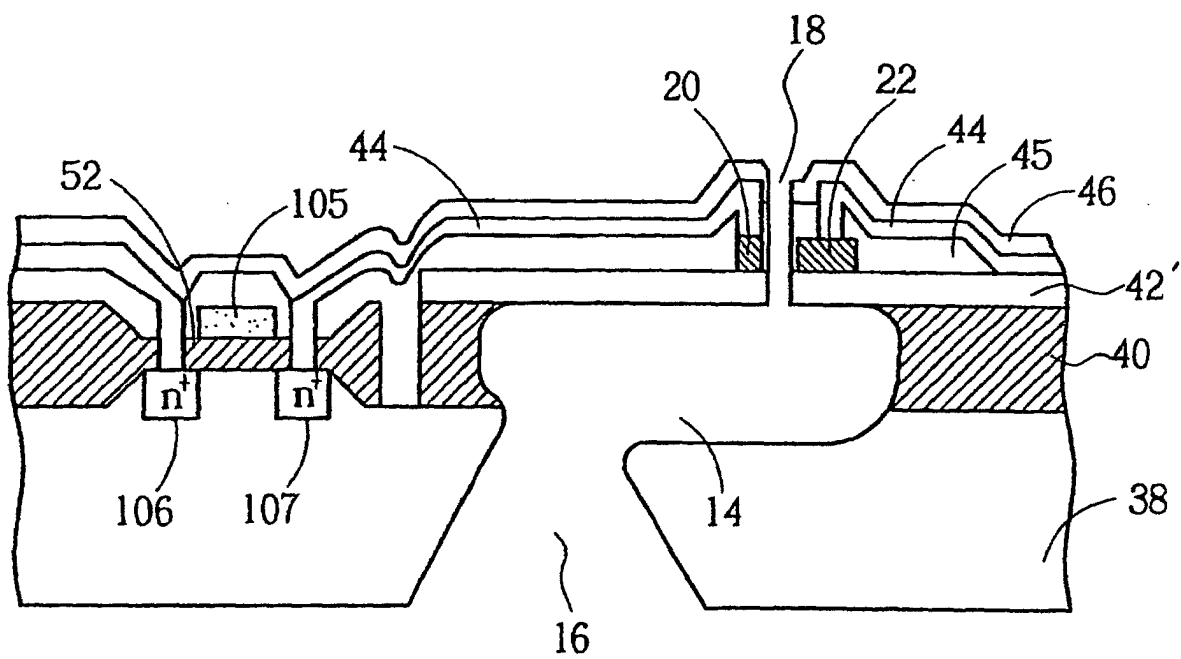


Fig. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN 01/01230

A. CLASSIFICATION OF SUBJECT MATTER		
IPC ⁷ B41J2/135, 2/16		
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)		
IPC ⁷ B41J2/135, 2/14, 2/16, 2/175, 2/19, 2/05, 2/015, 2/07, G01D15/16, 15/18		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
CHINESE INVENTION, CHINESE UTILITY MODELS		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
WPI, CNPAT, PODOC, PAJ		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US6102530A (Chang-Jin Kim, et al) 15 Aug. 2000 (15.08.00)	1-7
A	See the whole document	8-31
Y	EP0317171A2 (Hewlett-Packard Company) 24 May 1989 (24.05.89)	1-7
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Y	US4695853A (Hewlett-Packard Company) 22 Sept. 1987 (22.09.87)	1-7
A	See the whole document	8-31
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
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