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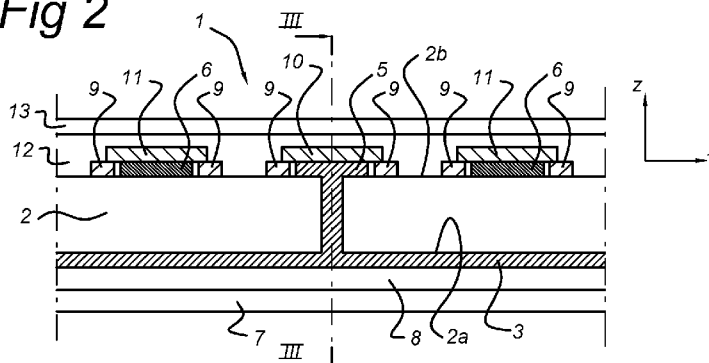
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(54) Title: SOLAR PANEL MODULE AND METHOD FOR MANUFACTURING SUCH A SOLAR PANEL MODULE

Fig 2



(57) Abstract: A solar panel module includes a plurality of solar cells (1) that have a light receiving front surface (2a) and a rear surface (2b) with contacts (5) of first polarity and counter contacts (6) of a second opposite polarity arranged on the rear surface. The contacts include a first metal as conductor, the counter contacts include a second metal as conductor. The solar cells are arranged in an array adjacent to each other on a transparent superstrate (7). In each solar cell the contacts and counter contacts are connected to first (10) and second (11) metallic contacting tabs respectively. The first and second contacting tabs are arranged in an electrical output network. A connection between the contact and the first contacting tab or the counter contact and the second contacting tab is embodied as a weld (8) where the metal of the contact or counter contact has a metallic interface with the metal of the respective contacting tab.

Solar panel module and method for manufacturing such a solar panel module

Field

The present invention relates to a solar panel module. Additionally, the present
5 invention relates to a method for manufacturing such a solar panel module.

Background

A solar panel module comprises a plurality of solar cells, arranged adjacent to
each other in an array. The solar cell module comprises a carrying frame for the array
10 of solar cells. Within the frame the solar cells are sandwiched between a front side
carrier and a rear side carrier. The front side carrier is arranged as light receiving
surface and is therefore made of a transparent material. The rear side carrier is typically
arranged as a carrier with a contacting foil comprising a conductive network pattern
that connects to contacts of the solar cells for transmitting electric energy from the solar
15 cells to a junction box. The junction box can be connected through a regulation unit to
an external energy carrier, e.g. an electric grid.

From the prior art, solar cells are known which have both negative and positive
contacts located at a rear surface in order to reduce the area of the metal pattern on the
front surface of the solar cell by arranging the contact(s) area to the rear surface so as to
20 reduce shadow loss and improve efficiency of the solar cell. Such solar cell types
comprise so-called metal-wrap-through (MWT), emitter-wrap-through (EWT) solar
cells and interdigitated back-contact solar cells in which a conductive path is arranged
from the light receiving surface of the solar cell to a contact on the rear surface. The
conductive path may comprise a metallic connection (MWT) or an extended emitter
25 region (EWT) through the substrate to the contact region(s) of a first polarity (e.g.,
negative polarity). In addition to these contacts of first polarity, contact regions of a
second opposite polarity (e.g., positive) are arranged on the rear surface. The contact
regions of the first and second polarity are connected to the conductive network layer
on the rear side carrier. A well known type of a rear side carrier is a polymer plate on
30 which a metallic patterned layer is applied as conductive network layer, e.g. a Tedlar
panel with a copper patterned layer. The pattern of the metallic layer is arranged to
match the positions of the contact regions on each of the solar cells arranged in the
solar panel module. In prior art solar panel modules, electric contact between the solar

cell's contact regions and the conductive network on the rear side carrier is obtained by soldering or glueing using a solder or a conductive glue, respectively.

The manufacturing of such a solar panel module has some drawbacks: The main driver to look for alternatives are the expensive copper material and the expensive
5 production of the copper foil with all recesses to produce a connectivity network. Furthermore for soldering contacts a relatively high temperature is needed to have a reflow of the solder between the contact region and a conductive surface portion of the conductive network layer. As result thermal stresses may built up in/between
10 aforementioned components of the solar panel module. Moreover, heating the solar panel module may contribute to the thermal budget of components and change mechanical or electrical properties of these components. Also, solder paste is often based on either lead which is environmentally unfriendly or on silver which is a precious metal with relatively high price.

Using conductive glues also involves additional thermal treatment for curing the
15 glued connections. Additionally, conductive glues contain substantial amounts of metal particles such as silver, with a relative high price.

Summary

It is an object of the present invention to remove one or more of the
20 disadvantages from the prior art.

The object is achieved by a solar panel module comprising a plurality of solar cells; the solar cells being of a type having a light receiving front surface and a rear surface with contacts of first polarity and counter contacts of a second opposite polarity arranged on the rear surface; the contacts comprising a first metal as conductor; the
25 counter contacts comprising a second metal as conductor; the plurality of solar cells being arranged in array adjacent to each other on a transparent superstrate, with the front surfaces of the solar cells facing towards the transparent superstrate; in each solar cell the contacts and counter contacts being connected to a first and second metallic contacting tab respectively, wherein the first and second contacting tabs are arranged in
30 a layout of a conductive network for electrical output, wherein a connection between either the contact and the first contacting tab or the counter contact and the second contacting tab is embodied as a weld in which the metal of the contact or counter contact has a metallic interface with the metal of the respective contacting tab with a

direct contact between the metals of either the contact or the counter contact and the contact tab.

Advantageously, the present invention provides that a direct mechanical and stable contact is obtained with the contact region on the rear surface of the solar cell.

- 5 No additional contacting materials such as a solder or conductive glue are needed in the solar panel module. In comparison to the prior art the thermal budget during manufacturing is reduced since a heat treatment step to reflow the solder or cure the conductive glue can be omitted.

According to an aspect of the invention there is provided a solar panel module as
10 described above, wherein the weld is a true metallurgical weld created by either ultrasonic welding or spot welding.

According to an aspect of the invention there is provided a solar panel module as described above, wherein the weld is a true metallurgical weld created by either ultrasonic welding or spot welding.

- 15 According to an aspect of the invention there is provided a solar panel module as described above, wherein the solar cells are of the back contact type, wherein the contacts on the rear surface of the solar cell are connected through a conductive path through the substrate with a metallic line pattern on the front surface of the solar cell

According to an aspect of the invention there is provided a solar panel module as
20 described above, wherein the solar cells are of the metal wrap through (MWT) type, wherein the contacts on the rear surface of the solar cell are connected through vias with a metallic line pattern on the front surface of the solar cell

According to an aspect of the invention there is provided a solar panel module as described above, wherein the first and second contacting tabs comprise a strip shaped
25 metallic foil.

According to an aspect of the invention there is provided a solar panel module as described above, wherein the strip shaped metallic foil comprises aluminum or an aluminum alloy.

- According to an aspect of the invention there is provided a solar panel module as
30 described above, wherein at least one of the first metal of the contact and the second metal of the counter contact comprises at least one selected from aluminum, aluminum alloy and silver.

According to an aspect of the invention there is provided a solar panel module as described above, wherein the contacting tab comprises, at location for connecting the contacting tab to either the contact or the counter contact on the solar cell, a tab lip .

According to an aspect of the invention there is provided a solar panel module as
5 described above, wherein further the tab lip has a free standing cutout contour with a free end.

According to an aspect of the invention there is provided a solar panel module as described above, wherein the free end of the tab lip is oriented along either a longitudinal or a transverse direction of the contacting tab.

10 According to an aspect of the invention there is provided a solar panel module as described above, wherein each tab lip on the contacting tab is oriented in the same direction.

According to an aspect of the invention there is provided a solar panel module as described above, wherein on the solar cell, on the contacting tab that connects contacts
15 of one polarity, tab lips are oriented along the longitudinal or transverse direction of the contacting tab and on the contacting tab that connects counter contacts of the opposite polarity, the tab lips are oriented in the opposite direction.

According to an aspect of the invention there is provided a solar panel module as described above, wherein on a contacting tab that runs as external connection from one
20 solar cell to the next solar cell in the solar panel module, tab lips on the one solar cell are oriented along the longitudinal or transverse direction of the contacting tab and the tab lips on the next solar cell are oriented in the opposite direction.

According to an aspect of the invention there is provided a solar panel module as described above, wherein an electrically insulating layer is arranged between the
25 contacts and the counter contacts and the respective contacting tab, the insulating layer having apertures corresponding to locations where the contacts/countercontacts and the contacting tab are connected by the respective weld.

According to an aspect of the invention there is provided a solar panel module as described above, wherein the insulating layer is a varnish layer or a resist layer.

30 According to an aspect of the invention there is provided a solar panel module as described above, wherein the insulating layer is insulating foil.

According to an aspect of the invention there is provided a solar panel module as described above, wherein the insulating layer is strip shaped, or an isolation sheet is substantially covering an area of one solar cell.

According to an aspect of the invention there is provided a solar panel module as described above, wherein the insulating layer is a double sided adhesive layer.

According to an aspect of the invention there is provided a solar panel module as described above, wherein contacting tabs on one solar cell and contacting tabs on the solar cell adjacent to the one solar cell are arranged in a contacting tab assembly for electrically interconnecting the one solar panel and the adjacent solar panel.

