

"VENT IN A MICRO ELECTRO-MECHANICAL DEVICE "**FIELD OF THE INVENTION**

This invention relates to a vent within a micro electro-mechanical (MEM) device. The invention has application in
5 ejection nozzles of the type that are fabricated by integrating the technologies applicable to micro electro-mechanical systems
(MEMS) and complimentary metal-oxide semiconductor ("CMOS") integrated circuits, and the invention is hereinafter
described in the context of that application. However, it will be understood that the invention does have broader application to
vents within other types of MEM devices.

CO-PENDING APPLICATIONS

Various methods, systems and apparatus relating to the present invention are disclosed in the following co-pending
applications filed by the applicant or assignee of the present invention simultaneously with the present application:

PCT/AU00/00518, PCT/AU00/00519, PCT/AU00/00520, PCT/AU00/00521, PCT/AU00/00522,
PCT/AU00/00523, PCT/AU00/00524, PCT/AU00/00525, PCT/AU00/00526, PCT/AU00/00527,
15 PCT/AU00/00528, PCT/AU00/00529, PCT/AU00/00530, PCT/AU00/00531, PCT/AU00/00532,
PCT/AU00/00533, PCT/AU00/00534, PCT/AU00/00535, PCT/AU00/00536, PCT/AU00/00537,
PCT/AU00/00538, PCT/AU00/00539, PCT/AU00/00540, PCT/AU00/00541, PCT/AU00/00542,
PCT/AU00/00543, PCT/AU00/00544, PCT/AU00/00545, PCT/AU00/00547, PCT/AU00/00546,
PCT/AU00/00554, PCT/AU00/00556, PCT/AU00/00557, PCT/AU00/00558, PCT/AU00/00559,
20 PCT/AU00/00560, PCT/AU00/00561, PCT/AU00/00562, PCT/AU00/00563, PCT/AU00/00564,
PCT/AU00/00565, PCT/AU00/00566, PCT/AU00/00567, PCT/AU00/00568, PCT/AU00/00569,
PCT/AU00/00570, PCT/AU00/00571, PCT/AU00/00572, PCT/AU00/00573, PCT/AU00/00574,
PCT/AU00/00575, PCT/AU00/00576, PCT/AU00/00577, PCT/AU00/00578, PCT/AU00/00579,
PCT/AU00/00581, PCT/AU00/00580, PCT/AU00/00582, PCT/AU00/00587, PCT/AU00/00588,
25 PCT/AU00/00589, PCT/AU00/00583, PCT/AU00/00593, PCT/AU00/00590, PCT/AU00/00591,
PCT/AU00/00592, PCT/AU00/00584, PCT/AU00/00585, PCT/AU00/00586, PCT/AU00/00594,
PCT/AU00/00595, PCT/AU00/00596, PCT/AU00/00597, PCT/AU00/00598, PCT/AU00/00516,
PCT/AU00/00517, PCT/AU00/00511, PCT/AU00/00501, PCT/AU00/00502, PCT/AU00/00503,
PCT/AU00/00504, PCT/AU00/00505, PCT/AU00/00506, PCT/AU00/00507, PCT/AU00/00508,
30 PCT/AU00/00509, PCT/AU00/00510, PCT/AU00/00512, PCT/AU00/00513, PCT/AU00/00514,
PCT/AU00/00515

The disclosures of these co-pending applications are incorporated herein by cross-reference.

an outlet aperture in the chamber for allowing exit of fluid from the chamber,
 an actuator for dispensing fluid from the chamber through the outlet aperture, and
 at least one vent in the chamber for venting to the exterior of the chamber air bubbles which form within the chamber.

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PREFERRED FEATURES OF THE INVENTION

Preferably the actuator includes a paddle located within the chamber, the chamber including a peripheral wall, and the at least one vent is arranged within the peripheral wall adjacent a peripheral portion of the paddle.

Preferably a plurality of vents are arranged in the peripheral wall, the plurality of vents being disposed about the peripheral wall adjacent to peripheral portions of the paddle.

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Preferably the vent is defined by a first layer and a second layer spaced apart from the first layer, a sacrificial layer being deposited between the first and second layers and the sacrificial layer being etched away to form the vent between the first and second layers.

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Preferably the first and second layers have a raised section defined by a pair of shoulders, the sacrificial material being deposited on the raised section of the first layer so as to define a vent passage which forms said vent when the sacrificial material is etched away, the second layer being deposited on the sacrificial material and the portion of the second layer deposited on the sacrificial material having a pair of side walls and a roof which, with the first layer, define the vent passage of the vent.

