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(71) Applicant: **VUEREAL INC.** [CA/CA]; 440 Phillip Street, Unit 100, Waterloo, Ontario N2L 5R9 (CA).

(72) Inventors: **CHAJI, Gholamreza**; 463 Kelso Dr, Waterloo, Ontario N2V 2S3 (CA). **FATHI, Ehsanollah**; 455 Havendale Crescent, Waterloo, Ontario N2T 2T1 (CA). **SIBONI, Hossein Zamani**; 703-55 Blue Spring Drive, Waterloo, Ontario N2J 4T3 (CA). **HWANG, David**; 22 Larch St, Waterloo, Ontario N2L 0J1 (CA).

(74) Agent: **ROWAND LLP**; 3080 Yonge Street, Suite 6060, Toronto, Ontario M4N 3N1 (CA).

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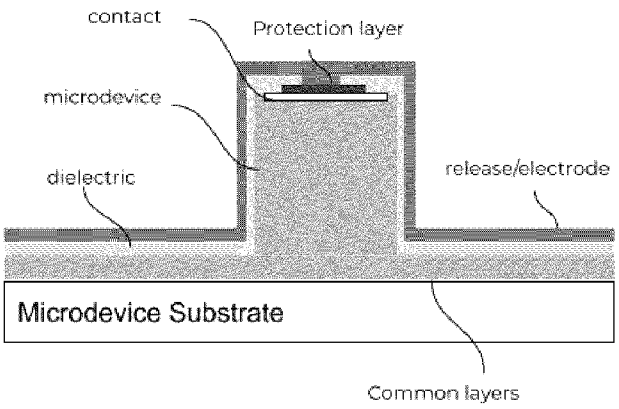


FIG. 1A

(57) Abstract: The present invention relates to the inspection process which includes providing access to the microdevice contacts, measuring the microdevice and analyzing the data to identify defects or performance of the micro device. The invention also relates to the forming of test electrodes on microdevices. The test electrodes may be connected to hidden contacts. The type of microdevices may be vertical, lateral or a flip chip.

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Cartridge For Inspection

BACKGROUND AND FIELD OF THE INVENTION

[001] The present invention relates to the inspection process which includes providing access to the microdevice contacts, measuring the microdevice and analyzing the data to identify defects or performance of the micro device.

SUMMARY

[002] The present invention relates to a method of forming test electrodes for vertical microdevice, the method comprising, forming a microdevice on a microdevice substrate, the microdevice having a hidden contact on a surface facing away from the microdevice substrate, forming a protection layer to cover a part of the hidden contact, forming a dielectric layer to cover a surface of the microdevice and at least part of the microdevice sidewall, forming an opening to provide access to the hidden contact and forming an electrode to provide access to the hidden contact outside of the microdevice.

[003] The present invention also relates to a method of forming test electrodes for a flip chip microdevice, the method comprising, forming a microdevice on a microdevice substrate, forming a dielectric layer to cover a surface of the microdevice and at least part of a microdevice sidewall, forming a release layer on the microdevice, forming common layers on top of the microdevice, covering the common layers by the dielectric, forming an opening on at least one side within the microdevice with the dielectric covering the sidewalls of the opening, filling a part of the opening with a conductive layer, forming a frame around the microdevice with a thicker dielectric, removing the microdevice substrate and common layers and having more than one contact facing away from a cartridge substrate.

[004] The present invention also relates to a method of forming test electrodes for a lateral microdevice, the method comprising, forming a microdevice on a microdevice

substrate, forming a first dielectric layer to cover a first surface of the microdevice and at least part of a microdevice sidewall, wherein the first surface is a p-type or n-type and an ohmic is on a top of the first surface, forming an opening provide access to a part of the first surface of the microdevice facing away from the microdevice substrate, covering sidewalls of the opening with the first dielectric, forming test electrodes the first surface, coupling a first test electrode to the first surface through the opening in the first dielectric, coupling a second electrode to a contact layer on a surface of the microdevice facing the microdevice substrate and opening the dielectric to provide access to the other contact layer of the microdevice.

[005] The present invention also relates to a method of forming test electrodes for a flip chip microdevice, the method comprising, forming a microdevice on a microdevice substrate, forming a dielectric layer to cover a surface of the microdevice and at least part of a microdevice sidewall, forming a release layer on the microdevice, covering the transfer layers by the dielectric, forming an opening on at least one side within the microdevice with the dielectric covering the sidewalls of the opening, forming electrodes on a top surface of the microdevice, patterning the electrodes so they are coupled to each contact individually, forming an ohmic structure is formed on a top contact of the microdevice, forming transfer layers on top of the microdevice, removing the microdevice substrate and transfer layers, and having more than one contact facing away from a cartridge substrate.

[006] The present invention also relates to a method of forming test electrodes for a lateral microdevice, the method comprising, forming a microdevice on a microdevice substrate, forming a first dielectric layer to cover a first surface of the microdevice and at least part of a microdevice sidewall, wherein the first surface is a p-type or n-type and an ohmic is on a top of the first surface, forming an opening provide access to a part of the first surface of the microdevice facing away from the microdevice substrate, covering sidewalls of the opening with the first dielectric, forming electrodes on a bottom surface of the microdevice, patterning the electrodes so they are coupled to each contact individually, forming transfer layers on top of the microdevice, opening the dielectric to provide access to the electrodes, removing the microdevice substrate and transfer layers, and bonding the microdevice to cartridge substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

[007] The foregoing and other advantages of the disclosure will become apparent upon reading the following detailed description and upon reference to the drawings.

[008] FIG 1A shows a vertical microdevice formed on a microdevice substrate.

[009] FIG 1B, shows the device is bonded to a cartridge.

[0010] FIG 1C shows a top view of a cartridge or donor substrate with electrode for hidden contact and electrode for top contact.

[0011] FIG 1D shows another related embodiment of devices with two types of contacts.

[0012] FIG 2A shows a flip chip microdevice formed on a microdevice substrate.

[0013] FIG 2B shows a flip chip micro device bonded to a cartridge.

[0014] FIG 2C shows a top view of a cartridge or donor substrate with two electrodes for top contact.

[0015] FIG 2D shows another related example of the flip chip with accessible contacts.

[0016] FIG 2E shows an example of a flip chip where the electrode to one contact is done through a hidden connection.

[0017] FIG 3A shows a lateral microdevice formed on a microdevice substrate.

[0018] FIG 3B shows the device bonded to a cartridge substrate.

[0019] FIG 3C shows a top view of a cartridge or donor substrate with two electrodes for the hidden contacts.

[0020] FIG 3D shows another related example of the lateral with hidden contacts.

[0021] FIG 3E shows an example of a lateral device where the electrodes to one contact is done through an accessible connection.

[0022] While the present disclosure is susceptible to various modifications and alternative forms, specific embodiments or implementations have been shown by way of example in the drawings and will be described in detail herein. It should be understood, however, that the disclosure is not intended to be limited to the particular forms disclosed. Rather, the disclosure is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION

[0023] In this description, the terms " device" and "microdevice" are used interchangeably. However, it is clear to one skilled in the art that the embodiments described here are independent of the device size.

