



(51) International Patent Classification:
G01L 1/18 (2006.01) *G01L 1/20* (2006.01)

(21) International Application Number:
PCT/GB2021/000088

(22) International Filing Date:
09 August 2021 (09.08.2021)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2012390.7 10 August 2020 (10.08.2020) GB

(71) Applicant: **PERATECH HOLDCO LTD** [GB/GB]; Old Repeater Station, 851 Gatherley Road, Brompton on Swale, Richmond, DL10 7JH (GB).

(72) Inventors: **DEMPSEY, Sarah Jessica**; 33 Edge Court, Durham, DH1 2JY (GB). **GOSPEL, Matthew**; 6 Beau-fighter Close, Scorton, DL10 6TG (GB).

(74) Agent: **REID, Alexandra** et al.; Atkinson & Company Intellectual Property Limited, 7 Moorgate Road, Rotherham S60 2BF (GB).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, IT, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,

(54) Title: FORCE SENSING DEVICE

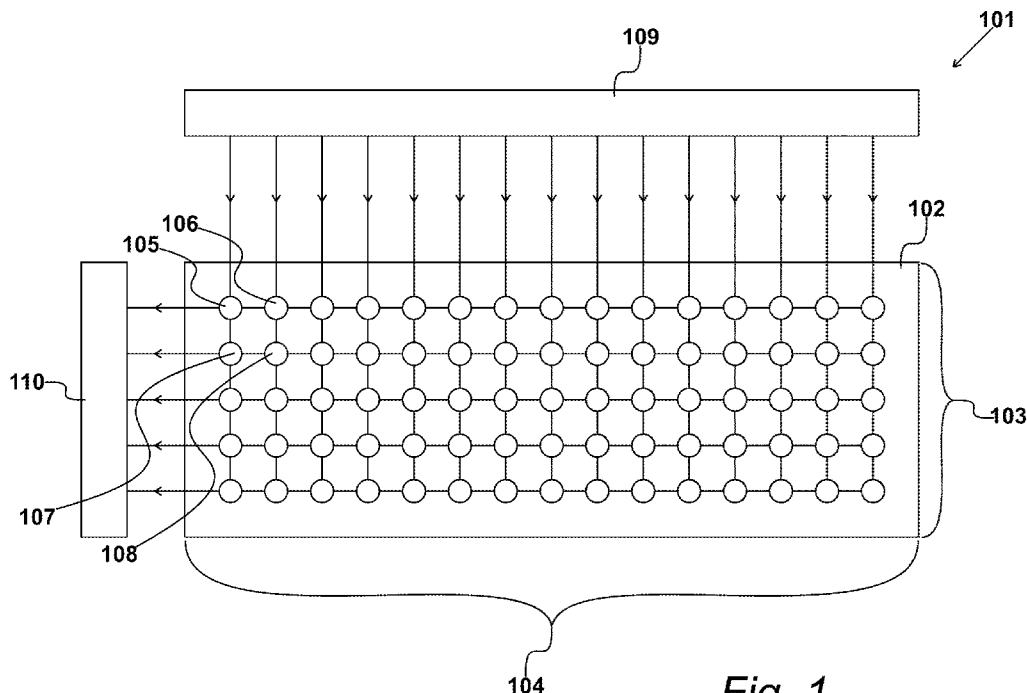


Fig. 1

(57) Abstract: A force sensing device (301) comprises a sensing array (102) comprising a first conductive layer having a plurality of conductive rows (103) and a second conductive layer having a plurality of conductive columns (104). The plurality of conductive rows and plurality of conductive columns are arranged to define a plurality of intersections. The force sensing device also comprises an electro-active layer overlaying the first conductive layer and comprising a pressure sensitive element (105, 106, 107, 108) at each intersection. A force concentrating structure (307) is positioned at each intersection on the second conductive layer.

MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

- *with international search report (Art. 21(3))*

Force Sensing Device

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority from United Kingdom Patent Application number GB 20 12 390.7, filed on 10 August 2020, the whole contents of which
5 are incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention relates to a force sensing device and a method of producing a force sensing device.

Multi-touch matrix sensors are known in the art and typically comprise
10 arrangements of conductive layers having a plurality of rows and plurality of columns defining an intersection.

The applicant has developed matrix sensors to include sensing elements at the intersections of the rows and columns to provide additional pressure sensitivity. However, in use, when a force is applied by a user, some
15 of this force is transmitted to areas between the sensing elements thereby reducing the pressure of the input force and decreasing the signal from the sensor.

In many applications, the matrix sensor is integrated beneath a top surface in an electronic device. A force is transmitted by a user through a top
20 layer such as, for example, a display module or a track pad. This top layer acts to spread the applied force across a larger area of the matrix sensor and may activate a plurality of sensing elements directly beneath and to the side of the location of the applied force. Force is spread to the sensing elements (thereby generating a signal) and regions between the sensing elements (not
25 generating a signal).

Thus, it is desirable to direct the force to sensing elements only, not to the regions between the sensing elements.

BRIEF SUMMARY OF THE INVENTION

According to a first aspect of the present invention, there is provided a

force sensing device comprising: a sensing array comprising a first conductive layer and a second conductive layer; said first conductive layer comprising a plurality of conductive rows and said second conductive layer comprising a plurality of conductive columns, said plurality of conductive rows and said plurality of conductive columns being arranged to define a plurality of intersections; an electro-active layer overlaying said first conductive layer, said electro-active layer comprising a pressure sensitive element at each intersection; and a force concentrating structure positioned at each intersection on said second conductive layer.

According to a second aspect of the present invention, there is provided a method of producing a force sensing device, comprising the steps of: printing a sensing array in the form of a first conductive layer comprising a plurality of conductive rows and a second conductive layer comprising a plurality of conductive columns, arranged to define a plurality of intersections; printing an electro-active layer over said first conductive layer such that said electro-active layer comprises a pressure sensitive element at each intersection; and providing a force concentrating structure at each intersection on said second conductive layer.

Embodiments of the invention will be described, by way of example only, with reference to the accompanying drawings. The detailed embodiments show the best mode known to the inventor and provide support for the invention as claimed. However, they are only exemplary and should not be used to interpret or limit the scope of the claims. Their purpose is to provide a teaching to those skilled in the art. Components and processes distinguished by ordinal phrases such as “first” and “second” do not necessarily define an order or ranking of any sort.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Figure 1 shows a force sensing device comprising a sensing array in accordance with the present invention;

Figures 2A and 2B show a cross-sectional view of an example of an

intersection in a sensing array;

Figure 3 shows a cross-sectional view of a force sensing device comprising a plurality of force concentrating structures;

Figures 4A, 4B, 4C and 4D show example embodiments of force
5 concentrating structures in accordance with the present invention;

Figure 5 shows a method of constructing a force sensing device comprising at least one force concentrating structure;

Figure 6 shows an alternative method of constructing a force sensing device comprising at least one force concentrating structure;

10 Figure 7 shows the effect of a force concentrating structure in a force sensing device when a force is applied to the force sensing device; and

Figure 8 shows a force sensing device in accordance with the present invention when laminated to a cover layer.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

15 *Figure 1*

An example force sensing device **101** in accordance with the present invention is illustrated in a schematic plan view in Figure 1.