According to an aspect of the invention there is provided a solar panel module as described above, wherein the contacting tab assembly comprises at least a first plurality of contacting tabs for contacting the contacts of the one polarity on the one solar cell and a second plurality of contacting tabs for contacting the contacts of the opposite polarity on the adjacent solar cell.

According to an aspect of the invention there is provided a solar panel module as described above, the contacting tab assembly further comprising a connecting bus for connecting the first plurality and the second plurality of contacting tabs.

According to an aspect of the invention there is provided a solar panel module as described above, wherein the contacting tab assembly has a double forked shape in which the first plurality of contacting tabs are arranged in parallel and are interconnected on an outer end by the connecting bus that runs substantially perpendicular to the longitudinal direction of the contacting tabs, and the second plurality of contacting tabs are arranged in parallel and are interconnected on an outer end by the connecting bus, wherein the connecting bus is arranged in between the first and the second pluralities of contacting tabs.

According to an aspect of the invention there is provided a solar panel module as described above, further comprising a first encapsulation layer, a second encapsulation layer and a back sheet foil, wherein the first encapsulation layer is transparent and is arranged between the transparent superstrate and the array of the plurality of solar cells, the second encapsulation layer is arranged between at one side surfaces of the contacting tabs and the solar cell that face away from the superstrate, and at the other side the back sheet foil that is arranged on the surface of the second encapsulating layer facing away from the superstrate.

According to an aspect of the invention there is provided a solar panel module as described above, wherein the solar panel module comprises at least a portion of a peripheral edge free standing ends of the contacting tabs that are arranged to extend, perpendicular to the edge, beyond the solar panel area; the free standing ends being
5 connected to a dedicated bussing bar; the dedicated bussing bar being arranged to extend substantially parallel to the peripheral edge, the free standing ends being foldable allowing the dedicated bussing bar to be foldable back over the solar cells at the peripheral edge of the solar panel module.

According to an aspect of the invention there is provided a solar panel module as
10 described above, wherein the dedicated bussing bar comprises on a free distal end a junction box bussing tab which is arranged for connection to a first junction box terminal, wherein the junction box bussing tab extends transverse to the longitudinal direction of the dedicated bussing bar.

According to an aspect of the invention there is provided a solar panel module as
15 described above, further comprising an electrically insulating strip which is arranged between the dedicated bussing bar in the folded back position and contacting tabs that are covered by the folded back dedicated bussing bar.

According to an aspect of the invention there is provided a solar panel module as described above, further comprising a second connecting tab arranged for connecting to
20 a second junction box terminal, provided at a position on the solar panel module substantially adjacent to the position of the junction box bussing bar on the solar panel module in the folded back position of the dedicated bussing bar.

According to an aspect of the invention there is provided a solar panel module as described above, wherein the junction box bussing tab and are provided with a copper
25 surface for connecting to the first junction box terminal and/or the second connecting bar is provided with a copper surface for connecting to the second junction box terminal.

Moreover, the present invention relates to a method for manufacturing a solar panel module comprising a plurality of solar cells; the solar cells being of a type having
30 a light receiving front surface and a rear surface with contacts of first polarity and counter contacts of a second opposite polarity arranged on the rear surface; the contacts comprising a first metal as conductor; the counter contacts comprising a second metal as conductor; the method comprising:

providing a transparent superstrate; arranging the plurality of solar cells in an array adjacent to each other on the transparent superstrate, with the front surfaces of the solar cells facing towards the transparent superstrate; connecting in each solar cell the contacts and counter contacts to a first and second metallic contacting tab respectively, wherein the first and second contacting tabs are arranged in a layout of a conductive network for electrical output, wherein the connection between the contact and the first contacting tab or the counter contact and the second contacting tab comprises a weld, in which the metal of the contact or counter contact has a metallic interface with the metal of the respective contacting tab with a direct contact between the metals of either the contact or the counter contact and the contacting tab.

Advantageous embodiments are further defined by the dependent claims.

Brief description of the drawings

The invention will be explained in more detail below with reference to drawings in which illustrative embodiments of the invention are shown. The drawings are intended for illustration purposes only without limitation of the scope of protection which is defined by the subject matter of the appended claims.

In the following figures, the same reference numerals refer to similar or identical features in each of the figures.

Figure 1 shows a cross-section of a metal-wrap-through back-contacted solar cell;

Figure 2 shows a cross-section of a solar panel module according to an embodiment of the present invention along a first direction;

Figure 3 shows a further cross-section of a solar panel module according to an embodiment of the present invention;

Figure 4 shows a detail of the contacting tab according to an embodiment of the invention;

Figures 5a, 5b, 5c show a layout of the rear surface of an array of solar cells arranged in the solar panel module on the level of the rear surface of the solar cell, the level of the isolation, a contacting tab assembly and the level of the conductive network layer, respectively;

figure 5d shows a contacting tab assembly;

figure 5e shows a layout of the rear surface of an array of solar cells arranged in the solar panel module on the level of the conductive network layer;

figures 6 and 7 show a planar view of a dedicated bussing tab for connecting to a junction box.

Detailed description

5 The present invention relates to solar panel modules that comprise back-contacted solar cells with both negative and positive contacts located at the rear surface (facing away from the light receiving surface of the solar panel module). The substrate of such back contacted solar cells may have either p-type or n-type conductivity. Further, such back contacted solar cells are designed so as to reduce the metal pattern area on the
10 front surface of the solar cell by arranging the metal contacts on the rear surface, that thus leads to a reduction of shadow losses and to an improved efficiency of the solar cell. Such solar cell types comprise so-called metal-wrap-through (MWT) solar cells in which a conductive path is arranged from the front side metal pattern on the light receiving surface of the solar cell to the metal contact on the rear surface. The
15 conductive path comprises a metallic connection (MWT) through the substrate to the rear surface contact region(s) of a first polarity (e.g., negative polarity). In addition to these contacts of first polarity, counter contact regions of a second opposite polarity (e.g., positive) are arranged at the rear surface. In EWT solar cells the conductive path comprises a doped conductive area from the front side emitter layer through the
20 substrate to the rear surface contact region(s) of the first polarity.

Below the invention will be explained and illustrated by an example of MWT solar cells. It will be appreciated by the skilled in the art, that the invention is not limited to MWT solar cell applications, but also can be put into practice in other known types of back-contacted solar cells.

25 Figure 1 shows a cross-section of a MWT back-contacted solar cell.

The solar cell 1 comprises a semiconductor substrate 2, e.g. a silicon substrate. On a light receiving surface 2a of the substrate 2 a metal pattern 3 is arranged for collecting charge carriers generated by radiation interacting with the semiconductor material. The substrate 2 comprises one or more via holes 4 that extend from the front
30 light receiving surface 2a to the rear surface 2b of the substrate.

The metal pattern 3 is connected through a (metallic) conductor in the via hole 4 to a via contact 5 below the via on the rear surface 2b. On the rear surface 2b also one

or more counter contacts 6 (with opposite polarity in comparison to the via contact polarity) are arranged, isolated from the via contact(s) 5.

Figure 2 shows a cross-section of a solar panel module 100 according to an embodiment of the present invention along a first direction.

5 The solar panel module 100 comprises a plurality of solar cells 1 as described above, a superstrate 7, a first encapsulation layer 8, a second encapsulation layer 12, insulating layers 9, a first tab 10, a second tab 11 and a back sheet 13.

In figure 2 the light receiving surface of the solar panel module is oriented downwards.

10 On the superstrate 7 which is a transparent plate, for example a glass plate, the plurality of solar cells 1 are arranged with the first encapsulation layer 8 as intermediate embedding layer. The first encapsulation layer 8 may comprise ethyl-vinyl-acetate as a constituent material. The light receiving surface 2a of the solar cells 1 is directed towards the superstrate 7.

15 On the solar cells 1 isolation layers 9, 9a and contacting tabs 10, 11 are arranged. In the present invention the via contact 5 of the solar cell 1 is contacted directly by the contacting tab 10. The direct contact is embodied as a true metallurgical weld, in which the metal of the via contact 5 interfaces with the metal of the contacting tab 10 and forms a direct contact between the metals.

20 In the present invention, the true metallurgical weld may be created by a spot welding technique, but is preferably created by an ultrasonic welding technique.

25 The ultrasonic welding technique uses a ultrasonic probe that, while exerting some external pressure, inputs vibrational energy into the contacting tab /via contact metal arrangement so as to create a true metallurgical weld that joins the via contact metal and contacting tab material. Typically, the interface between the via contact metal and the contacting tab metal strongly resembles a friction weld interface in which the transition between the metals is substantially abrupt. Virtually no mixing zone in-between the via metal and the contacting tab metal may be observed, since the input of heat during this type of welding is typically low.

30 Advantageously, this welding technique simplifies the production of the solar panel in comparison to the prior art, since the application of either solder joints or adhesive glue bonds are no longer necessary. This saves on the consumption of relatively costly materials.

In an embodiment, the via contact metal comprises silver and the contacting tab 10 consists of an aluminum- or aluminum alloy-based foil strip.

In a similar manner, the counter contact 6 of the solar cell which consists of a metalized contact is connected to a second contacting tab 11 by ultrasonic welding. The
5 second contacting tab 11 consists of an aluminum- or aluminum alloy-based foil strip.

In the longitudinal direction of the contacting tab strips (which extends perpendicular to the plane of the drawing), the contacting tabs 10, 11 and the solar cells are isolated from each other outside of the welding areas by an insulating layer 9 as will be explained in detail with reference to figure 3.

10 At figure 2, in the transverse direction, indicated by arrow X, the contacting tabs are separated by a second encapsulation layer 12, which covers the free upper surfaces of the contacting tabs 10, 11 and the solar cell 1.