[0024] The present invention relates to the inspection process which includes providing access to the microdevice contacts, measuring the microdevice and analyzing the data to identify defects or performance of the microdevice.

[0025] In one case, providing access to the microdevice includes forming test electrodes coupled to the hidden contacts (e.g. vertical, lateral, or flip chip) before transferring to a cartridge substrate. In another related case forming test electrodes for accessible contacts (e.g. vertical, lateral, or flip chip). The hidden contacts are the bias point in a microdevice where it is facing the substrate and cannot be accessed from the surface.

[0026] A flip chip device has at least two contacts on the surface facing away from a substrate. A vertical device has at least one contact facing the substrate and one contact facing away from the substrate. A lateral device has at least two contacts facing the substrate.

[0027] In another case an opening is formed to provide access to the test electrode coupled to the hidden contacts of a microdevice (e.g. p for vertical and p,n for lateral).

[0028] In another aspect, the devices in a cartridge (or donor substrate) are measured through the test electrodes. The measurement can be electrical or electrical and optical.

[0029] After measurement, at least one test electrode is removed or isolated for

microdevices.

[0030] In another case, the test electrode is isolated from the microdevice during the transfer process where the microdevice is placed in a system substrate from the cartridge (or donor) substrate.

[0031] In another case, after measurement or electrode isolation, pads are formed on the devices enabling bonding of microdevices into a system substrate.

[0032] The pads can be formed prior to the measurement process as well. A protection layer can be formed on top of the pads so that the pads do not get damaged/deformed prior to transfer during the measurement process.

[0033] In another related embodiment, the pads are formed, and the electrodes are formed and isolated after measurement. In this case, removing the electrode enables pads for bonding. In one case, the pads can be Gold and the electrodes can be Aluminum. Removing Aluminum after measurement cleans the surface of the pads and enables them for bonding.

[0034] The microdevices can have top surface and bottom surface. The top surface is facing away from the substrate and the contacts on that surface are accessible. The bottom surface is facing the substrate and covered by other layers and the contacts at that surface are hidden. The embodiments here describe methods of providing access to both hidden and accessible contact in one device. In one case, an electrode is formed on the surface of the microdevice substrate. The electrode is coupled to the hidden contact through an opening in the dielectric covering the contact. The wafer is then bonded to another substrate and the donor substrate is removed. Then the dielectric is removed to provide access to the electrode of the hidden contact. Another electrode may get deposited on the second surface of the device exposed by removing the microdevice wafer. The second electrode can be connected to the accessible contact through an opening in a second dielectric on top of the second surface. The patterned

part of the second electrode can also connect to the first electrode through the opening in the dielectric covering the first electrode.

[0035] FIG.1 shows an exemplary embodiment of a structure and a method of forming test electrodes for a vertical device with at least one hidden contact. In one related embodiment a release layer is used. As highlighted in FIG. 1A, the microdevice is formed on a microdevice substrate. The microdevice has at least one contact on the surface facing away from the microdevice substrate. A protection or contact layer can be formed to cover part of the contact. The contact can be a combination of an ohmic layer and doped layers. It can be either a p-doped or n-doped layer. A dielectric layer is formed to cover the surface of the microdevice and at least part of the device sidewall. An opening is formed to provide access to the contact (or protective layer). An electrode is formed to bring the access to the microdevice contact to the outside area of the microdevice. The electrode can also act as a release layer or other layers can be formed on top of the electrode as release layers. There can be some common layers also on top of the substrate. The dielectric can cover the common layers as well. As shown in FIG 1B, the device is bonded to a cartridge (donor substrate). Prior to bonding or during the bonding a housing layer(s) can form around the device. The microdevice substrate is then removed and common layers can be etched back (or removed by other means). Here, the device can have a top contact facing away from the cartridge substrate. An ohmic structure can form on the contact point of the device. The ohmic can be either n-type or p-type. An electrode is formed to provide access to the top contact. In this example, the electrode is n-electrode coupled to the top n-ohmic (it can be p-electrode in another case). A dielectric can form on the top surface of the microdevice prior to the formation of n-electrode or n-ohmic. In this case an opening can be formed to provide access to the device top contact or n-ohmic.

[0036] FIG. 1C shows a top view of a cartridge or donor substrate with an electrode for hidden contact and an electrode for top contact. The electrodes can be coupled to more than one microdevice. In one case, the electrodes can form rows and columns. In another case they can form either row or column. To have access to the electrode for the hidden contact(s), the dielectric is patterned (or removed from a part of the test electrode). Here p-electrode is coupled to the hidden contacts and n-electrode is

coupled to the top contacts (the n and p electrode can be replaced, or other functional electrodes can be developed depending on the type of microdevice).

[0037] After the measurement is performed, the top electrode (n-electrode) can be patterned or removed to isolate each microdevice. Pads can form on the top contact. In another case, the n-electrode can be left on the substrate.

[0038] Prior to the transfer of microdevices from cartridge to another substrate (system substrate), the electrode of the hidden contact also can be isolated or removed. This process can be the same as removing the release layer. It can be done either chemically, thermally, or optically.

[0039] FIG. 1D shows another related embodiment of devices with two types of contacts (hidden and accessible contacts). Here, transfer layers are formed after or at the same time as forming the 2nd electrode to contact the hidden contact. After the devices are separated from the main substrate (one example in FIG 1B), the second electrode (electrode 2) is formed and other layers such as membrane, anchors, release layer, force layer, buffer layers (called transfer layer) are formed. The devices are bonded to another substrate called cartridge substrate.

[0040] FIG. 1 examples show related embodiments of microdevices by two types of contacts (hidden and accessible contacts). One electrode connects to the hidden electrode and is separated from the other electrode connecting to the accessible electrode by at least a dielectric layer. The dielectric layer is patterned to provide access to the electrode connected to the hidden contact. The electrode can be on a planarized layer, or they can cover the side of the device.

[0041] FIG. 2 shows an exemplary embodiment of a structure and a method of forming test electrodes for a flip chip device with no hidden contact. Here, all contacts are accessible from the top surface. In one embodiment a release layer is used. As highlighted in FIG. 2A, the microdevice is formed on a microdevice substrate. A dielectric layer can be formed to cover the surface of the microdevice and at least part of the device sidewall. A release layer can be formed to facilitate the further integration process. There can be some common layers also on top of the substrate. The dielectric

can cover the common layers as well. This embodiment works with different flip chip device structures such as double mesa, corner mesa, side contact traces, and other methods. Here we use the VIA through structure to explain the embodiment. There can be a VIA formed that at least one side of it is within the microdevice. The dielectric can also cover the sidewalls of the VIA. A conductive layer can fill at least part of the VIA. The VIA can be partially filled with another layer. A frame can be formed around the device with a thicker dielectric. Or the thicker dielectric can be only on the surface of the device facing away from the microdevice substrate. The frame can be applied to other embodiments presented here as well. As shown in FIG. 2B, the device is bonded to a cartridge (donor) substrate. Prior to bonding or during the bonding a housing layer(s) can form around the device. The microdevice substrate is removed and the common layers are etched back or removed by other means. Here, the device can have more than one contact facing away from the cartridge substrate. An ohmic structure can form on one of the contact points of the device. The other contract point is coupled to the other side of the device using the VIA formed before (the VIA can also be formed after the device is transferred into the cartridge substrate). The top ohmic can be either n-type or p-type. An electrode is formed to provide access to the top contact. Another electrode is formed to provide access to the VIA. In this example, one of the electrodes is n-electrode coupled to the top n-ohmic (it can be p-electrode in another case) and the other electrode is p-electrode. A dielectric can form on the top surface of the microdevice prior to the formation of electrodes or n-ohmic. In this case an opening can be formed to provide access to the device top contact or n-ohmic.