Force sensing device **101** may be incorporated into any suitable electronic device, for example, an electronic device comprising a touch screen.
20 Force sensing device **101** comprises a sensing array **102** which provides an electrical response to an applied force or applied pressure.

Sensing array **102** comprises a plurality of conductive rows **103** and a plurality of conductive columns **104** which are arranged to define a plurality of intersections. At each intersection, a pressure sensitive element is provided,
25 such as pressure sensitive elements **105**, **106**, **107** and **108**. The plurality of pressure sensitive elements are provided as an electro-active layer printed as part of the array.

In the embodiment, the plurality of conductive rows **103** are comprised as a first conductive layer and the plurality of conductive columns are
30 comprised as a second conductive layer.

Each pressure sensitive element comprises a pressure sensitive material which is responsive to an applied pressure. In the embodiment, each pressure sensitive element comprises a quantum tunnelling material. The quantum tunnelling material may be of the type supplied by the applicant
5 Peratech Holdco Limited under the trade mark QTC®, which exhibits a reduction in electrical resistance following the application of a force or pressure. In this way, the sensing array can be configured to provide both two-dimensional positional data and an extent property in response to an applied pressure.

10 In alternative embodiments, it is appreciated that alternative pressure sensitive materials may be utilised which exhibit a change in electrical resistance following the application of a force or pressure.

In this illustrated example, sensing array **102** comprises fifteen columns and five rows. It is appreciated that the number of rows and columns are an illustrative example, and any suitable number of rows and columns may be
15 utilised depending on the application and customer requirements. Furthermore, while the illustrated example describes a square array, it is appreciated that other alternative array forms may be utilised, for example, a hexagonal array or similar.

20 A column connector **109** receives driving voltages from a processor and a row connector **110** supplies scan voltages to the processor. Without the application of force or pressure, all of the pressure sensitive elements at the intersections of sensing array **102** remain non-conductive. However, when sufficient pressure is applied to sensing array **102**, this activates at least one
25 of the pressure sensitive elements to provide a response between an input driving line and an output scanned line allowing two-dimensional positional data and an extent property to be calculated as necessary.

Figures 2A and 2B

An example pressure sensitive element which can be utilised in a
30 sensing array such as sensing array **102** is shown in Figures 2A and 2B.

In the embodiment, the pressure sensitive element is positioned at the

intersection of a conductive row and a conductive column. Figures 2A and 2B show an isolated cross section of the layers of sensing array in schematic form. Thus, the sensing array comprises a first substrate **201** onto which conductive row **202** is printed thereon to form a conductive electrode. Printed onto conductive row **202** is an electro-active layer which comprises one of the plurality of pressure sensitive elements **203** as shown. The pressure sensitive element **203** may comprise a quantum tunnelling material as described previously.

The force sensing device comprises a second substrate **204** onto which a corresponding conductive column **205** is printed to form a further conductive electrode which is substantially perpendicular to conductive row **202**.

Between conductive electrode **205** and the electro-active layer is an air gap **206** which maintains the layers a distance apart in a rest configuration in which an external force has not been applied to the sensing array. This is illustrated with respect to Figure 2A.

Figure 2B, in contrast, shows the response of the pressure sensitive element in a configuration in which an external force, indicated by arrow **207**, has been applied to the sensing array and the pressure sensitive element in question.

When a force is applied to substrate **204**, a first component **208** of force **207** is transmitted through the pressure sensitive element **203** providing a response. However, a further component **209**, is transmitted into the air gap **206** in the space around pressure sensitive element **203**, which may be referred to as 'dead zones'.

Thus, when a force is applied, the conductive layers are brought into contact with the electro-active layer. A signal is only generated where contact with the electro-active layer (i.e. the pressure sensitive element) and it is this signal which is used to calculate a change in electrical resistance. However, in the space between each pressure sensitive element and the corresponding intersections, the pressure which is transmitted into the 'dead zones' does not generate a signal and some of the applied force is spread outwards affecting

the calculated electrical resistance.

When incorporated into an electronic device, a cover layer is also typically present, which in turn causes a force distribution effect, ensuring that the force is distributed over a larger area, thereby resulting in a reduction in the overall pressure.

If the force is spread to neighbouring pressure sensitive elements at neighbouring intersections, this can be beneficial as the results can be utilised, however any force applied between each intersection reduces the signal output and reduces the effective force on each pressure sensitive element.

This is an increased problem with substantially thin force sensing devices which are increasingly attractive to industry due to the benefits of smaller, more flexible devices and their increased applicability.

The present invention proposes to include a force concentrating structure to address these issues at least and ensure that force is transmitted primarily to each pressure sensitive element rather than the spaces therebetween.

Figure 3

In contrast into the conventional arrangement of the sensing array of Figures 2A and 2B, the present invention includes a force concentrating structure at each intersection in the sensing array. Thus, a force sensing device in accordance with the present invention is shown in Figure 3 in schematic cross section.

Force sensing device **301** comprises a first substrate **302**, a second substrate **303** which are separated by a spacer gasket **304**.

Substrate **303** includes a plurality of conductive rows **305** printed thereon, with electro-active layer **306** overprinted on the conductive rows **305** in a pattern comprising a plurality of pressure sensitive elements such as those illustrated in Figure 1 (**105**, **106**, **107**, **108**).

In contrast, substrate **302** comprises a plurality of force concentrating structures **307**. A conductive layer of columns **308** is printed over force concentrating structures **307**. In the embodiment, a spacer layer comprising a

plurality of spacer elements **309** is also provided so as to retain the structure of force sensing device **301**.

In the embodiment, conductive layer **305** is separated from conductive layer **308** by means of air gap **310** therebetween. In the embodiment, each force concentrating structure **307** provides a protrusion of conductive layer **308** into air gap **310**. This protrusion provides a comparatively three-dimensional structure compared to conventional two-dimensional structured force sensing devices, such that, the combination of the conductive layer **308** and force concentrating structures **307** protrude into air gap **310** by a given height **311**. The protrusion height **310** is dependent on the thickness of conductive layer **308** and the thickness of force concentrating structure **307**.