The second encapsulation layer 12 may comprise ethyl-vinyl-acetate as a constituent material.

15 Finally, on the free upper surface of the second encapsulation layer 12 a capping sheet 13 is arranged. The capping sheet 13 may comprise one or more layers comprising a polyvinyl fluoride layer and a polyethylene terephthalate (PET) layer, or a stack of a polyvinyl fluoride layer, a polyethylene terephthalate layer and a second polyvinyl fluoride layer, also known as a TPT layer (T: Tedlar ®, P: PET)

20 A cross-section of the solar panel module over the via contact along line III-III is shown in Figure 3.

Figure 3 shows a cross-section of a solar panel module 100 according to an embodiment of the present invention along a second direction, perpendicular to direction X.

25 In the second direction the contacting tab 10 is shown along its longitudinal direction. In the longitudinal direction of the contacting tab strips, the contacting tab 10 and the rear surface 2b of the solar cell 1 are isolated from each other outside of the welding areas by an insulating layer 9. In an embodiment, the insulating layer 9 is an isolation tape in which an aperture is made at the location where the true metallurgical
30 weld between the contacting tab 10 and the via contact 5 (or the true metallurgical weld between the second contacting tab 11 and the counter contact 6) is arranged.

In a further embodiment, the insulating layer 9 is a double-sided self adhesive tape. Due to the double sided adhesive areas the manufacturing process is simplified.

The insulating layer can be attached easily to the rear surface of the solar cell 1 and the contacting tab can be attached easily to the insulating layer.

In an alternative embodiment, the insulating layer comprises a varnish layer or resist layer that has been applied on the rear surface. The varnish layer or resist layer is
5 patterned with apertures at the locations where a connection between a contact or counter contact on the rear surface and a contacting tab is planned.

A method for manufacturing the solar panel module of the present invention thus comprises the following steps: first a superstrate plate 7 is provided. Next, on the superstrate plate a first encapsulation layer 8 is arranged. On the first encapsulation
10 layer 8, a plurality of solar cells 1 is arranged, with the front surfaces, i.e. light receiving surfaces, of the solar cells facing towards the superstrate 7. Then, on the rear surfaces of the solar cells insulating layer(s) 9 are arranged. The insulating layers may be strip-shaped and they comprise apertures at the locations where contacting tabs are to be in contact with either a via contact or a counter contact of the solar cell.

15 Alternatively, the insulating layer may have substantially similar areal size and dimensions as the solar cell substrate so as to cover the rear surface of the solar cell to a large or even a substantially full extent. The insulating layer comprises apertures at locations where a connection between a contact or counter contact on the rear surface and a contacting tab is foreseen.

20 In a further step, strip-shaped contacting tabs are arranged on the insulating layer(s) according to a contact network scheme that corresponds with the arrangement of the solar cells 1.

Then, the contacting tabs are connected to the via contacts and/or counter contacts of the solar cells corresponding to the contact network scheme. The
25 connections are made by using a suitable welding technique such as ultrasonic welding technique for creating a true metallurgical weld at each respective contact between the contacting tab and the via contact through the aperture(s) in the insulating layer (or between the second contacting tab and the counter contact through a corresponding aperture in the insulating layer).

30 After (ultrasonic) welding, on the contacting tabs and any still exposed portion of the rear surface of the solar cell (not covered by the contacting tabs), the second encapsulating layer is arranged.

The second encapsulating layer is covered by a capping sheet.

Finally, the solar panel module is now cured at a suitable temperature and a suitable external pressure to have a reflow of the first and second encapsulating layer material and bind all components in the solar panel module.

In an exemplary embodiment of the solar panel module, the superstrate 7 has a thickness of in the range of 2 – 6 mm, the first encapsulating layer 8 has a thickness in the range of 0.1 – 0.4 mm, the solar cell 1 has a thickness of about 0.25 mm. The insulating tape 9 has a thickness of about 0.05 mm. The contacting tabs 10, 11 have a thickness of about 0.1 mm. The second encapsulating layer 12 has a thickness of about 0.3 – 0.5 mm. The capping sheet 13 may have a thickness of about 0.35 mm.

Figure 4 shows a plane view of a portion of the contacting tab 10, 11 according to an embodiment of the invention.

The contacting tabs are shaped as strips of foil that are arranged on the insulating tape 9 in order to connect to contacts on the solar cell(s) underneath the insulating tape 9 layer.

In an embodiment, at the location of the connection of the tab to the contact on the solar cell, the contacting tab comprises a tab lip 21 created by a cutout 20.

The tab lip 21 may be U-shaped or more generally shaped such that the tab lip is free standing but still attached to the foil at a connecting portion. In this manner the tab lip becomes bendable relative to the body of the contacting tab strip.

In an embodiment, the tab lip 21 extends in the longitudinal direction of the contacting tab. Alternatively, the tab lip 21 may extend in the transverse direction of the contacting tab.

The provision of tab lips enhances the ultrasonic welding process since the tab lip is substantially free standing and bending of the tab lip towards the solar cell contact is made easier with relatively less deformation of the body of the contacting tab strip. Also alignment of the contacting tab and the contacts on the solar cell is better facilitated.

The cutouts 20 on the contacting tabs may be created by one of various techniques such as punching and laser cutting.

Below, an exemplary layout of the rear surface of the solar panel module according to the invention is described in more detail.

Figures 5a, 5b, 5c show a layout of the rear surface of an array of solar cells arranged in the solar panel module on the level of the rear surface of the solar cell, the level of the isolation, and the level of the conductive network layer, respectively.

In figure 5a, a part of the arrangement of solar cells 1 in the solar panel module 100 is shown.

The solar cells 1 are arranged in a substantially planar array, with the solar cells adjacent to each other. In figure 5a the solar cells are shown on the rear surface. On each solar cell a number of terminals or contacts 5, 6 are shown. The via contacts 5, schematically indicated as square symbols, are distributed over the rear surface in an ordered array, for example in a 4 by 4 array. The counter contacts 6, schematically indicated as circle symbols, are also distributed over the rear surface in an ordered fashion, for example in a 5 by 3 array, wherein the counter contacts are positioned in between the via contacts. The skilled in the art will appreciate that other arrangements of contacts and counter contacts are possible.

In figure 5b, the arrangement of solar cells in the solar panel module are shown after application of the insulating layer 9. In the embodiment of figure 5b, the insulating layer 9 comprises a plurality of insulating strips that are positioned above the via contacts 5 and the counter contacts 6. In the example shown in figure 5b, the insulating strips 9 are arranged along lines on which contacts of the same polarity are arranged. The skilled in the art will appreciate that different arrangements and shapes of the insulating strips or isolation layers are possible.

In the insulating strips 9, openings are provided that corresponds with the position of the via and counter contacts 5, 6 on the rear surface of the solar cell(s) in the present embodiment. In case no isolation layer with opening for the via contacts 5 and counter contact 6 has been used covering the whole solar cell, additional blank insulating strips 9a (i.e., insulating strip without openings for contacts) are arranged on the solar cells as insulated area below a connecting bus strip 23 between contacting tabs 10, 11. Below the arrangement and interconnection of contacting tabs on adjacent solar cells is explained in more detail with reference to a contacting tab assembly as shown in figure 5c.

In figure 5c, the layout of the solar panel module is schematically shown at the level of the contacting tab assembly.

On adjacent solar cells that are to be interconnected, a contacting tab assembly 22 is arranged in such a way that via contacts 5 (contacts of one polarity) on one solar cell connect to a corresponding tab lip 21 in the contacting tab 10, counter contacts 6 (of the opposite polarity) on an adjacent solar cell connect to a corresponding tab lip 21 in the contacting tab 11. An exemplary contacting tab assembly 22 is illustrated with reference to figure 5d.

At a lower end portion of the solar cell array a bussing 24 is arranged to connect one solar cell in one column of the array to a further solar cell in a neighboring column of the array. Contacts of one polarity type of the one solar cell are contacted by contacting tabs 10; 11 which are connected through a bussing to contacting tabs 11; 10 of the further solar cell in the neighboring column of the array.

The connection between each tab lip and its corresponding solar cell contact is created by ultrasonic welding. For this reason, between the step of arranging the insulation strips 9 and the step of arranging the contacting tab assembly thereon, no intermediate solder or contacting paste is required on the solar cell contacts. In an embodiment of the invention, the contacting tabs are connected to the bussing 24 by welding preferably ultrasonic welding, since ultrasonic welding is also used for connecting the tab lips 21 to the via contacts or counter contacts.

In an embodiment, the tab lips 21 on contacting tabs that connect to the via contacts of one solar cell may be directed in one direction, while the tab lips on contacting tabs that connect to counter contacts of said one solar cell are directed in a different direction, preferably in a direction opposite to the one direction.

Such an arrangement may advantageously provide that in a solar panel module where contacting tabs provide connections between one solar cell and an adjacent solar cell, relative displacements of solar cells that may occur can be compensated by the relatively well deformable tab lips and reduce the risk of damage.

Additionally in an embodiment, on a contacting tab that runs as external connection from one solar cell to the next solar cell in a solar panel module, the present invention provides that the tab lips 21 on the one solar cell extend in one direction and the tab lips on the next solar cell extend in the opposite direction. This difference in orientation of the tab lips may improve (thermal) stress relief during thermal cycling of the solar panel module.

Figure 5d shows a layout of a contacting tab assembly 22. The contacting tab assembly 22 according to an embodiment of the invention is configured to provide contact between contacts of one polarity on one solar cell and contacts of opposite polarity on an adjacent solar cell.