[0042] FIG. 2C shows a top view of a cartridge or donor substrate with two electrodes for top contact. The electrodes can be coupled to more than one microdevice. In one case, the electrodes can form rows and columns. In this case, a dielectric is needed to be used between the n and p electrodes to prevent shorting at the crossing points. In another case they can form either row or column (shown in FIG. 2C).

[0043] FIG. 2D shows another related example of the flip chip with accessible contacts. Here the electrodes are formed on the top surface of the devices and patterned so they are coupled to each contact individually. The electrodes are coupled to the contacts through opening in a dielectric layer on top of the contacts. After the electrodes are

formed on top, a microdevice substrate (e.g., FIG 2B) is formed and other layers such as membrane, anchors, release layer, force layer, buffer layers (called transfer layer) are formed. The devices are bonded to another substrate called cartridge substrate.

[0044] FIG. 2E is an example of a flip chip where the electrode to one contact is done through a hidden connection. This is done through a VIA contact in the device. The benefit of this structure is that the two electrodes are more isolated through the dielectric layer. This can also allow forming rows and columns structure with electrodes which can enable more control on testing the devices (down to individual devices).

[0045] After the measurement is performed, the top electrodes can be patterned or removed to isolate each microdevice. Pads can form on the top contact. In another case, the electrodes can be left on the substrate.

[0046] Prior to the transfer of microdevices from cartridge to another substrate (system substrate), the release layer is removed. It can be done either chemically, thermally, or optically.

[0047] FIG.3 shows an exemplary embodiment of a device structure and a method of forming test electrodes for a lateral device with no contact that can be accessed directly. In one embodiment a release layer is used. As highlighted in FIG. 3A, the microdevice is formed on a microdevice substrate. A dielectric layer (dielectric 1) can be formed to cover the surface of the microdevice and at least part of the device sidewall. A VIA can form to provide access to the surface facing away from the microdevice substrate. This surface can be p-type or n-type or other type of functional layer. There can be an ohmic layer on the top of this surface. Test electrodes are formed on the surface. One of the electrodes coupled to the top surface through the opening in the dielectric 1. The second electrode is coupled to the other contact layer that can be at the other surface of the device facing the substrate. The sidewall of the VIA is covered by dielectric. The dielectric can be open to provide access to the other contact of the microdevice. A release layer can be formed to facilitate the further integration process. The release layer can be formed on another dielectric layer (dielectric layer 2). The electrode can act as release layers as well. There can be some common layers also on top of the substrate. The dielectric 1 or dielectric 2 can cover the common layers as well. There

can be a VIA formed that at least one side of it is within the microdevice. The dielectric can also cover the sidewalls of the VIA. A conductive layer can fill at least part of the VIA. The VIA can be partially filled with another layer. A frame can be formed around the device with a thicker dielectric. Or the thicker dielectric can be only on the surface of the device facing away from the microdevice substrate. The frame can be applied to other embodiments presented here as well. The frame can be part of dielectric 2 or it can separate layers. As shown in FIG. 3B, the device is bonded to a cartridge (donor) substrate. Prior to bonding or during the bonding a housing layer(s) can form around the device. The microdevice substrate is removed and the common layers are etched back or removed by other means. Here, the device can have more than one contact facing away from the cartridge substrate. An ohmic structure can form on one of the contact points of the device. The other contact point is coupled to the other side of the device using the VIA formed before (the VIA can also be formed after the device is transferred into the cartridge substrate). If the conductive layer in the VIA is not coupled to the microdevice contact point another layer can be deposited after the device is transferred to the cartridge substrate. The new layer can also be a top ohmic.

[0048] FIG. 3C shows a top view of a cartridge or donor substrate with two electrodes for the hidden contacts. The electrodes can be coupled to more than one microdevice. In one case, the electrodes can form rows and columns. In this case, a dielectric is needed to be used between the n and p electrodes to prevent shorting at the crossing points. In another case they can form either row or column (shown in FIG. 3C). Here, the dielectric needs to be patterned and open to provide access to the two test electrodes.

[0049] FIG. 3D shows another related example of the lateral with hidden contacts. Here the electrodes are formed on the bottom surface of the devices and patterned so they are coupled to each contact individually. The electrodes are coupled to the contact through opening in a dielectric layer on top of the contact. After forming the electrode on the surface (e.g. FIG 3B) other layers such as membrane, anchors, release layer, force layer, buffer layers (called transfer layer) are formed. The devices are bonded to another substrate called cartridge substrate and the microdevice substrate is removed. The dielectric is open to provide access to the electrodes.

[0050] FIG. 3E is an example of a lateral device where the electrodes to one contact is done through an accessible connection. This is done through a VIA contact in the device. The benefit of this structure is that the two electrodes are more isolated through the dielectric layer. This can also allow forming rows and columns structure with electrodes which can enable more control on testing the devices (down to individual devices).

[0051] After the measurement is performed, the electrodes can be patterned or removed to isolate each microdevice.

[0052] Prior to the transfer of microdevices from cartridge to another substrate (system substrate), the release layer is removed. It can be done either chemically, thermally, or optically.

[0053] The foregoing description of one or more embodiments of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of the above teachings. It is intended that the scope of the invention be limited not by this detailed description, but rather by the claims appended hereto.

Claims

1. A method of forming test electrodes for vertical microdevice, the method comprising:

   forming a microdevice on a microdevice substrate;

   the microdevice having a hidden contact on a surface facing away from the microdevice substrate;

   forming a protection layer to cover a part of the hidden contact;

   forming a dielectric layer to cover a surface of the microdevice and at least part of the microdevice sidewall;

   forming an opening to provide access to the hidden contact; and

   forming a first electrode to provide access to the hidden contact outside of the microdevice.

2. The method of claim 1 wherein the hidden contact is a combination of an ohmic layer and a doped layer.
3. The method of claim 2 wherein the doped layer is either a p-doped layer or a n-doped layer.
4. The method of claim 1 wherein the first electrode can also act as a release layer.
5. The method of claim 1 wherein other layers can be formed on top of the first electrode as release layers.
6. The method of claim 1, wherein there are common layers on top of the microdevice substrate.
7. The method of claim 6, wherein the dielectric covers the common layers.
8. The method of claim 7, wherein a housing is formed around the microdevice.
9. The method of claim 8, wherein microdevice substrate and common layers are removed.