The first touch-sensitivity of the force sensing device can therefore be adapted by tuning the thickness of spacer gasket **304**, the protrusion height **310** and the combined thickness of conductive layer **305** and electro-active layer **306**. The first touch-sensitivity is the force required to deform substrate **302** and create electrical contact with electro-active layer **306** to enable a resistance to be calculated in the manner previously described with respect to Figure 1.

Figures 4A, 4B, 4C and 4D

Force concentrating structure **307** can be constructed by any suitable means. Figure 4 illustrates four separate examples in which force concentrating structure **307** can be constructed for use in force sensing device **301**.

In the examples shown in Figures 4A, 4B, 4C and 4D, each example force concentrating structure is shown in isolation in combination with conductive layer **308** which surrounds the force concentrating structure in question.

In each of the example embodiments shown, the force concentrating structures may comprise a dielectric material and, in a specific embodiment the force concentrating structure comprises a dielectric ink. Thus, the dielectric material can be printed or deposited using a bead deposition process onto

substrate **302**.

In the embodiment depicted in Figure 4A, force concentrating structure **401** is constructed by deposition of a single microbead **402** of dielectric material by means of a bead deposition process. As necessary, this procedure
5 may involve a drying or curing process to ensure that bead **402** is successfully deposited onto substrate **302**. Conductive layer **308** may then be printed over force concentrating structure **401** to complete the arrangement of Figure 3.

In the embodiment of Figure 4B, force concentrating structure **403** illustrates an example whereby a plurality of printed layers of dielectric ink of
10 differing radii are printed successively. Thus, a first dielectric ink layer **404** having a first radius is printed onto substrate **302**. Subsequently, a second dielectric ink layer **405** is overprinted over first dielectric ink layer **404** having a smaller radius than that of dielectric ink layer **404**. Similarly, a further layer of dielectric ink **406** is overprinted over dielectric ink layer **405** and this has a
15 smaller radius again than both dielectric ink layers **404** and **405**. In the embodiment, each layer is printed and then dried to ensure successful deposition onto substrate **302**.

In contrast to existing conventional force sensing devices, the
20 conductive layers are typically in the region of around six microns. The force concentrating structure in this case may therefore have a height in the region of eighteen microns due to the additional layering effect thereby creating a comparative three-dimensional structure.

In the embodiments of Figures 4C and 4D, the deposition of a plurality of dielectric beads is conducted by means of a bead deposition process. Thus,
25 in the embodiment of Figure 4C force concentrating structure **407** comprises microbead **408** and microbead **409**. Similarly, in the embodiment of Figure 4D force concentrating structure **410** comprises three microbeads **411**, **412** and **413** each deposited onto substrate **302**. Conductive layer **308** is then overprinted over the respective microbeads to form the combined structure as
30 shown.

Figure 5

A method of producing a force sensing device in line with the embodiment shown in Figures 3 and 4 will now be described with respect to Figure 5.

5 At step **501** substrate **302** is obtained and the force concentrating structure is deposited onto the substrate. As previously explained, this may involve printing a dielectric ink or the deposition of one or more microbeads of dielectric or polymer material by means of a bead deposition process.

10 At step **502**, conductive layer **308** is printed in the manner of a plurality of conductive rows overlying the force concentrating structure. At step **503**, the second conductive layer **308** comprising a plurality of conductive columns is printed onto substrate **303**. At step **504** an electro-active layer comprising pressure sensitive elements (which are configured to be printed at each intersection of the conductive rows and columns when the conductive layers
15 are combined in the manner of Figures 1 and 3) is printed over the second conductive layer.

 At step **505** substrate **302** and substrate **303** are combined to create the force sensing device **301** in the manner shown in Figure 3.

Figure 6

20 An alternative method of producing a force sensing device providing an alternative to the dielectric ink or bead structures described with respect to Figures 4 and 5 is shown in Figure 6.

 In the embodiment of Figure 6, substrate **302** is obtained and first conductive layer **308** is printed onto substrate **302** at step **601**. In the
25 embodiment, substrate **302** comprises a thermoplastic material and at step **602** the substrate comprising the conductive layer is embossed by a embossing process utilising heat applied to the substrate as the substrate is rolled over a preform comprising a suitable shape for the force concentrating structures. Thus, the substrate and the first conductive layer is deformed in a
30 manner to create the plurality of force concentrating structures which are positioned at the intersections of the sensing array in the end product.

At steps **603**, the second conductive layer **305** is printed onto substrate **303** and the electro-active layer **306** is overprinted at step **604**. Steps **603** and **604** are substantially similar to steps **503** and **504** in the previously described method. The substrates can then be combined to form a substantially similar force sensing device **301** at step **605**.

It is appreciated that, alternative force concentrating structures may be created through alternative deposition routes to those indicated and it is further appreciated that the examples given are not exhaustive. Alternative deposition routes include monolithic deposition and growth of crystal structures in addition to those described herein. However, in each case the force concentrating structures protrude into the air gap beyond the conventional two-dimensional structures known in the art.

Figure 7

A cross-sectional schematic of a single intersection in sensing array **102** is shown in Figure 7. The schematic illustrates the effects of the force concentrating structure **307** when a force is applied to substrate **302** in use.

In the embodiment, a force, indicated by arrow **701**, is applied to substrate **302**, bringing force concentrating structure **307** and conductive layer **308** into contact with electro-active layer **306**. In this embodiment, force **701** is transmitted through force concentrating structure **307** to conductive layer **308** to electro-active layer **306**.

Force **701** is transmitted across the protruding conductive layer **308**, such that the force received **702** by electro-active layer **306** aligns with the conductive layer **308**. In the air gap **309**, a limited amount of force **703** is transmitted to this area and does not contact with electro-active layer **306**. Thus, force concentrating structure creates an effective three-dimensional structure compared to conventional force sensing devices in which the conductive layers are relatively thin and considered two-dimensional. In this way, each force concentrating structure avoids spreading the input force **701** across the layer and focusses the input force on the intersections.

At low forces therefore only the tip of the comparatively domed

conductive layer **308** contacts the electro-active layer **306**. However, at higher forces, an increased portion of the curved profile is brought into contact with the electro-active layer **306**.

5 In an embodiment, the effect is increased by introducing a material for the force concentrating structure having a relatively high Young's modulus. This is typically provided by a material having a high Young's modulus comparison to the substrate material.