Preferably the shoulders include apertures for preventing wicking of fluid from the shoulders onto a substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

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A preferred embodiment of the invention will be described, by way of example, with reference to the accompanying drawings in which:

Figure 1 is a plan view of one embodiment of the invention in an ink jet nozzle for a printer;

Figure 2 is a cross-sectional view of the nozzle of Figure 1 along line 2-2 of Figure 1;

Figure 3 is a more detailed cross-sectional view similar to Figure 2 of the preferred embodiment of the invention in an extreme actuated position showing a drop being ejected from the nozzle;

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Figure 4 is a detailed view of a portion of the preferred embodiment shown in Figures 1 to 3; and

Figure 5 is a view from the direction of arrow A in Figure 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As illustrated with approximately 3000x magnification in Figure 1, and other relevant drawing Figures, a single ink jet nozzle device 1 is shown as a portion of a chip which is fabricated by integrating MEMS and CMOS technologies. The complete nozzle device includes a support structure having a silicon substrate 20, a metal oxide semiconductor layer 21, a passivation layer 22, and a non-corrosive dielectric coating/chamber defining layer 29. Reference may be made to the above identified International Patent Application No. PCT/AU00/0038 for disclosure of the fabrication of the nozzle device.

Operation of the device is also more fully disclosed in co-pending application entitled "Movement Sensor In A Micro Electro-mechanical Device" (Reference: MJ12) by the same Applicant. The contents of these two applications are incorporated into

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this specification by this reference.

The nozzle device incorporates an ink chamber 24 which is connected to a source (not shown) of ink. The layer 29 forms, amongst other components as will be described hereinafter, a chamber wall 23 which has a nozzle aperture 13 for the ejection of a droplet from ink 25 contained within the chamber 24. As best shown in Figure 1 the wall 23 is generally cylindrical in configuration with the aperture 13 being provided substantially in the middle of the cylindrical wall 23. The wall 23 has a straight edge portion 10 which forms part of the periphery of the wall 23.

As best seen in Figure 3, the chamber 24 is also defined by a peripheral side wall 23a, a lower side wall 23b, a base wall (not shown), and by an edge portion 39 of substrate 20. An actuating arm 28 is formed on layer 22 and support portion 23c is formed at one end of the actuating arm 28.

The actuating arm 28 is deposited during fabrication of the device and is pivotable with respect to the substrate 20 and support 23c. The actuating arm 28 comprises upper and lower arm portions 31 and 32. Lower portion 32 of the arm 28 is an electrical contact with the CMOS layer 21 for the supply of electrical current to the portion 32 to cause movement of the arm 28, by thermal bending, from the position shown in Figure 2 to the position shown in Figure 3 so as to eject droplet D through aperture 13 for deposition on a sheet (not shown). The layer 22 therefore includes the power supply circuitry for supplying current to the portion 32 together with other circuitry for operating the nozzle shown in the drawings as described in the aforesaid co-pending applications.

A block 8 is mounted on the actuator arm 28. The block 8 includes a generally T-shaped portion 50 (when viewed in plan) which has a peripheral wall 10. The upper wall 23 of the chamber 24 has a generally T-shaped slot 60, defined by edge portion 52 of the wall 23, which receives the T-shaped portion 50 of the block 8. The actuator 28 carries a paddle 27 which is arranged within the chamber 24 and which is moveable with the actuator as shown in Figures 1 and 3 to eject the droplet D.

The peripheral wall 23a, chamber wall 23, block 8 and support portion 23c are all formed by deposition of material which forms the layer 29 and by etching sacrificial material to define the chamber 24, nozzle aperture 13, the discrete block 8 and the space between the block 8 and the support portion 23c. The lower wall portion 23b is also formed during deposition with the substrate 20.

The space between end edge 22a of layer 22 and edge portion 50 of the wall 23 defines an actuator aperture 54 which is substantially entirely closed by T-shaped portion 50 of the block 8 when the actuator 28 is in a rest or quiescent state as shown in Figures 1 and 2. In the quiescent position shown in Figures 1 and 2, the wall 10 of the portion 50 is separated from the edge 52 by a distance of less than one micron so as to define a fine slot between the edge 57 and the wall 10.

As the actuator arm 28 moves up and down to eject droplet D from the chamber 24, the block 8 and wall 10 move up and down relative to edge 52 of slot 60 of the wall 23 whilst maintaining a closely spaced apart relationship with the edge 52 of the wall 23. A meniscus M is formed between the wall 10 and the edge 52 as the wall 10 moves up and down relative to the edge 52 in view of the close proximity of the wall 10 to the edge 52. The maintenance of the meniscus M, forms a seal between edge 52 and wall 10, and therefore reduces opportunities for ink leakage and wicking from chamber 24. A meniscus M2 is also formed between support flange 56 formed on the layer 22 and portion 58 of the actuator 28 on which block 8 is

formed. When in the quiescent position the portion 58 rests on the flange 54. The formation of the meniscus M2 also reduces opportunities for ink leakage and wicking during movement of the actuating arm 28 and the paddle 27. A meniscus (not shown) is also formed between the sides (not shown) of actuator aperture 54 and the edges (not shown) of wall 23a which define the aperture 54.