5 The contacting tab assembly comprises a first plurality of contacting tabs 10 for contacting the contacts of the one polarity on the one solar cell, a second plurality of contacting tabs 11 for contacting the contacts of the opposite polarity on the adjacent solar cell and a connecting bus 23.

10 Depending on the arrangement of the via and counter contacts on the rear surface of the solar cells, the contacting tab assembly may have a double forked shape, in which the first plurality of contacting tabs 10 are arranged in parallel and are interconnected on an outer end by the connecting bus that runs substantially perpendicular to the longitudinal direction of the contacting tabs. Likewise, the second plurality of contacting tabs 11 are arranged in parallel and are interconnected on an
15 outer end by the connecting bus, wherein the connecting bus 23 is arranged in between the first and the second pluralities of contacting tabs 10, 11.

Each of the contacting tabs is provided with a number of tab lips 21 that corresponds to the number of contacts to be contacted with.

20 In an embodiment, the tab lips of the contacting tabs on contacts of a solar cell have a free end directed in one longitudinal direction, while the contacting tabs on counter contacts on the same solar cell comprise tab lips that have a free end directed in the opposite longitudinal direction.

25 In a further or alternative embodiment, the tab lips of the contacting tabs on one solar cell have a free end directed in one longitudinal direction, while the contacting tabs on the adjacent solar cell comprise tab lips that have a free end directed in the opposite longitudinal direction.

This mutually opposite orientation of the tab lips on different contacting tabs may improve the reduction of stresses in the contacting tabs after assembly of the solar panel module.

30 It is noted that the contacting tab assembly 22 may consist of a single shape punched or cut from a single continuous foil material. Alternatively, the contacting tab assembly 22 may be constructed from separate contacting tabs 10, 11 and connecting

bus 23 elements that are mutually connected by welding, for example ultrasonic welding or spot welding.

The skilled person will appreciate that the contacting tab assembly may have a different shape depending on the arrangement of contacts and counter contacts on the rear surface of the solar cells. Figure 5e shows an alternative layout of the rear surface of an array of solar cells at the level of the contacting tab assembly.

In this layout the solar panel module comprises a rectangular array of solar cells, arranged in rows and columns.

The solar cells are equipped with a plurality of contacts and counter contacts on the rear surface of the solar cell, grouped in pairs.

The contacts 5 and counter contacts 6 are grouped in pairs arranged adjacent to each other in a first direction X, while in a second direction Y perpendicular to first direction X, the contacts and counter contacts are arranged in adjacent columns.

The positions of contacts and counter contacts is such that by rotation over 180° around the normal on the surface, the position of counter contacts on the rotated solar cell coincide with the position of contacts of the solar cell in the original non-rotated position. The orientation of each solar cell is indicated by a reference symbol 30.

For example, each solar cell comprises three rows, with each row having five pairs of contacts and counter contacts.

The pattern of contacts and counter contacts is arranged in such a way that contacting tabs, extending in the second direction Y, provide a series connection between contacts in one column on one solar cell and counter contacts in the same column of an adjacent solar cell, relatively rotated over 180°. According to the present invention, the connection between the contacting tabs and the contacts/counter contacts is a true metallurgical weld of the contacting tab metal with the metal of the contact/counter contact. Additional this embodiment avoids using the additional blank isolation strip 9a.

Between the contacting tabs and the solar cells in the solar panel module, an insulating layer, such as an insulating tape or foil, or a varnish layer or resist layer is arranged in a similar manner as described above with reference to figures 5a – 5c. For reason of clarity, the insulating layer is not specifically shown in figure 5e.

Figure 6 shows a planar view of a dedicated bussing tab for connecting to a junction box.

Typically, a solar panel module is electrically connected to a junction box (not shown) to allow transport of solar cell generated power to the outside world. The junction box is arranged with terminals to connect at one end to the electrical network of the solar panel as embodied by the contacting tabs and contacting tab assemblies on the rear surface of the solar cells. At another end the junction is arranged with further terminals for connection to an external electric network.

In an embodiment of the invention, at an peripheral edge 100a of the solar panel module 1 free standing ends 25 of the contacting tabs 10 are arranged to extend beyond the solar panel area. The free standing ends 25 are connected to a dedicated bussing bar 26, made of one piece or assembled from parts for example by welding. The dedicated bussing bar 26 is arranged to extend substantially parallel to the edge of the peripheral portion 100a. The dedicated bussing bar 26 can be folded back at the free standing ends 25 over the solar cells of the peripheral portion.

On a free distal end 27 of the dedicated bussing bar 26, a junction box bussing tab 28 is arranged for connection to a terminal of the junction box of a first polarity (e.g. +). The junction box bussing tab 28, which is coupled to the free distal end, extends transverse to the longitudinal direction of the dedicated bussing bar 26. The junction box bussing tab 28 is made of one piece with the free end 27 or is connected to the free end 27 of the dedicated bussing bar 26, for example by spot or ultrasonic welding.

On the solar panel module a insulating strip 31 is arranged that extends parallel to the longitudinal direction of the dedicated bussing bar 26. The insulating layer 31 is arranged at a distance from the peripheral edge, wherein the distance corresponds with a position of the dedicated bussing bar in the folded position. In this manner, the dedicated bussing bar 26 in folded position is isolated from the contacting tabs and/or solar cells as covered by the dedicated bussing bar.

The connecting bus 23a at the edge of the peripheral portion 1a is arranged with a second connecting bar 29 for connection to a terminal of the junction box of a second opposite polarity (e.g. -).

In an embodiment, the second connecting bar 29 is provided at a position which is substantially adjacent to the position of the junction box bussing tab on the solar panel module in the folded back position of the dedicated bussing bar.

In an embodiment, the dedicated bussing bar 26 comprises a same material as the contacting tabs (or contacting tab assembly)

In an embodiment, the material of the contacting tab comprises aluminum or an aluminum alloy.

The junction box bussing tab 28 may comprise the same material as the dedicated bussing bar 26.

- 5 In an embodiment, the junction box bussing tab 28 comprises a surface layer of copper or a copper alloy on the aluminum based contacting tab. The copper based surface layer improves the connection of the junction box bussing tab to the corresponding terminals of the junction box by reduction of the contact resistance and by a reduction of corrosion of the contacting tab metal and/or metal of the junction box
- 10 terminals. In an embodiment, the copper surface layer is a copper clad layer.

Figure 7 shows a part of the solar panel module when the free ends 25 of the contacting tabs 10 are folded back over the peripheral portion of the solar cell array, with the insulating layer 31 being between the dedicated bussing bar and the contacting tab (assembly) connected to the solar cells in the solar panel module.

- 15 It should be noted that the above-described embodiments are intended to illustrate rather than to limit the invention, and that those skilled in the art will be able to design alternative embodiments without departing from the scope of the invention as defined by appended claims.

Claims

1. A solar panel module comprising a plurality of solar cells;
the solar cells being of a type having a light receiving front surface and a rear
5 surface with contacts of first polarity and counter contacts of a second opposite
polarity arranged on the rear surface;
the contacts comprising a first metal as conductor; the counter contacts
comprising a second metal as conductor;
the plurality of solar cells being arranged in array adjacent to each other on a
10 transparent superstrate, with the front surfaces of the solar cells facing towards
the transparent superstrate;
in each solar cell the contacts and counter contacts being connected to a first
and second metallic contacting tab respectively, wherein the first and second
contacting tabs are arranged in a layout of a conductive network for electrical
15 output,
wherein a connection between either the contact and the first contacting tab or
the counter contact and the second contacting tab is embodied as a weld in
which the metal of the contact or counter contact has a metallic interface with
the metal of the respective contacting tab with a direct contact between the
20 metals of either the contact or the counter contact and the contact tab.
2. Solar panel module according to claim 1, wherein the weld is a true
metallurgical weld created by either ultrasonic welding or spot welding.
- 25 3. Solar panel module according to claim 1 or 2, wherein the solar cells are of the
back contact type, wherein the contacts on the rear surface of the solar cell are
connected through a conductive path through the substrate with a metallic line
pattern on the front surface of the solar cell
- 30 4. Solar panel module according to any one of claims 1 – 3, wherein the solar cells
are of the metal wrap through (MWT) type, wherein the contacts on the rear
surface of the solar cell are connected through vias with a metallic line pattern
on the front surface of the solar cell

5. Solar panel module according to any one of the preceding claims, wherein the first and second contacting tabs comprise a strip shaped metallic foil.
- 5 6. Solar panel module according to claim 4, wherein the strip shaped metallic foil comprises aluminum or an aluminum alloy.
7. Solar panel module according to any one of the preceding claims wherein at least one of the first metal of the contact and the second metal of the counter
10 contact comprises at least one selected from aluminum, aluminum alloy and silver.
8. Solar panel module according to any one of the preceding claims, wherein the contacting tab comprises, at location for connecting the contacting tab to either
15 the contact or the counter contact on the solar cell, a tab lip .
9. Solar panel module according to claim 7, wherein the tab lip has a free standing cutout contour with a free end.
- 20 10. Solar panel module according to claim 8, wherein the free end of the tab lip is oriented along either a longitudinal or a transverse direction of the contacting tab.
11. Solar panel module according to claim 10, wherein each tab lip on the
25 contacting tab is oriented in the same direction.
12. Solar panel module according to claim 10 or 11, wherein on the solar cell, on the contacting tab that connects contacts of one polarity, tab lips are oriented along the longitudinal or transverse direction of the contacting tab and on the
30 contacting tab that connects counter contacts of the opposite polarity, the tab lips are oriented in the opposite direction.