10 In conventional force sensing devices, the upper substrate traditionally provides a substantially flat surface which interacts with the electro-active layer. In such previous force sensing devices, a force threshold level is reached when all of the conductive layer is in contact with the electro-active layer. Increasing the force does not expand the area of contact at this force threshold which results in an on/off effect, thereby limiting the dynamic range of resistance which decreases with force at each intersection. The introduction
15 of the force concentrating structure provides a solution to the on/off effect to ensure that contact between the conductive layers and electro-active layer and the corresponding pressure area is dependent on an applied force. Thus, the present invention increases the dynamic range of resistance decrease with applied force at each intersection of the sensing array.

20 This is beneficial in force sensing applications as the higher dynamic range allows for improved mapping of input force to a change in resistance. Thus, the change in resistance can be used to set a specific response such that different outputs can be provided in response to specific applied pressures. This may be affected by means of a software application in an
25 electronic device in which the force sensing device is utilised.

In a further embodiment, a force sensing device in accordance with the invention, comprises a first array of force concentrating structures having a first height and a second array of force concentrating structures having a second height. In this embodiment, the first height and the second height are
30 configured to be substantially different to each other. Thus, each of the force concentrating structures, may be responsive to different applied forces to

provide further flexibility in the applications of the force sensing device. Thus, at low forces, the force concentrating structures having the greatest height would activate their corresponding pressure sensitive elements, and at higher forces, the higher force concentrating structures would provide activation along with the pressure sensitive elements corresponding to the lower height force concentrating structures.

Figure 8

Force sensing device **301** may be incorporated in practice into an electronic device and is typically integrated with a cover layer in the manner shown in Figure 8.

Force sensing device **301** shown in Figure 8 is substantially similar to any of the embodiments described previously, comprising a sensing array having a plurality of conductive columns and conductive rows which are arranged to define a plurality of intersections. Each intersection comprises a pressure sensitive element of an electro-active layer and a force concentrating structure at each intersection.

In the embodiment, cover layer **801** is positioned substantially parallel to substrate **302** such that an applied force in use is applied to a cover layer **801** directly rather than to substrate **302**.

Cover layer **801** is integrated to force sensing device **801** by means of a lamination process utilising a lamination adhesive. Thus, in the embodiment, cover layer **801** is laminated to force sensing device **301** by means of adhesive layer **802**. Adhesive layer **802** comprises an adhesive **803** and a plurality of openings **804** in adhesive layer **802**. In an embodiment, the adhesive comprises a continuous adhesive film.

Cover layer **801** may be of any suitable thickness or rigidity which is typically dependent on the application. In an embodiment, cover layer **801** comprises an LED or OLED display which may be rigid or flexible/foldable. In a further embodiment, cover layer **801** comprises a track pad.

Typically, cover layer **801** provides a mechanical constraint on force sensing device **301** in that cover layer **801** would typically act to distribute any

force applied to cover layer **801** over a larger area thereby decreasing the effective force applied. This presents the issue of activating a plurality of pressure sensitive elements at each intersection while also providing a force into the spaces between each intersection which as noted previously can be undesirable.

In the embodiment, adhesive layer **802** comprises a pattern which conforms to the configuration of force sensing device **301**. Spacer layer comprises a plurality of spacer elements **309** which are positioned between each force concentrating structure **307**. In the embodiment, openings **804** are aligned with spacer elements **309** such that an air gap is created between cover layer **801** and substrate **302** of force sensing device **301**. This arrangement can be utilised to aid force transfer onto force sensing device **301** by directing the force from cover layer **801** to the intersections and pressure sensitive elements only without the need to include further spacer layers.

In conventional force sensing devices utilising sensing arrays, a spacer layer is required to hold the layers apart and reduce initial pressure on the electro-active layer. However, this creates an issue in that the spacer elements prevent force transmission or pressure transfer to the electro-active layer **306**. Thus, in this embodiment, the arrangement of the adhesive layer in respect of the spacer elements creates a shear effect on substrate **302** such that the force is distributed to the intersections in the sensing array. This is because an air gap is created in openings **804** which functions in the manner of a spring.

CLAIMS

The invention claimed is:

1. A force sensing device comprising:
a sensing array comprising a first conductive layer and a second
5 conductive layer;
said first conductive layer comprising a plurality of conductive rows and
said second conductive layer comprising a plurality of conductive columns,
said plurality of conductive rows and said plurality of conductive columns being
arranged to define a plurality of intersections;
10 an electro-active layer overlaying said first conductive layer, said
electro-active layer comprising a pressure sensitive element at each
intersection; and
a force concentrating structure positioned at each intersection on said
second conductive layer.
15
2. The force sensing device of claim 1, wherein said force
concentrating structure comprises a dielectric material.
3. The force sensing device of claim 1, wherein said force
20 concentrating structure comprises a dielectric ink.
4. The force sensing device of any one of claims 1 to 3, wherein
said force concentrating structure comprises a plurality of layers.
- 25 5. The force sensing device of claim 1, wherein said force
concentrating structure comprises an embossed substrate.
6. The force sensing device of any one of claims 1 to 5, wherein
said pressure sensitive element comprises a quantum tunnelling material.

7. The force sensing device of any preceding claim, further comprising a cover layer laminated to said force sensing device by means of an adhesive layer.

5 8. The force sensing device of claim 7, wherein said adhesive layer comprises an adhesive and a plurality of openings in said adhesive.

9. The force sensing device of claim 8, further comprising a spacer layer comprising a plurality of spacer elements, wherein said plurality of
10 openings are aligned with said spacer elements to create an air gap between said cover layer and a supporting substrate of said force sensing device.

10. The force sensing device of any one of claims 1 to 8, further comprising a spacer layer comprising a plurality of spacer elements.

15 11. The force sensing device of any preceding claim, wherein said force concentrating structure provides a protrusion of said first conductive layer into an air gap between said first conductive layer and said second conductive layer.

20 12. The force sensing device of any preceding claim, wherein the height of said force concentrating structure is at least six microns.

25 13. The force sensing device of any preceding claim, further comprising a first array of force concentrating structures having a first height, and a second array of force concentrating structures having a second height, wherein said first height and said second height are substantially different.

30 14. An electronic device comprising the force sensing device of any preceding claim.

15. A method of producing a force sensing device, comprising the steps of:

printing a sensing array in the form of a first conductive layer comprising a plurality of conductive rows and a second conductive layer comprising a plurality of conductive columns, arranged to define a plurality of intersections;

printing an electro-active layer over said first conductive layer such that said electro-active layer comprises a pressure sensitive element at each intersection; and

providing a force concentrating structure at each intersection on said second conductive layer.

16. The method of claim 15, wherein said step of providing a force concentrating structure comprises the step of:

depositing a dielectric material onto a substrate.