10. The method of claim 9, wherein the microdevice is bonded to a donor substrate, and having a top contact facing away from the donor substrate.

11. The method of claim 10, the top contact of the device has an ohmic structure which is either a n-type or a p-type.
12. The method of claim 11, wherein a second electrode is formed providing access to the top contact.
13. The method of claim 12, wherein the second electrode is an n-electrode coupled to the top contact which has the n-type ohmic structure.
14. The method of claim 12, wherein a dielectric is formed on the top surface of the microdevice prior to the formation of the n-electrode or the n-type ohmic structure.
15. The method of claim 13 wherein an opening is formed providing access to the top contact or n-type ohmic structure.
16. The method of claim 13, wherein the electrodes for hidden contact and top contact are coupled to more than one microdevice.
17. The method of claim 13, wherein the electrodes form rows and columns.
18. The method of claim 13, wherein the electrodes form rows or columns.
19. The method of claim 13, wherein the dielectric is patterned providing access to hidden contact.
20. The method of claim 19, wherein a p-electrode is coupled to the hidden contact and n-electrode is coupled to the top contact.
21. The method of claim 1, wherein the microdevice also has an accessible contact.
22. The method of claim 21, wherein transfer layers are formed after or at the same time as forming a second electrode to contact the hidden contact.
23. The method of claim 22, wherein the second electrode is formed and the transfer layers such as membrane, anchors, release layer, force layer, buffer layers are formed after the microdevice is separated from the microdevice substrate.
24. The method of claim 23, wherein the microdevice is bonded to a cartridge substrate.

25. A method of forming test electrodes for a flip chip microdevice, the method comprising:

forming a microdevice on a microdevice substrate;

forming a dielectric layer to cover a surface of the microdevice and at least part of a microdevice sidewall;

forming a release layer on the microdevice;

forming common layers on top of the microdevice;

covering the common layers by the dielectric;

forming an opening on at least one side within the microdevice with the dielectric covering the sidewalls of the opening;

filling a part of the opening with a conductive layer;

forming a frame around the microdevice with a thicker dielectric;

removing the microdevice substrate and common layers; and

having more than one contact facing away from a cartridge substrate.

26. The method of claim 25, wherein an ohmic structure is formed on a top contact of the microdevice.
27. The method of claim 25, wherein a second contact is coupled to another side of the microdevice through an opening.
28. The method of claim 26, wherein the ohmic structure can be either a n-type or a p-type.
29. The method of claim 26, wherein an electrode is formed to provide access to the top contact.
30. The method of claim 27, wherein another electrode is formed to provide access to the opening.
31. The method of claim 30, wherein a p-electrode is coupled to the contact through the opening and n-electrode is coupled to the top contact.
32. The method of claim 31, wherein the electrodes are coupled to more than one microdevice.

33. The method of claim 32, wherein the electrodes form rows and columns and a dielectric is used between the n and p electrodes to prevent shorting at the crossing points.
34. The method of claim 31, wherein the electrodes form rows or columns.

35. A method of forming test electrodes for a lateral microdevice, the method comprising:

forming a microdevice on a microdevice substrate;

forming a first dielectric layer to cover a first surface of the microdevice and at least part of a microdevice sidewall, wherein the first surface is a p-type or n-type and an ohmic is on a top of the first surface;

forming an opening provide access to a part of the first surface of the microdevice facing away from the microdevice substrate;

covering sidewalls of the opening with the first dielectric;

forming test electrodes the first surface;

coupling a first test electrode to the first surface through the opening in the first dielectric;

coupling a second electrode to a contact layer on a surface of the microdevice facing the microdevice substrate; and

opening the dielectric to provide access to the other contact layer of the microdevice.

36. The method of claim 35, wherein a release layer is formed on a second dielectric.
37. The method of a claim 36, wherein common layers cover a top of the microdevice substrate, and the common layers are covered by the first or second dielectric.
38. The method of a claim 36, wherein a second opening is formed so at least one side the second opening is within the microdevice.
39. The method of a claim 38, wherein the second opening is covered by the first dielectric and is partly filled by a conductive layer.
40. The method of a claim 38, wherein a frame is formed around the microdevice

with a thicker dielectric.

41. The method of a claim 34, wherein the thicker dielectric is on the surface of the device facing away from the microdevice substrate.
42. The method of a claim 40, wherein the frame is part of dielectric 2 or it comprises separate layers.
43. The method of claim 38, wherein a housing is formed around the microdevice.
44. The method of claim 43, wherein microdevice substrate and common layers are removed.
45. The method of claim 44, wherein the microdevice is bonded to a donor substrate, and having more than one contact facing away from the donor substrate.
46. The method of claim 45, wherein an ohmic structure is formed on one of the contact points of the microdevice.
47. The method of claim 46, wherein the other contact point is coupled to the other side of the microdevice using the second opening.
48. The method of claim 47, wherein the two contacts are hidden connected with their electrodes.
49. The method of claim 48, wherein the electrodes are coupled to more than one microdevice.
50. The method of claim 49, wherein the electrodes form rows and columns and a dielectric is used between the n and p electrodes to prevent shorting at the crossing points.
51. The method of claim 48, wherein the electrodes form rows or columns.

52. A method of forming test electrodes for a flip chip microdevice, the method comprising:

forming a microdevice on a microdevice substrate;

forming a dielectric layer to cover a surface of the microdevice and at least part of a microdevice sidewall;

forming a release layer on the microdevice;

covering the transfer layers by the dielectric;

forming an opening on at least one side within the microdevice with the dielectric covering the sidewalls of the opening;

forming electrodes on a top surface of the microdevice;
patterning the electrodes so they are coupled to each contact individually;
forming an ohmic structure is formed on a top contact of the microdevice;

forming transfer layers on top of the microdevice;

removing the microdevice substrate and transfer layers; and

having more than one contact facing away from a cartridge substrate.

53. The method of claim 48 wherein the electrode to one contact is done through a hidden connection through a VIA contact in the microdevice.

54. A method of forming test electrodes for a lateral microdevice, the method comprising:

forming a microdevice on a microdevice substrate;

forming a first dielectric layer to cover a first surface of the microdevice and at least part of a microdevice sidewall, wherein the first surface is a p-type or n-type and an ohmic is on a top of the first surface;

forming an opening provide access to a part of the first surface of the microdevice facing away from the microdevice substrate;

covering sidewalls of the opening with the first dielectric;

forming electrodes on a bottom surface of the microdevice;
patterning the electrodes so they are coupled to each contact individually;
forming transfer layers on top of the microdevice;

opening the dielectric to provide access to the electrodes;

removing the microdevice substrate and transfer layers; and

bonding the microdevice to cartridge substrate.

55. The method of claim 50 wherein the electrode to one contact is done through an accessible connection through a VIA contact in the microdevice.