5 As shown in Figure 3, the edge portion 52 may carry a lip 81 and the wall 10 may also carry a lip 83 to further reduce the likelihood of wicking of ink from the chamber 24 onto the block 8 or upper surface of the wall 23. The lip 81 may extend completely about the periphery of the wall 23 and similar lips may also be provided on the aperture 13.

 As shown in Figure 1, a plurality of vents 5 are arranged in the peripheral wall 23a of the chamber 24. In the preferred embodiment, five vents 5 are included. The vents 5 are arranged adjacent to the periphery of paddle 27 (which is
10 generally circular in configuration matching the configuration of the chamber 24) when the paddle 27 is in the quiescent position shown in Figure 2.

 As shown in more detail in Figures 4 and 5, the vent 5 is formed by a first deposited titanium nitride layer 14 which includes a ledge portion 16, and a second titanium nitride layer 15 which has a ledge portion 17. In the formation of the nozzle shown in the drawings, a sacrificial material is deposited on the layer 14 onto which the layer 15 is then deposited and
15 the sacrificial material is etched away to leave a vent passage 11 between the layers 14 and 15, which forms the vent 5, and which has an outlet opening 11a. The passage 11 communicates with the interior of the chamber 24.

 As best shown in Figure 5, the vent opening 11a is formed in a raised portion of the layers 14 and 15. The layers 14 and 15 are generally annular in configuration extending about the periphery of the chamber 24. The layers 14 and 15 are in contact with one another except at the positions where the vent passages 11 are formed. As best shown in Figure 5, the layers
20 14 and 15 extend upwardly at the vents 5 to form shoulders 80. The portion of the layer 14 between the shoulders 80 is generally planar as shown in Figure 5. However, the layer 15 diverges upwardly from the layer 14 to define walls 82 and a roof section 84 which with the layer 14 define the vent passage 11 and vent opening 11a. The sacrificial material is deposited generally to take the shape of the vent passage 11 so that the layer 15 is deposited on the layer 14 except for where the
25 sacrificial material is located, and the layer 15 extends over the sacrificial material where the vent passage 11 is to be formed so as to form the side walls 82 and roof 84 shown in Figure 5. As noted above, the sacrificial material is then etched away
30 leaving the vent passage 11 between the layers 14 and 15.

 The shoulders 80 are provided with slots 25 and 26 which prevent the possibility of any fluid which may leak from the chamber 24 through the vents 5 wicking along the lower surface of the layer 14 and reaching the layer 22 which may cause damage to the layer 22. In general, fluid is prevented from leaking out of the vents 5 by an ink meniscus which forms across
30 the vent opening 11a between the layers 13 and 14 to thereby form a seal which reduces the likelihood of any ink leaking from the vents 5.

 During the operation of the nozzle, when the paddle 27 moves from the quiescent position shown in Figures 1 and 2 to the position shown in Figure 3 to eject a drop D of fluid, there is a possibility that bubbles may form particularly adjacent the ledges 16 and 17. Any bubbles which form will be able to pass through the vent passage 11 and out of the vent opening
35 11a of each vent 5 to expire to the external ambient atmosphere.

I CLAIM:

1. A micro electro-mechanical device comprising:
a fluid chamber for containing a fluid,
5 an outlet aperture in the chamber for allowing exit of fluid from the chamber,
an actuator for dispensing fluid from the chamber through the outlet aperture, and
at least one vent in the chamber for venting to the exterior of the chamber air bubbles which form within the
chamber.
- 10 2. The device of claim 1 wherein the actuator includes a paddle located within the chamber, wherein the chamber
includes a peripheral wall, and wherein the or, if more than one, vent is located within the peripheral wall adjacent a peripheral
portion of the paddle.
3. The device of claim 2 wherein a plurality of vents is arranged in the peripheral wall, the plurality of vents being
15 disposed about the peripheral wall adjacent to peripheral portion of the paddle.
4. The device of claim 1 wherein the vent is defined by a first layer and a second layer spaced apart from the first
layer, a sacrificial layer being deposited between the first and second layers and the sacrificial layer being etched away to form
the vent between the first and second layers.
- 20 5. The device of claim 4 wherein the first and second layers have a raised section defined by a pair of shoulders, the
sacrificial material being deposited on the raised section of the first layer so as to define a vent passage which forms said vent
when the sacrificial material is etched away, the second layer being deposited on the sacrificial material and the portion of the
second layer deposited on the sacrificial material having a pair of side walls and a roof which, with the first layer, define the
25 vent passage of the vent.
6. The device of claim 5 wherein the shoulders include apertures for preventing wicking of fluid from the shoulders
onto a substrate.