17. The method of claim 16, wherein said step of depositing comprises printing a plurality of layers of dielectric material.

18. The method of claim 16, wherein said step of depositing comprises providing a bead of dielectric material at each intersection.

19. The method of claim 16, wherein said step of depositing comprises providing a plurality of beads of dielectric material at each intersection.

20. The method of claim 15, wherein said step of providing a force concentrating structure comprises the step of:

embossing a supporting substrate onto which said sensing array and electro-active layer is printed.

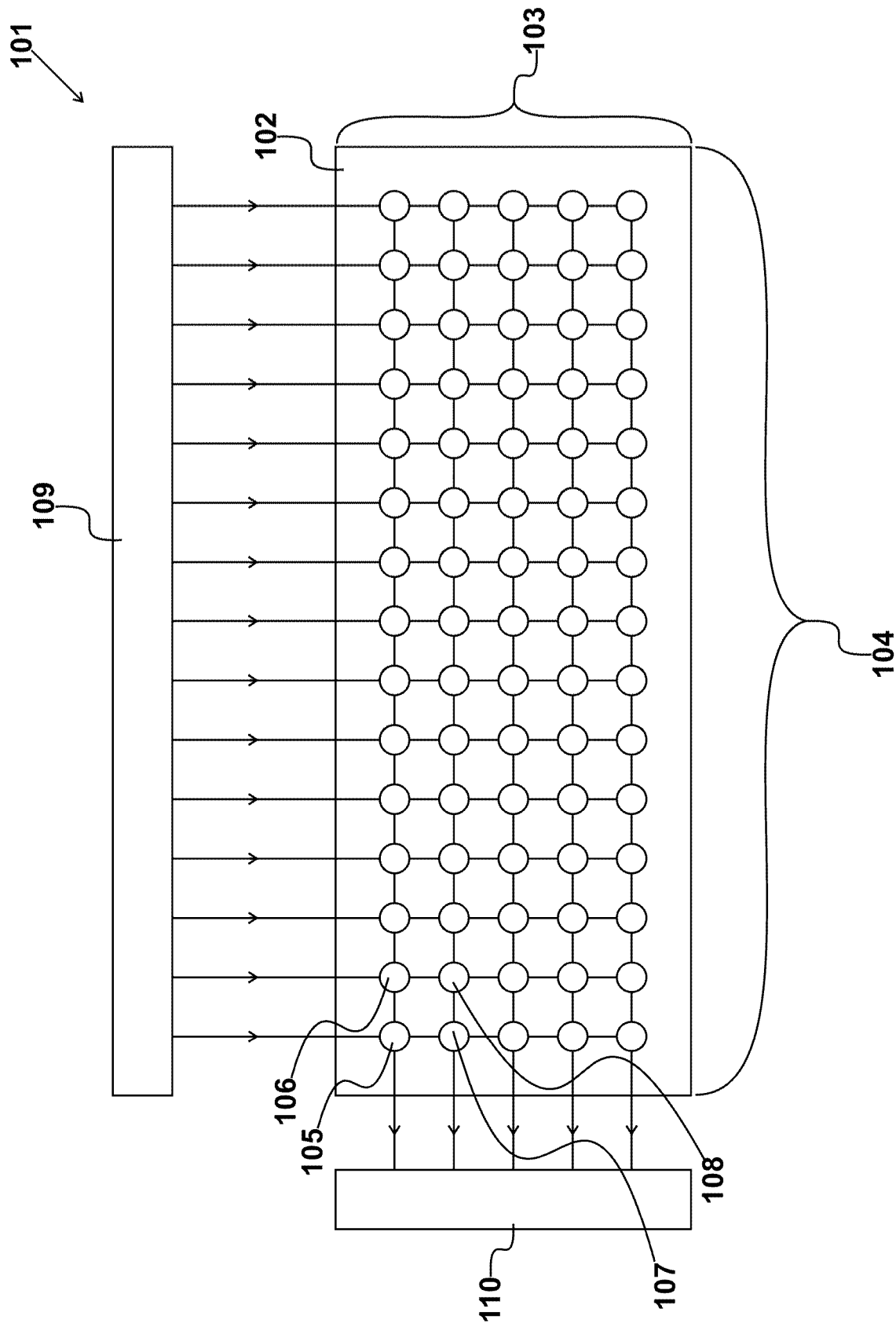


Fig. 1

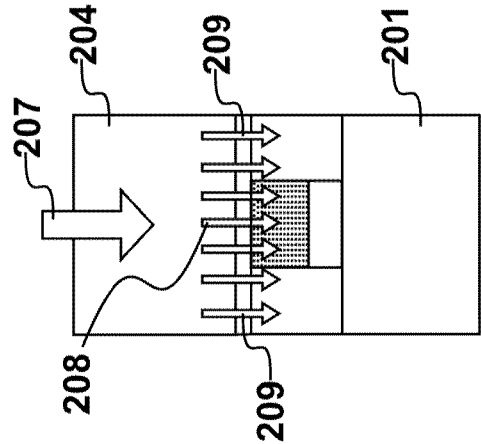


Fig. 2B