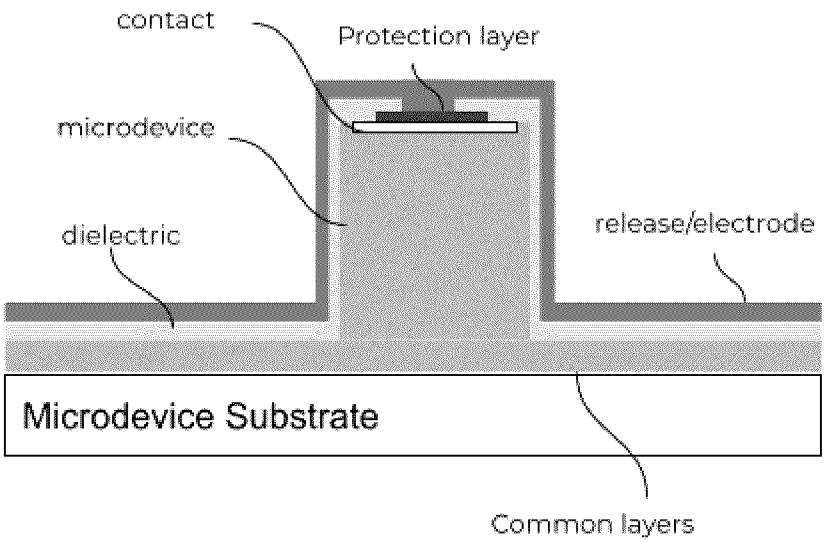

contact
Protection layer
microdevice
dielectric
release/electrode
Microdevice Substrate
Common layers

FIG. 1A

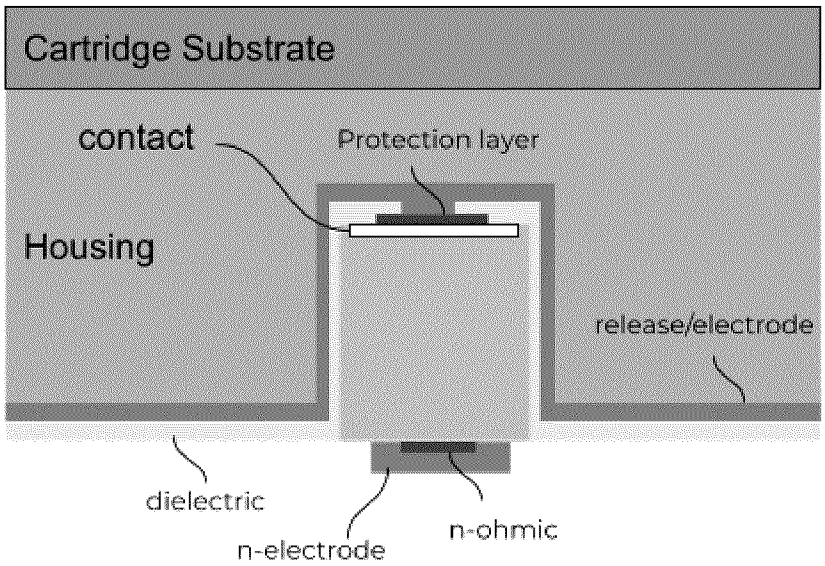

Cartridge Substrate
contact
Protection layer
Housing
release/electrode
dielectric
n-electrode
n-ohmic

FIG. 1B

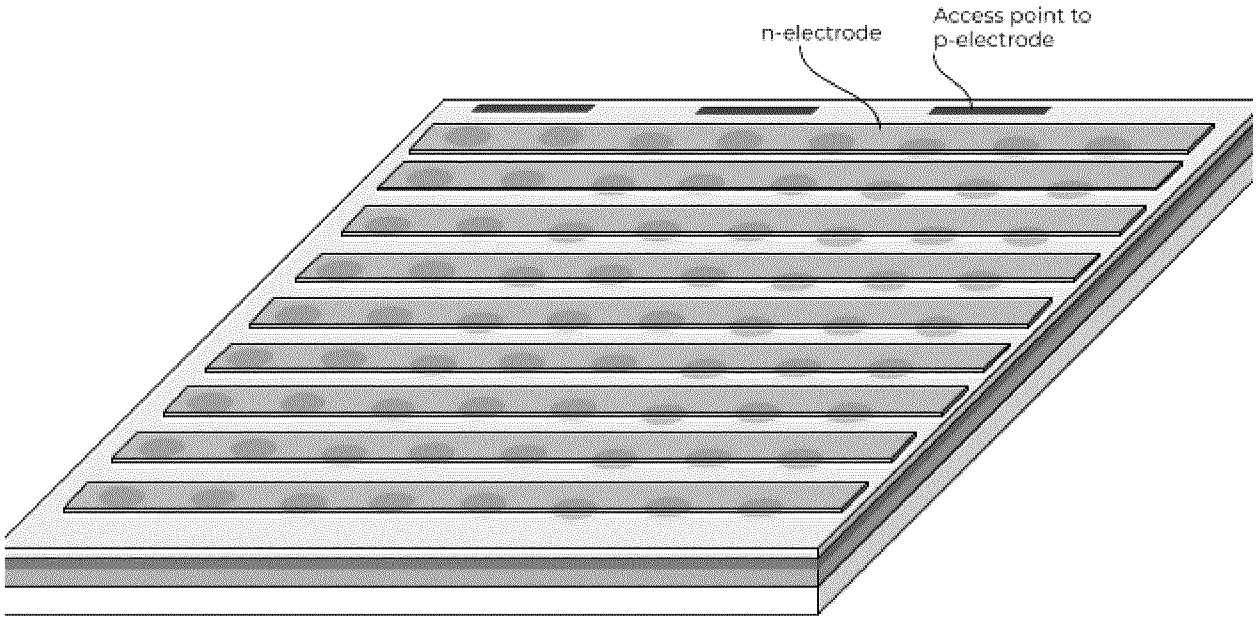

n-electrode
Access point to
p-electrode

FIG. 1C

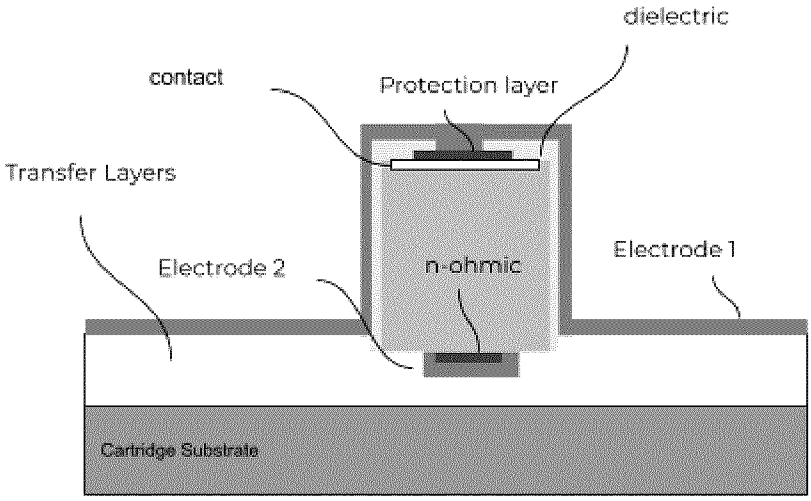

dielectric
contact
Protection layer
Transfer Layers
Electrode 2
n-ohmic
Electrode 1
Cartridge Substrate