13. Solar panel module according to claim 10 or 11, wherein on a contacting tab that runs as external connection from one solar cell to the next solar cell in the solar panel module, tab lips on the one solar cell are oriented along the longitudinal or transverse direction of the contacting tab and the tab lips on the next solar cell are oriented in the opposite direction.
14. Solar panel module according to any one of the preceding claims, wherein an electrically insulating layer is arranged between the contacts and the counter contacts and the respective contacting tab, the insulating layer having apertures corresponding to locations where the contacts/countercontacts and the contacting tab are connected by the respective weld.
15. Solar panel module according to claim 14, wherein the insulating layer is a varnish layer or a resist layer.
16. Solar panel module according to claim 14, wherein the insulating layer is insulating foil.
17. Solar panel module according to claim 16, wherein the insulating layer is strip shaped, or an isolation sheet is substantially covering an area of one solar cell.
18. Solar panel module according to claim 16 or 17, wherein the insulating layer is a double sided adhesive layer.
19. Solar panel module according to any one of the preceding claims, wherein contacting tabs on one solar cell and contacting tabs on the solar cell adjacent to the one solar cell are arranged in a contacting tab assembly for electrically interconnecting the one solar panel and the adjacent solar panel.
20. Solar panel module according to claim 19, wherein the contacting tab assembly comprises at least a first plurality of contacting tabs for contacting the contacts of the one polarity on the one solar cell and a second plurality of contacting tabs for contacting the contacts of the opposite polarity on the adjacent solar cell.

21. Solar panel module according to claim 20, the contacting tab assembly further comprising a connecting bus for connecting the first plurality and the second plurality of contacting tabs.
- 5
22. Solar panel module according to claim 20 or 21, wherein the contacting tab assembly has a double forked shape in which the first plurality of contacting tabs are arranged in parallel and are interconnected on an outer end by the connecting bus that runs substantially perpendicular to the longitudinal direction of the contacting tabs, and
- 10
- the second plurality of contacting tabs are arranged in parallel and are interconnected on an outer end by the connecting bus, wherein the connecting bus is arranged in between the first and the second pluralities of contacting tabs.
- 15
23. Solar panel module according to any one of the preceding claims 1 – 22, further comprising a first encapsulation layer, a second encapsulation layer and a back sheet foil, wherein the first encapsulation layer is transparent and is arranged between the transparent superstrate and the array of the plurality of solar cells, the second encapsulation layer is arranged between at one side surfaces of the contacting tabs and the solar cell that face away from the superstrate, and at the other side the back sheet foil that is arranged on the surface of the second encapsulating layer facing away from the superstrate.
- 20
24. Solar panel module according to claim 23, wherein the solar panel module comprises at least a portion of a peripheral edge free standing ends of the contacting tabs that are arranged to extend, perpendicular to the edge, beyond the solar panel area; the free standing ends being connected to a dedicated bussing bar; the dedicated bussing bar being arranged to extend substantially parallel to the peripheral edge, the free standing ends being foldable allowing the dedicated bussing bar to be foldable back over the solar cells at the peripheral edge of the solar panel module.
- 25
- 30

25. Solar panel module according to claim 24, wherein the dedicated bussing bar comprises on a free distal end a junction box bussing tab which is arranged for connection to a first junction box terminal, wherein the junction box bussing tab extends transverse to the longitudinal direction of the dedicated bussing bar.
- 5
26. Solar panel module according to claim 25, further comprising an electrically insulating strip which is arranged between the dedicated bussing bar in the folded back position and contacting tabs that are covered by the folded back dedicated bussing bar.
- 10
27. Solar panel module according to any one of claims 24 – 26, further comprising a second connecting tab arranged for connecting to a second junction box terminal, provided at a position on the solar panel module substantially adjacent to the position of the junction box bussing bar on the solar panel module in the folded back position of the dedicated bussing bar.
- 15
28. Solar panel module according to claim 27, wherein the junction box bussing tab and are provided with a copper surface for connecting to the first junction box terminal
- 20 and/or the second connecting bar is provided with a copper surface for connecting to the second junction box terminal.
29. Method for manufacturing a solar panel module comprising a plurality of solar cells; the solar cells being of a type having a light receiving front surface and a rear surface with contacts of first polarity and counter contacts of a second opposite polarity arranged on the rear surface; the contacts comprising a first metal as conductor; the counter contacts comprising a second metal as conductor;
- 25 the method comprising:
- 30 providing a transparent superstrate;
- arranging the plurality of solar cells in an array adjacent to each other on the transparent superstrate, with the front surfaces of the solar cells facing towards the transparent superstrate;

connecting in each solar cell the contacts and counter contacts to a first and second metallic contacting tab respectively, wherein the first and second contacting tabs are arranged in a layout of a conductive network for electrical output,

5 wherein the connection between the contact and the first contacting tab or the counter contact and the second contacting tab comprises a weld, in which the metal of the contact or counter contact has a metallic interface with the metal of the respective contacting tab with a direct contact between the metals of either the contact or the counter contact and the contacting tab.