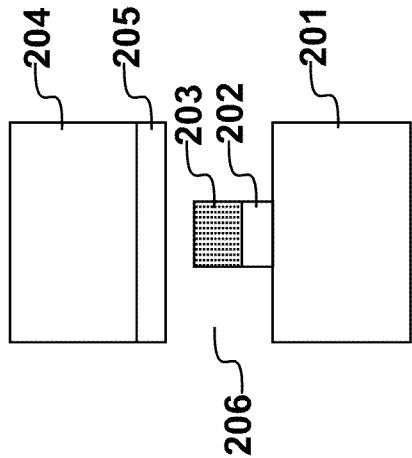


Fig. 2A

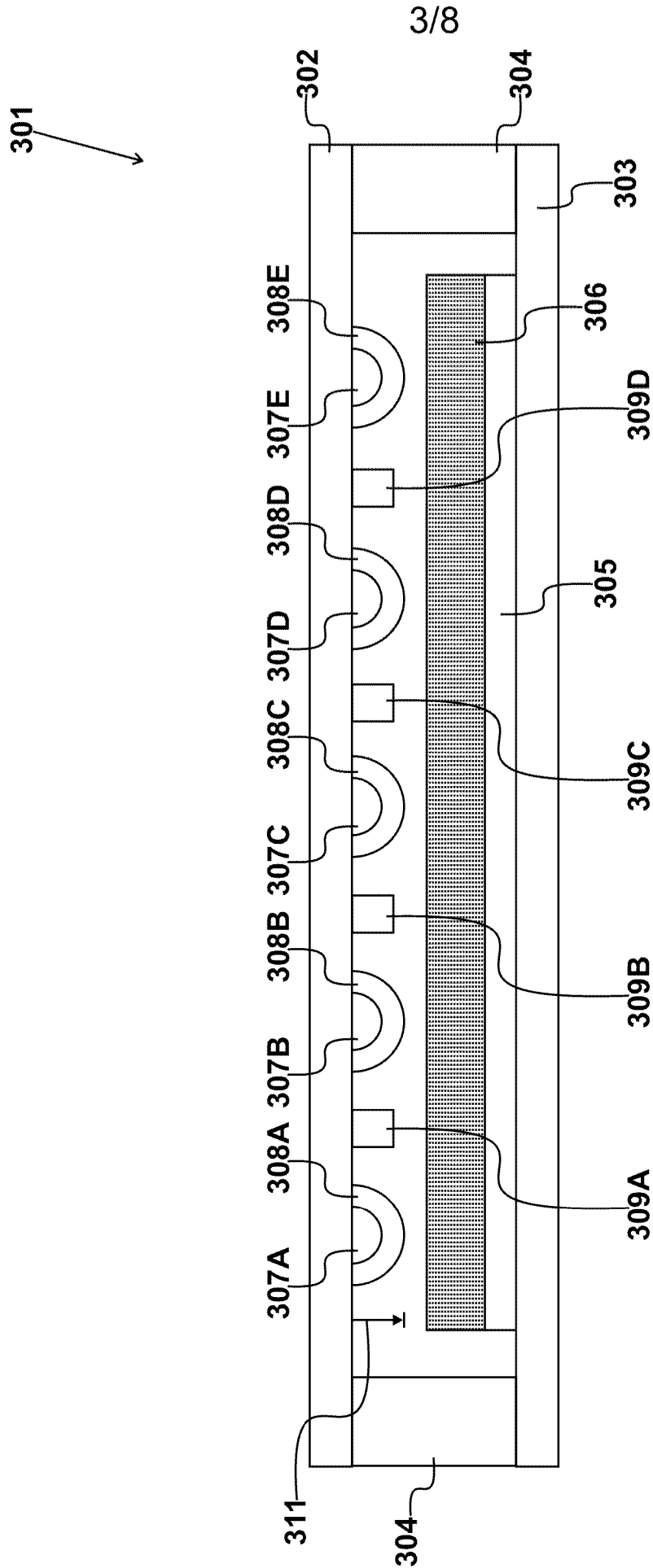


Fig. 3

4/8

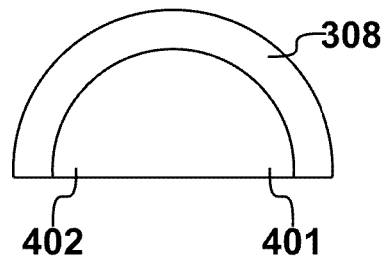


Fig. 4A

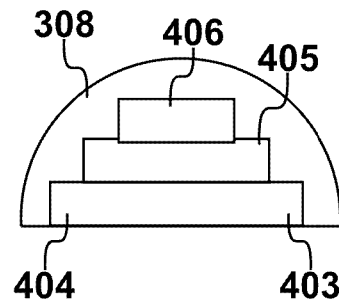


Fig. 4B

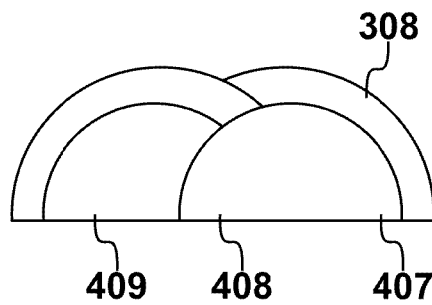


Fig. 4C

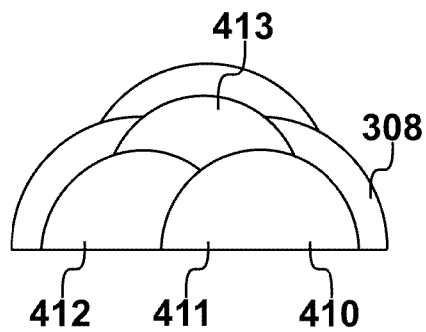
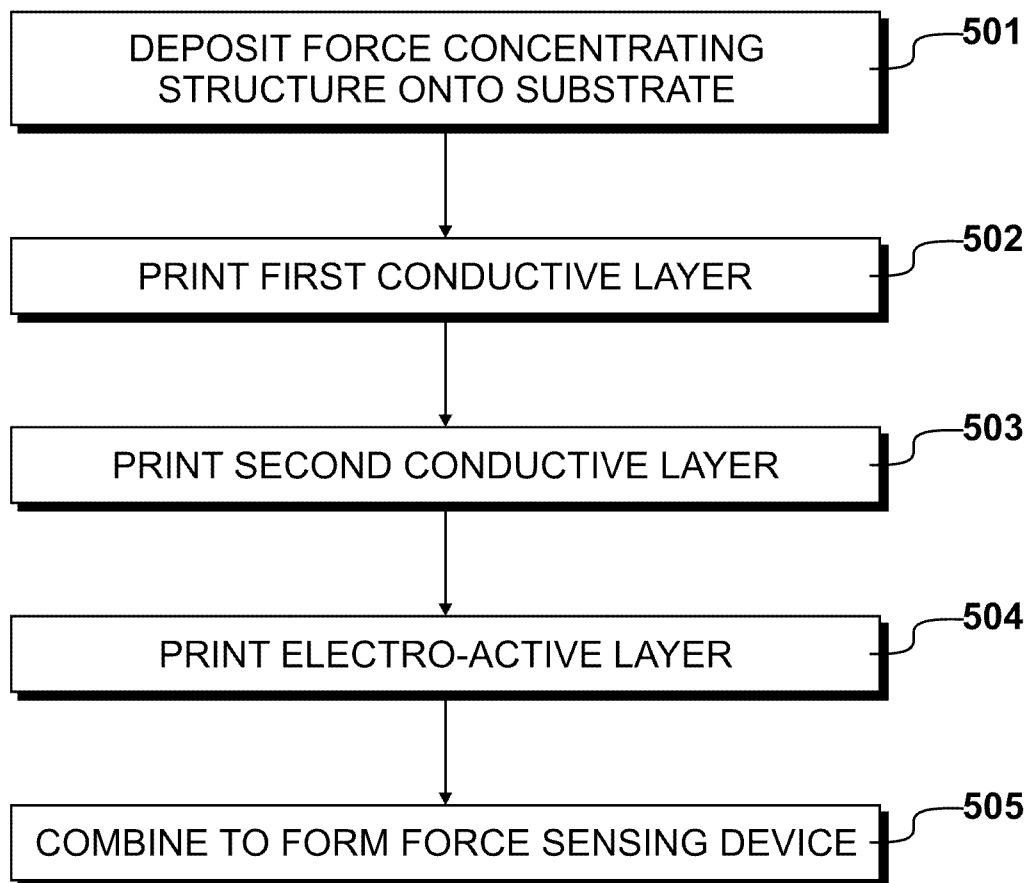
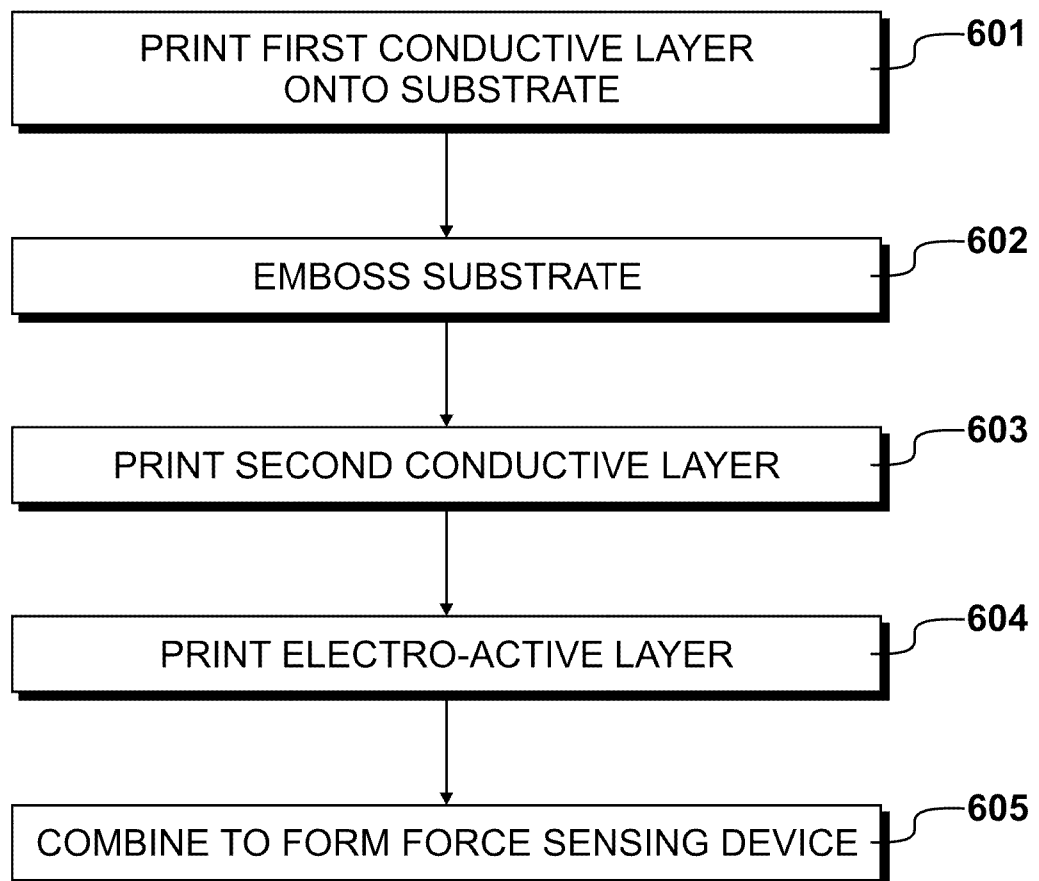