FIG. 1D

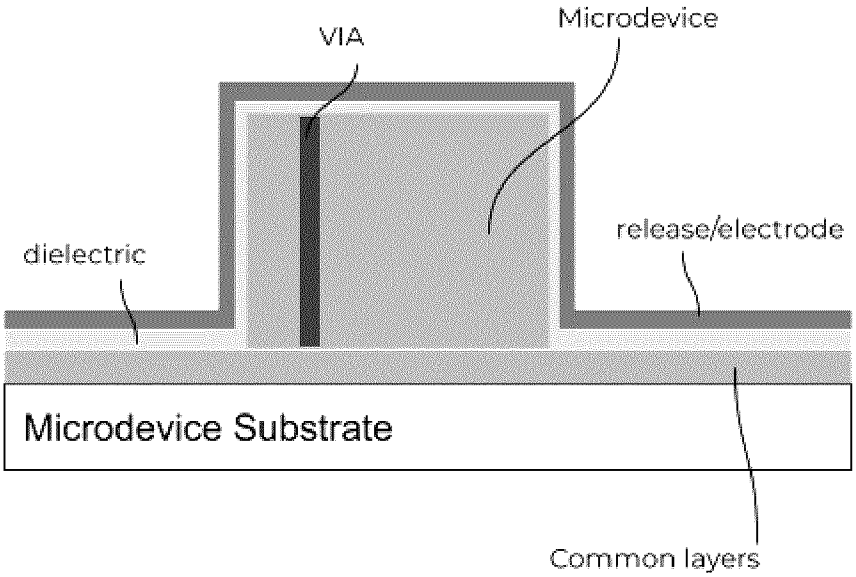

VIA
Microdevice
dielectric
release/electrode
Microdevice Substrate
Common layers

FIG. 2A

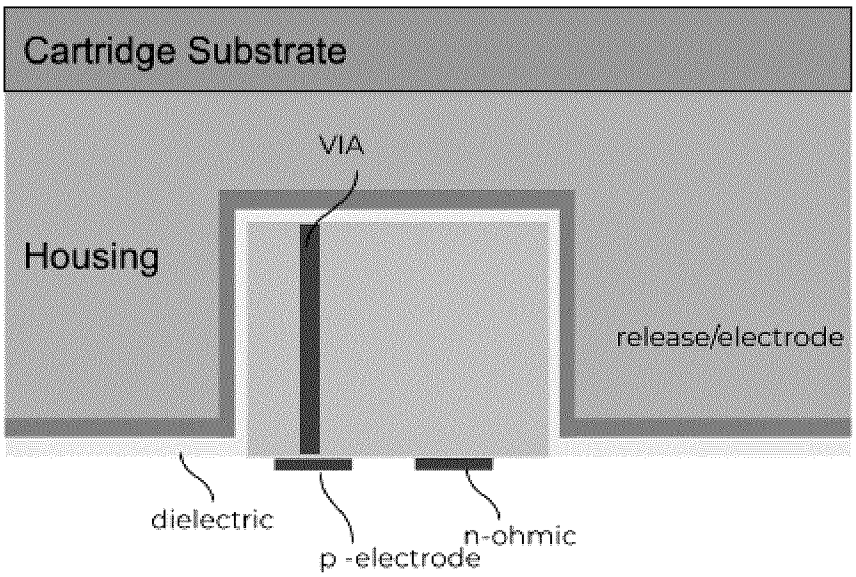

Cartridge Substrate
VIA
Housing
release/electrode
dielectric
p -electrode
n-ohmic