10

Fig 1

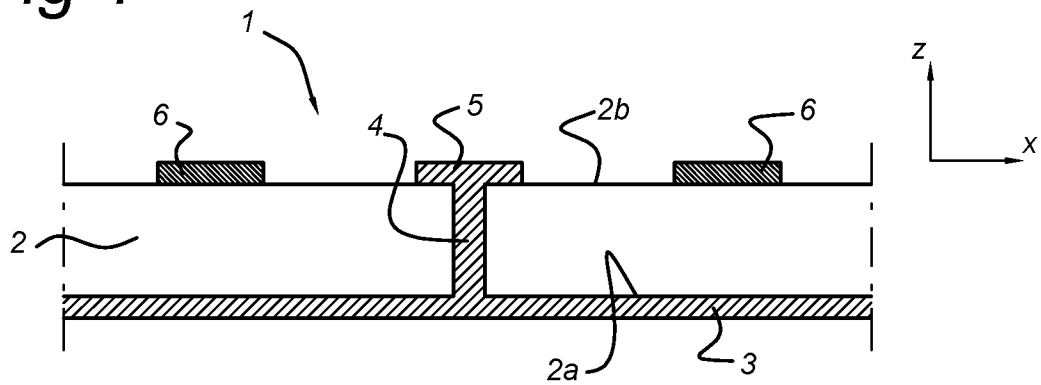


Fig 2

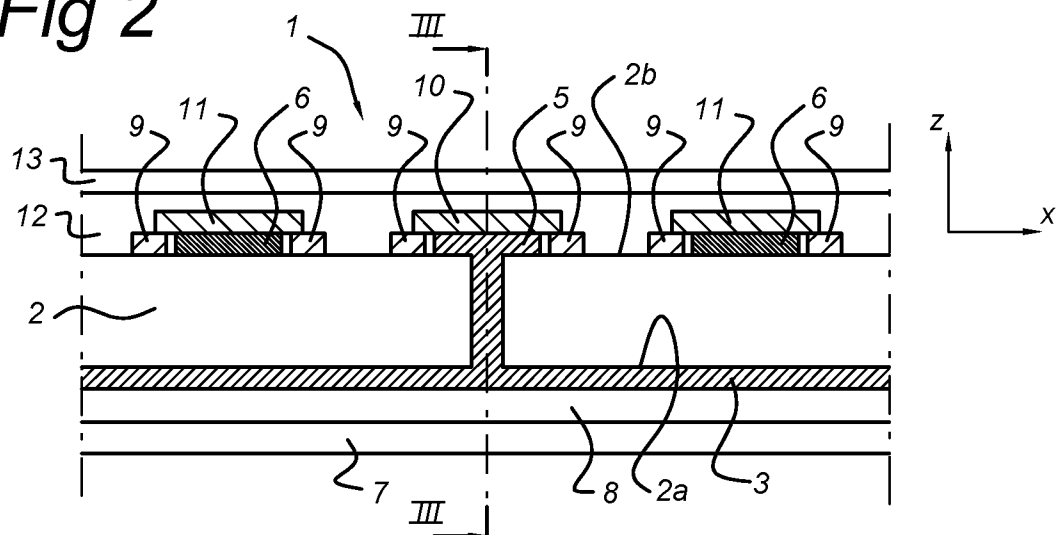


Fig 3

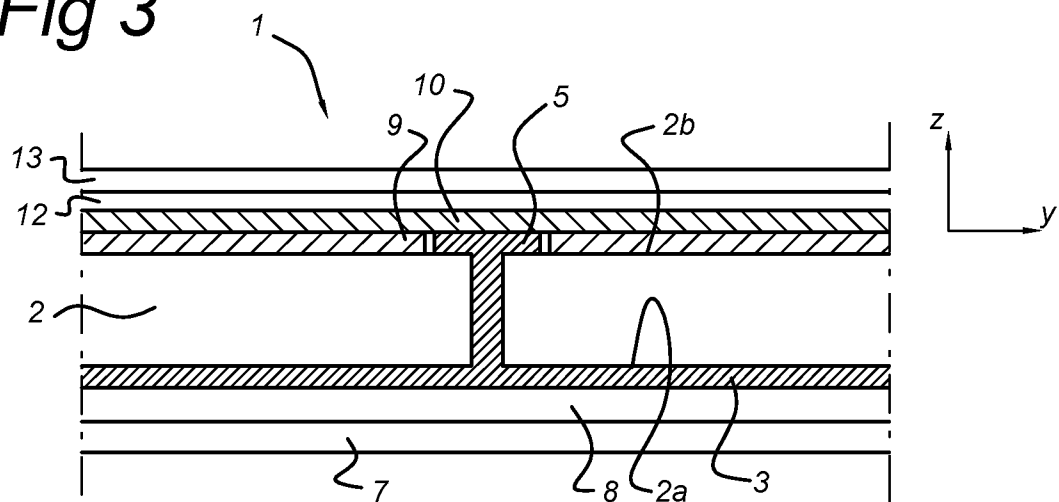


Fig 4

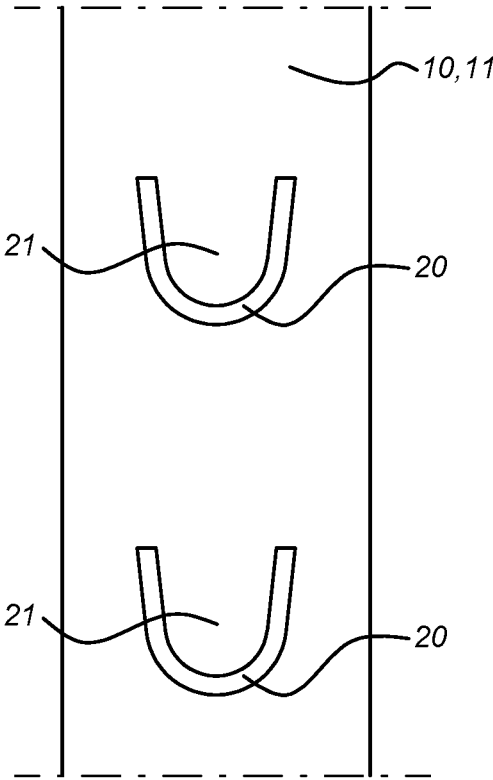


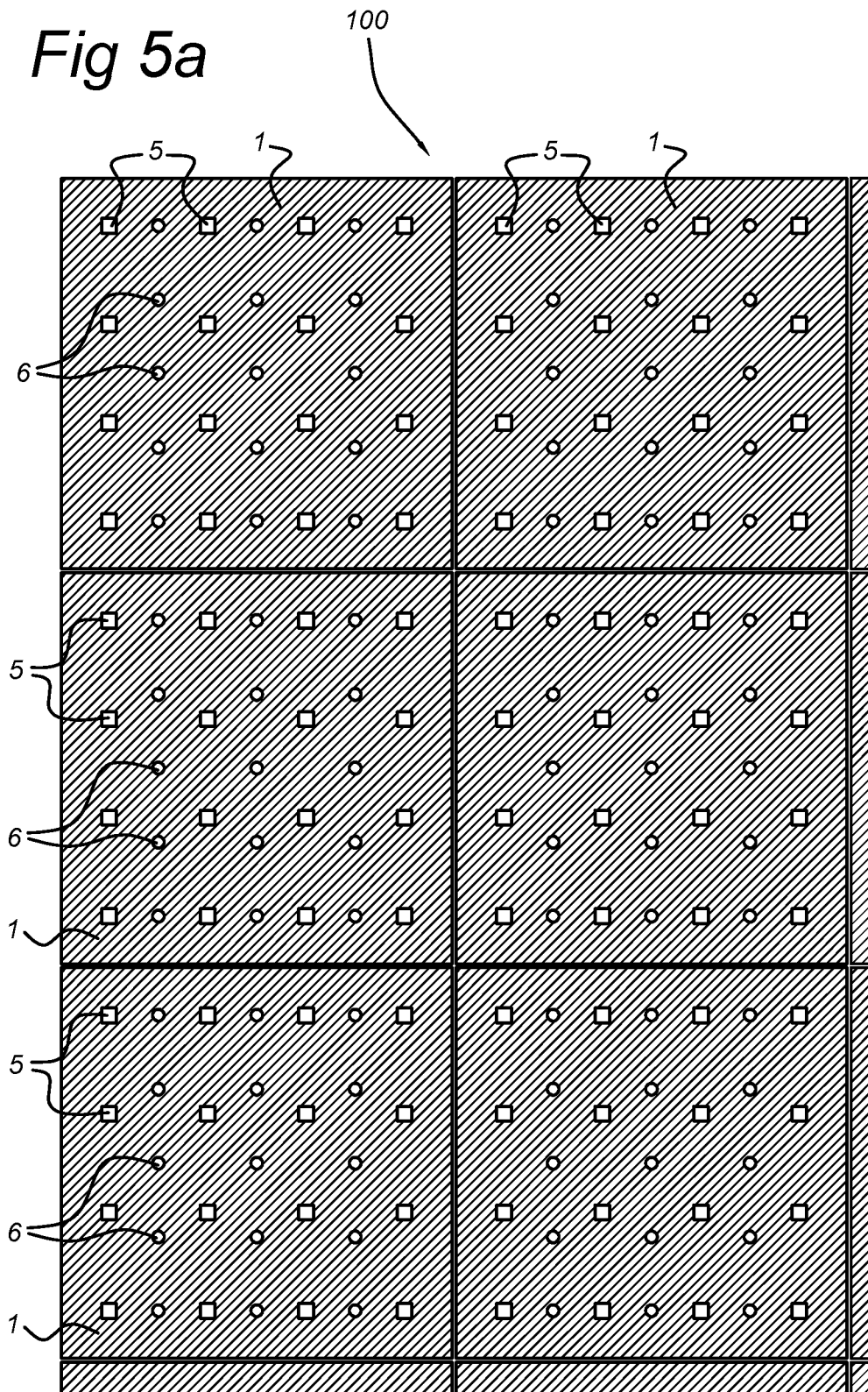
Fig 5a

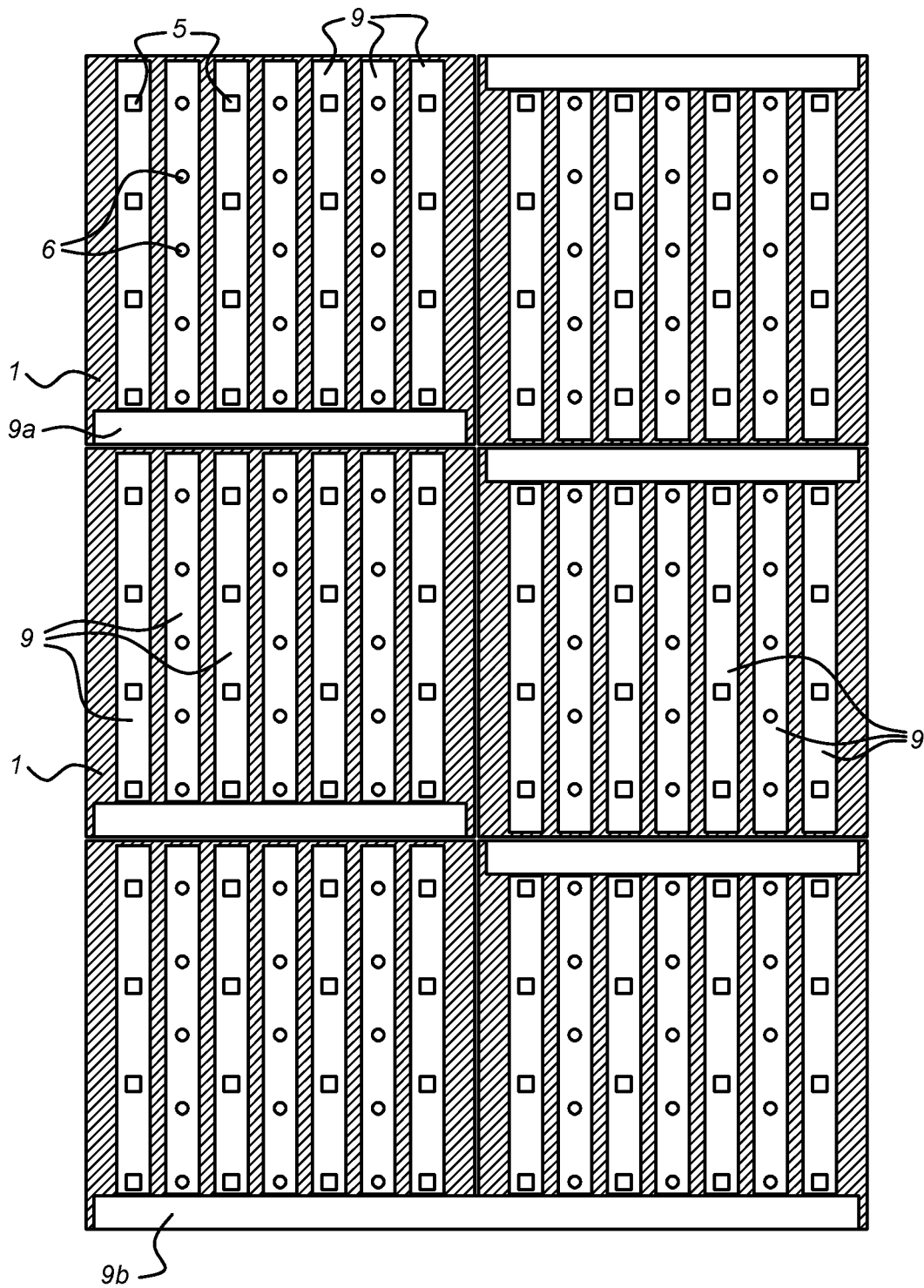
Fig 5b

Fig 5c

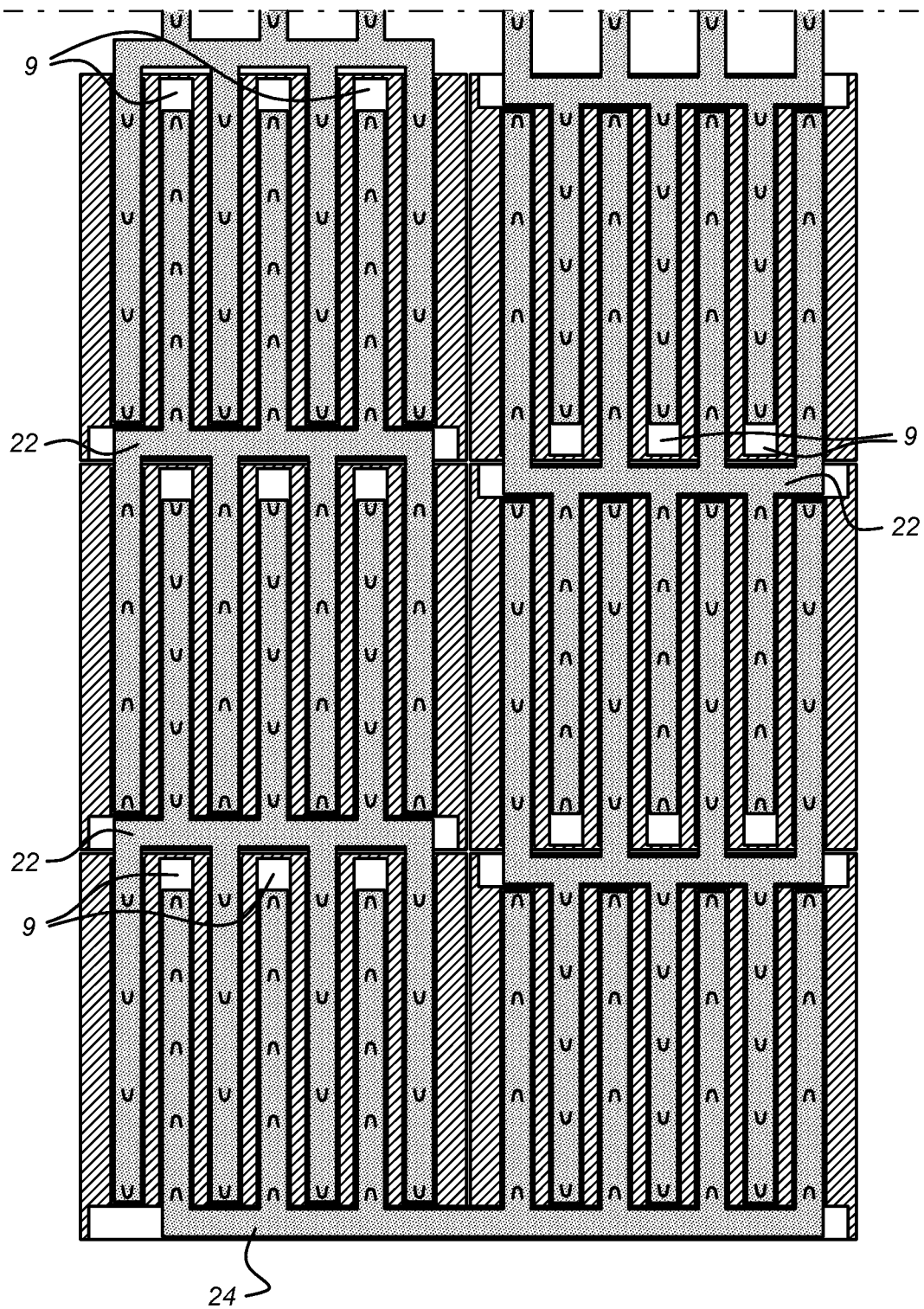


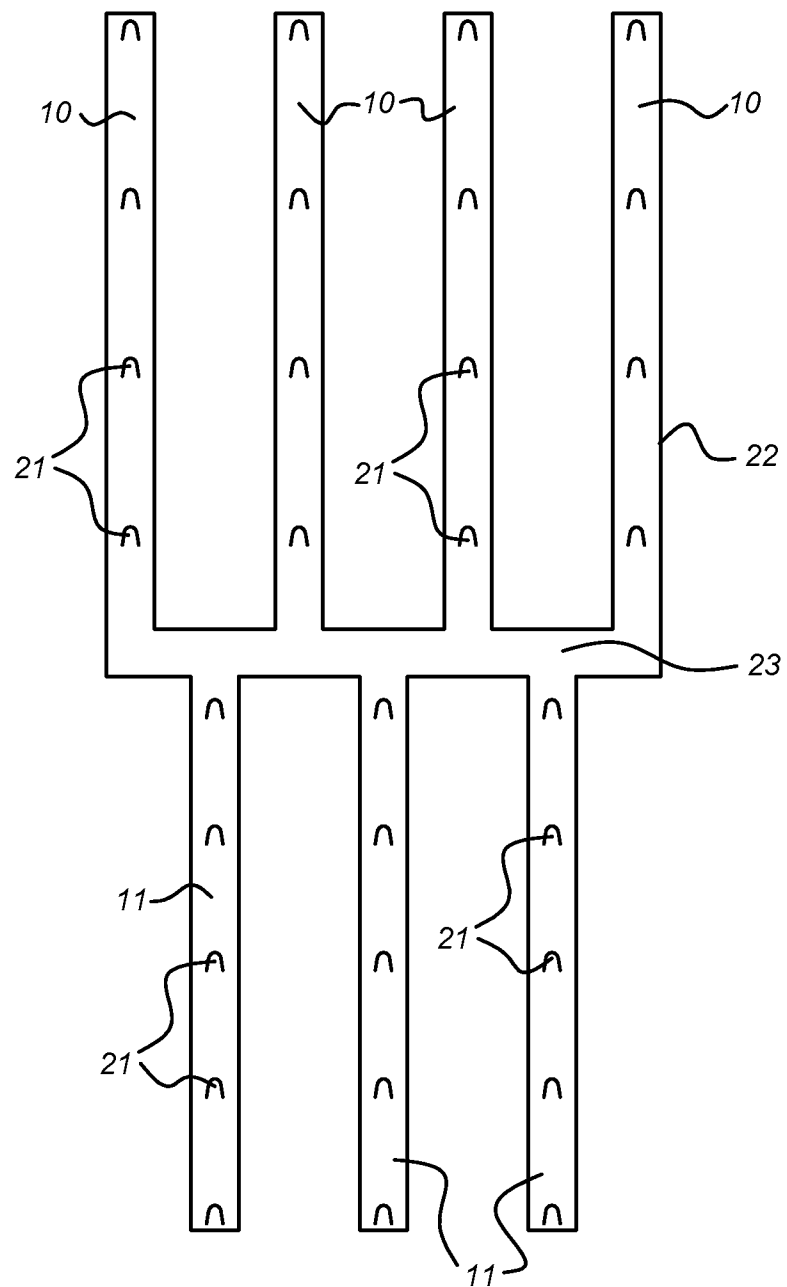
Fig 5d

Fig 5e

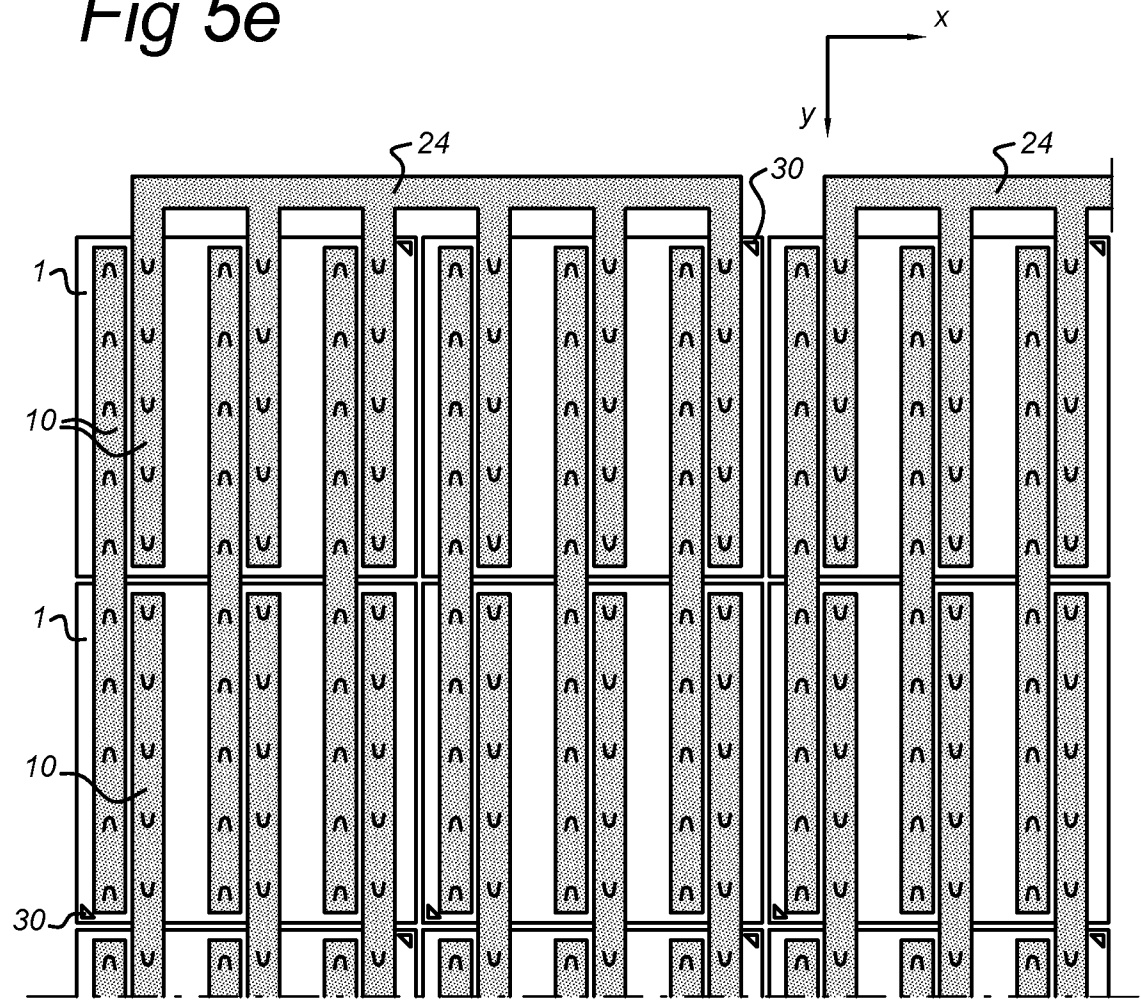


Fig 6

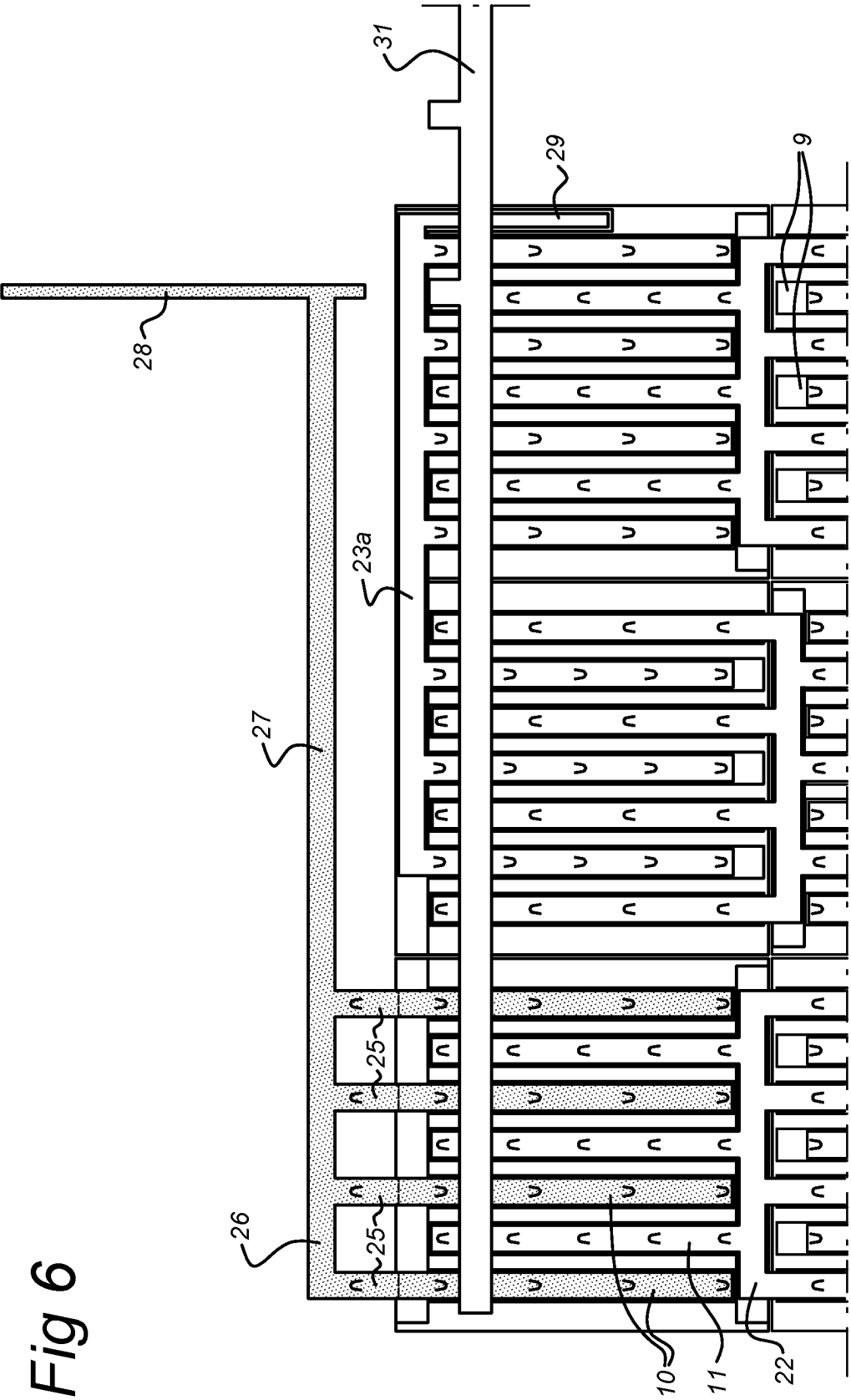