Fig. 4D

5/8

*Fig. 5*

6/8

*Fig. 6*

7/8

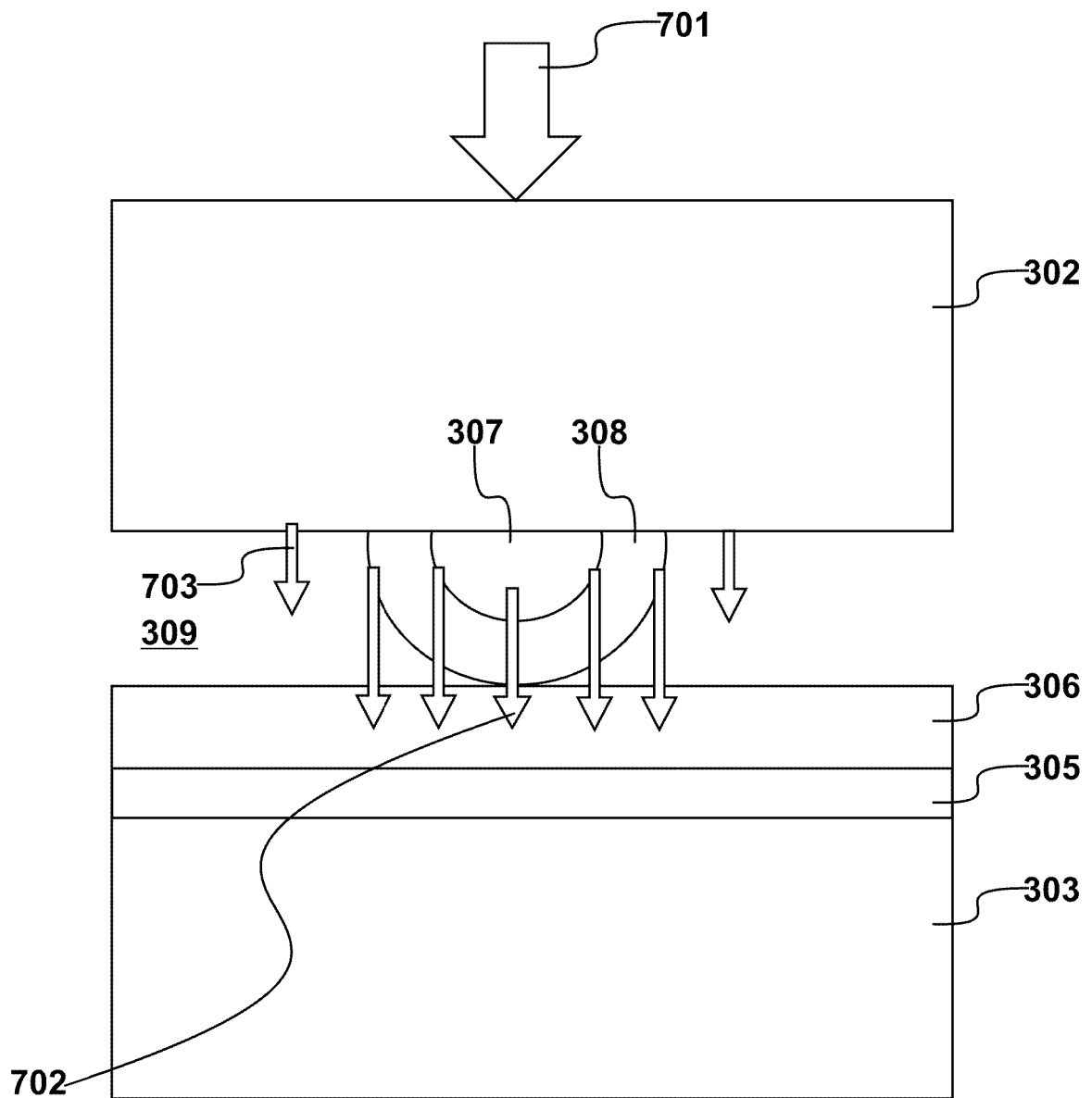


Fig. 7

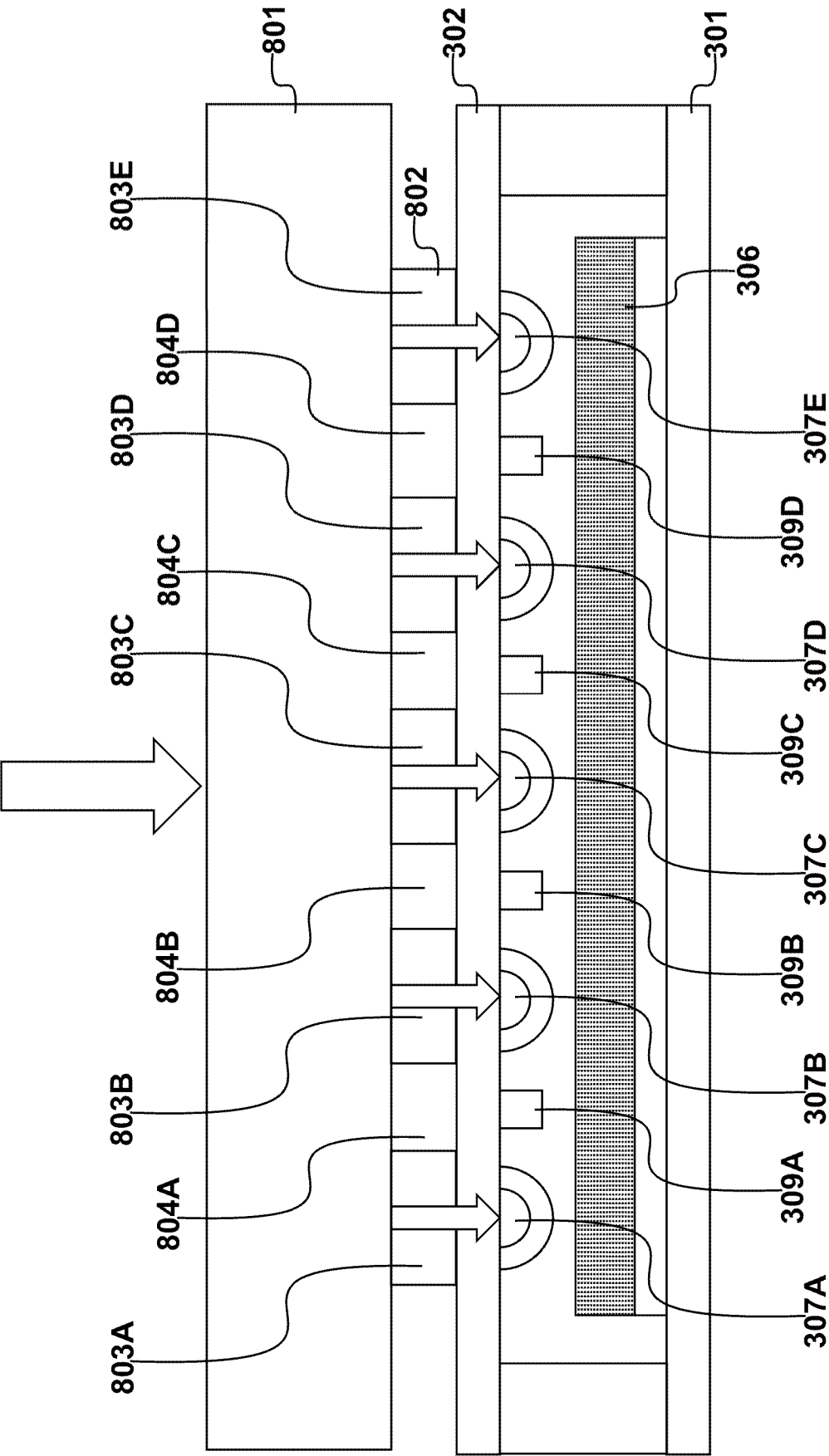


Fig. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2021/000088

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01L1/18 G01L1/20
ADD.

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)
G01L

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/275057 A1 (PERLIN KENNETH [US] ET AL) 17 October 2013 (2013-10-17) abstract paragraphs [0244], [0257] figures 1, 4, 13 -----	1-20
A	US 2019/305052 A1 (WANG YANG [CN]) 3 October 2019 (2019-10-03) paragraph [0076] figure 2 -----	3,4,11, 16-19
A	US 2020/133418 A1 (GOSPEL MATTHEW [GB]) 30 April 2020 (2020-04-30) paragraph [0040] -----	6
A	US 2014/107532 A1 (ANDERSON MARK [TW]) 17 April 2014 (2014-04-17) figure 8 -----	10



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"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

"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

"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

"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

"&" document member of the same patent family

Date of the actual completion of the international search

9 November 2021

Date of mailing of the international search report

17/11/2021

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Grewe, Clemens F.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2021/000088

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013275057 A1	17-10-2013	US 2013275057 A1	17-10-2013
		US 2017131821 A1	11-05-2017
		US 2021173511 A1	10-06-2021
US 2019305052 A1	03-10-2019	CN 108509081 A	07-09-2018
		US 2019305052 A1	03-10-2019
US 2020133418 A1	30-04-2020	CN 109844705 A	04-06-2019
		EP 3519929 A2	07-08-2019
		GB 2557894 A	04-07-2018
		JP 2019533243 A	14-11-2019
		KR 20190059915 A	31-05-2019
		US 2020133418 A1	30-04-2020
		WO 2018060667 A2	05-04-2018
US 2014107532 A1	17-04-2014	CN 103728056 A	16-04-2014
		TW 201415340 A	16-04-2014
		US 2014107532 A1	17-04-2014