FIG. 2B

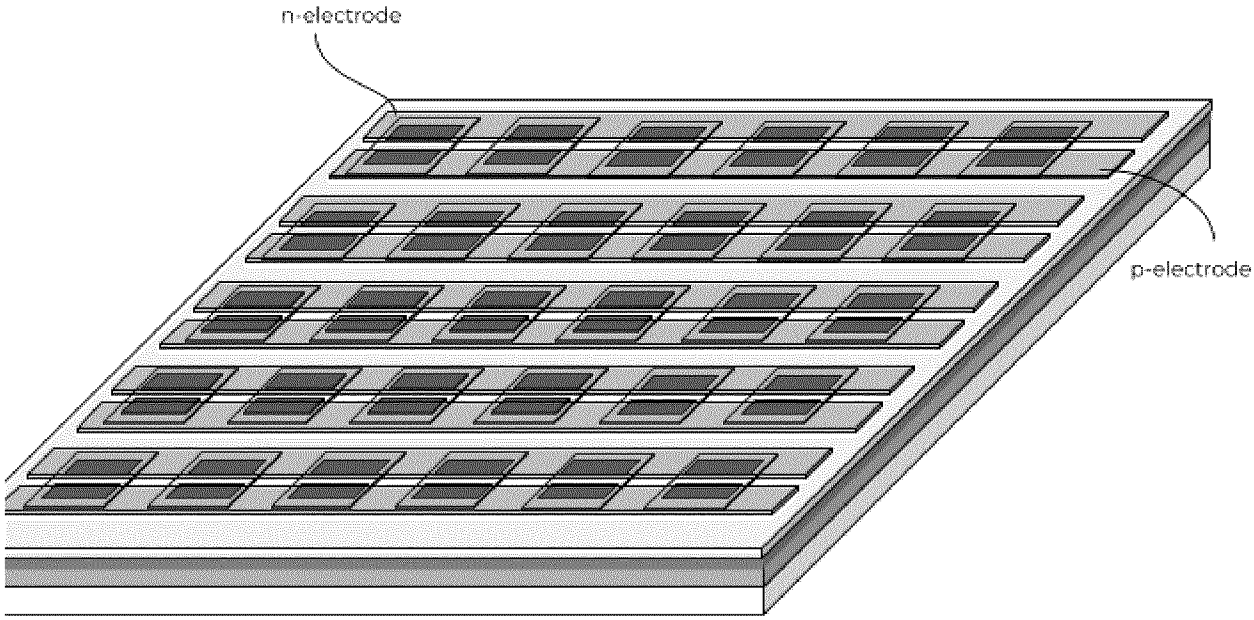

n-electrode
p-electrode

FIG. 2C

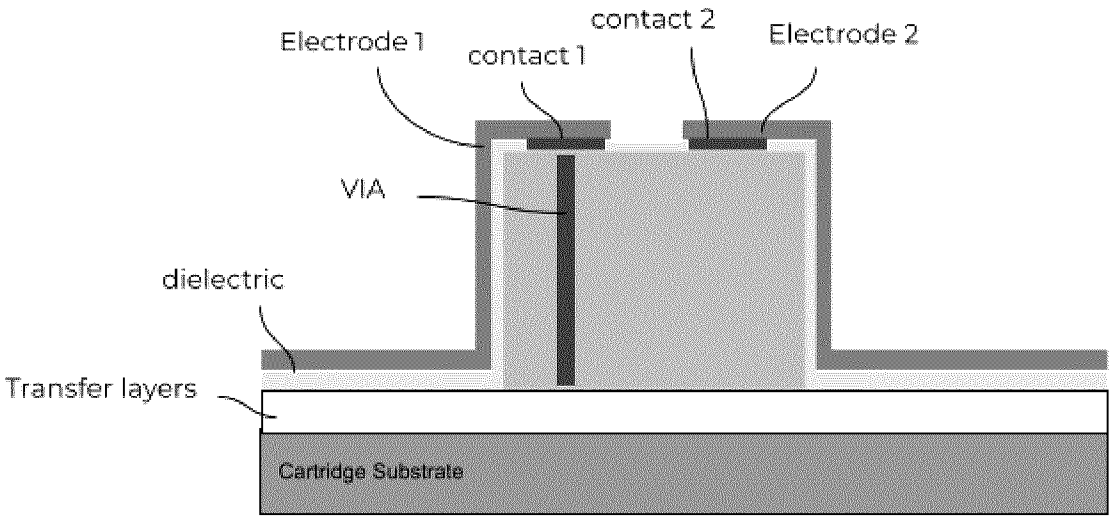

Electrode 1
contact 1
contact 2
Electrode 2
VIA
dielectric
Transfer layers
Cartridge Substrate

FIG. 2D

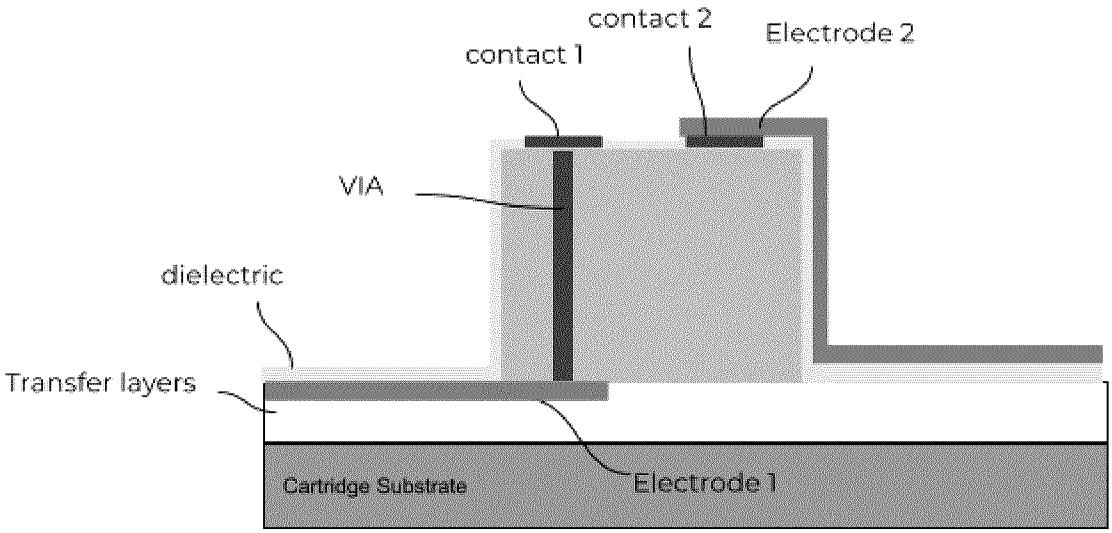

contact 2
Electrode 2
contact 1
VIA
dielectric
Transfer layers
Cartridge Substrate
Electrode 1

FIG. 2E

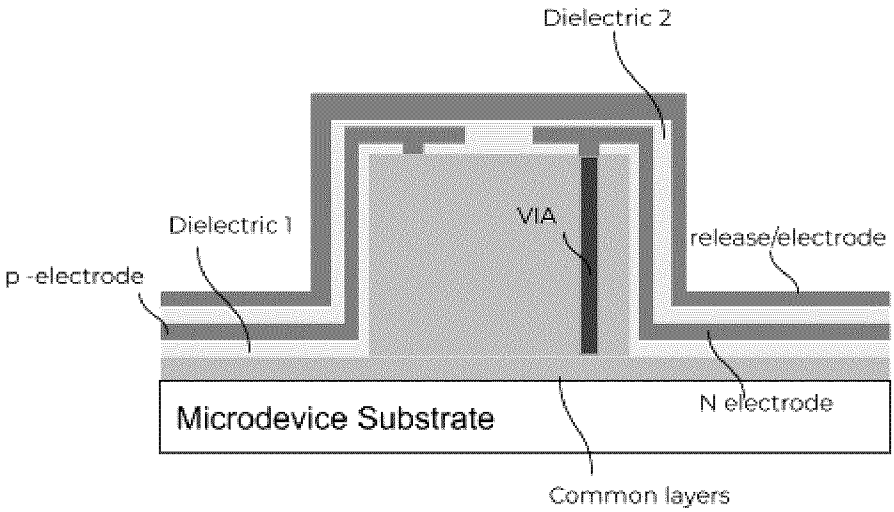

Dielectric 2
Dielectric 1
VIA
release/electrode
p -electrode
Microdevice Substrate
N electrode
Common layers

FIG. 3A

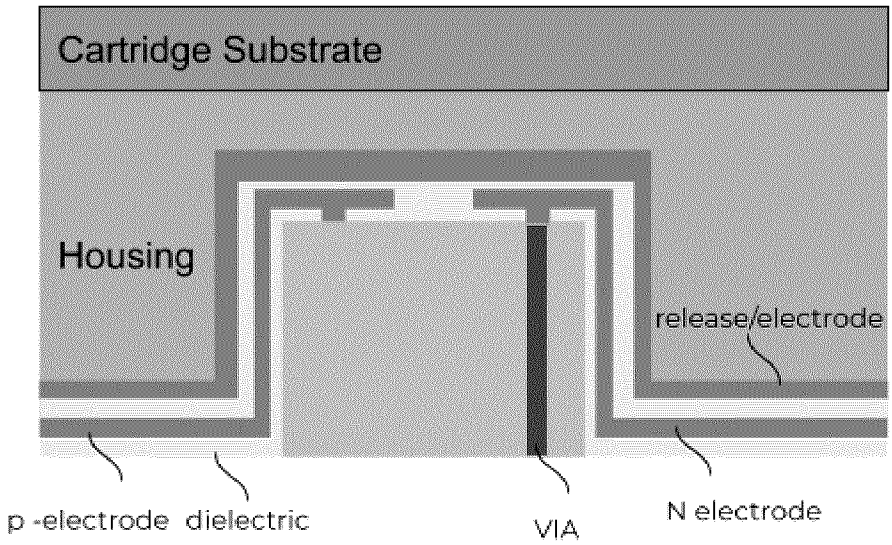

Cartridge Substrate
Housing
release/electrode
p -electrode
dielectric
VIA
N electrode