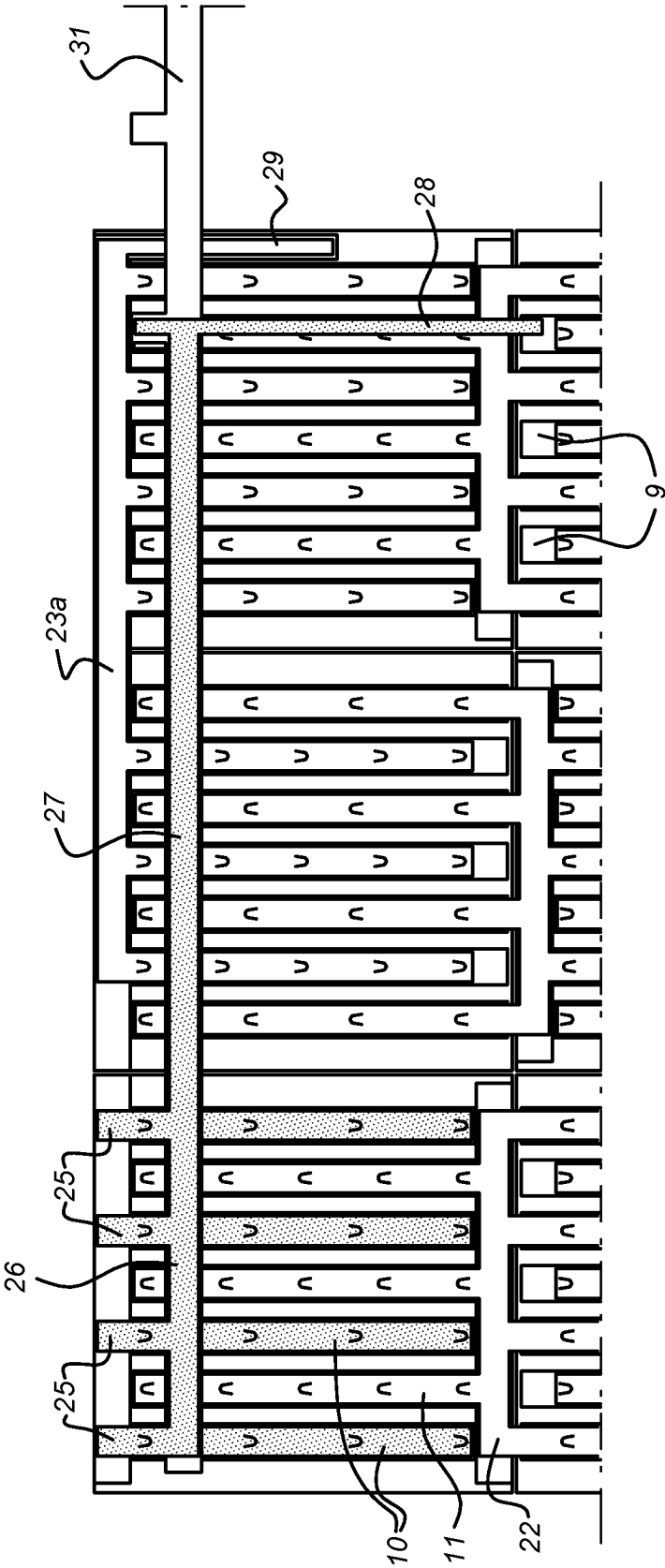


Fig 7



INTERNATIONAL SEARCH REPORT

International application No

PCT/NL2012/050366

A. CLASSIFICATION OF SUBJECT MATTER INV. H01L31/0224 H01L31/042 H01L31/05 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) H01L 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	WO 2010/082594 A1 (SHARP KK [JP]; SAINOO YASUSHI; NISHINA TOMOHIRO; IMATAKI TOMOO; SHIRAK) 22 July 2010 (2010-07-22) the whole document - & EP 2 388 828 A1 (SHARP KK [JP]) 23 November 2011 (2011-11-23) -----	1-7, 14-29
☐ 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 23 July 2012		Date of mailing of the international search report 31/07/2012
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 Persat, Nathalie

INTERNATIONAL SEARCH REPORT

International application No

PCT/NL2012/050366

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EP 2388828 A1	23-11-2011	CN 102356472 A EP 2388828 A1 US 2011272006 A1 WO 2010082594 A1	15-02-2012 23-11-2011 10-11-2011 22-07-2010