FIG. 3B

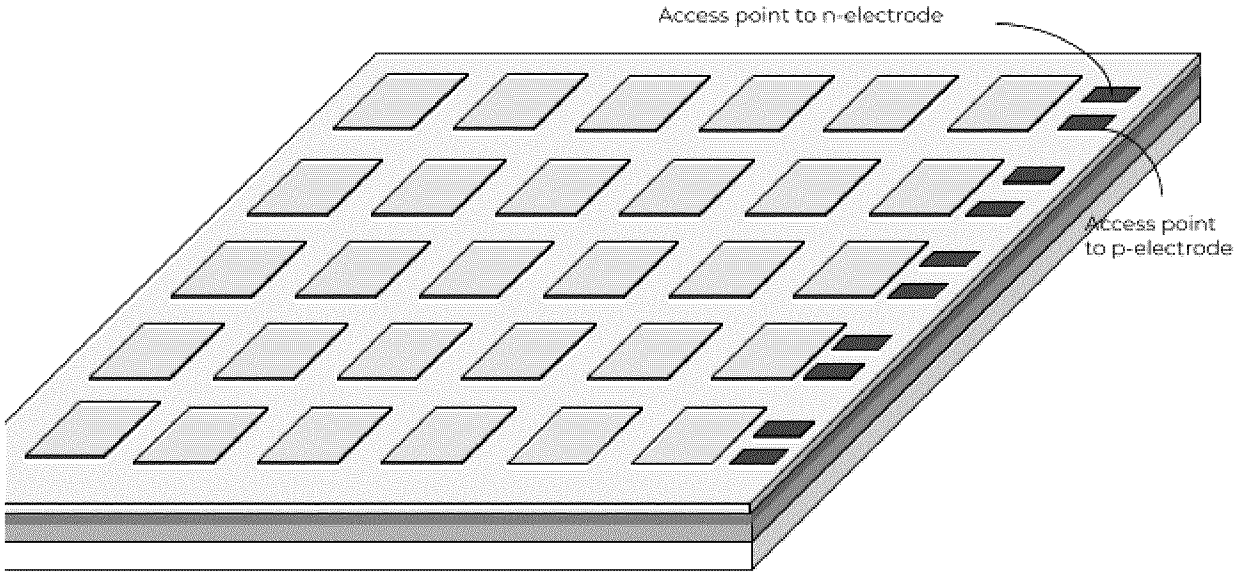

Access point to n-electrode
Access point
to p-electrode

FIG. 3C

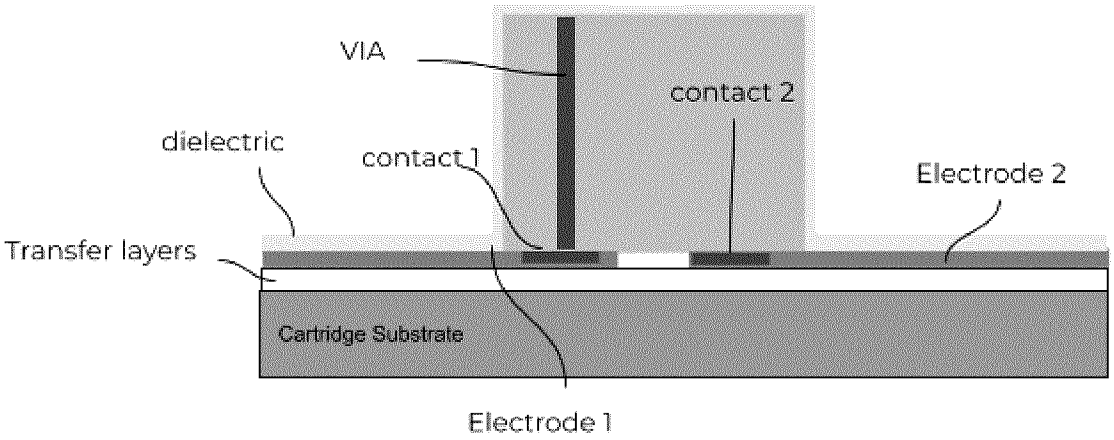

VIA
contact 2
dielectric
contact 1
Electrode 2
Transfer layers
Cartridge Substrate
Electrode 1

FIG. 3D

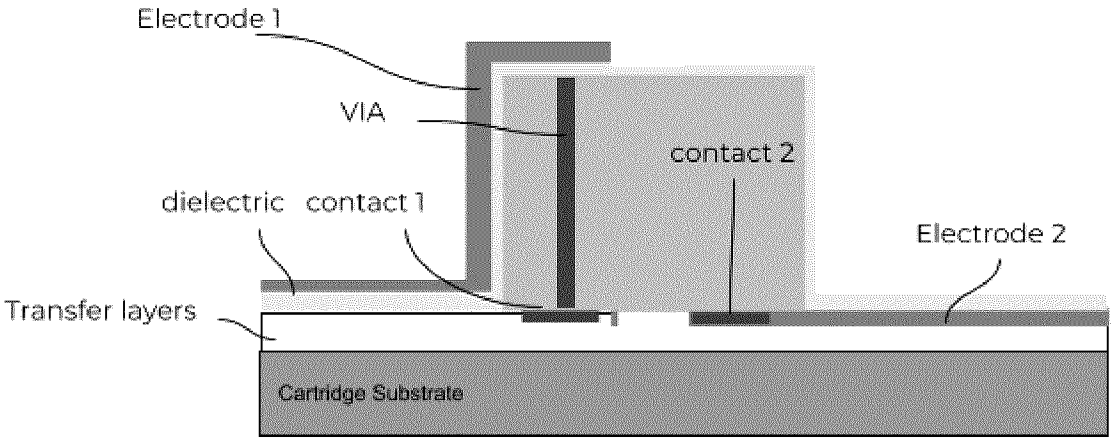

Electrode 1
VIA
contact 2
dielectric
contact 1
Electrode 2
Transfer layers
Cartridge Substrate

FIG. 3E

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2021/050977

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***G01R 31/00*** (2006.01) , ***H01L 21/66*** (2006.01)

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: ***G01R 31/00*** (2006.01) , ***H01L 21/66*** (2006.01)

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

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Questel Orbit™, IEEEXplore™, Google Patents™ and keywords: integrated circuit, microdevice, vertical 3D microdevice, flip chip microdevice, fabrication, contact , hidden contact, electrode, wafer, substrate, opening, hole.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US8518204 (HU et al.) 27 August 2013 (27-08-2013) *abstract; cols. 1-4; col. 19, lines 59-67, col. 22, lines 6-17; figs. 9-9', 10-10''*	1 – 55
A	US20070070311 (Bijnen et al.) 29 March 2007 (29-03-2007) *abstract; pars. 0004-0016, 0063-0068*	1 – 55
A	US20030111441 (JEROMINEK et al.) 19 June 2003 (19-06-2003) *abstract; pars. 0007-0018, 0092-0094*	1 – 55

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

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"D"	document cited by the applicant in the international application	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"E"	earlier application or patent but published on or after the international filing date	"&"	document member of the same patent family
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)		
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 02 November 2021 (02-11-2021)	Date of mailing of the international search report 02 November 2021 (02-11-2021)
Name and mailing address of the ISA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 819-953-2476	Authorized officer Dan Marinescu (819) 639-8202

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