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(54) Title: A METHOD FOR FORMING A CONTACTING STRUCTURE TO A BACK CONTACT SOLAR CELL

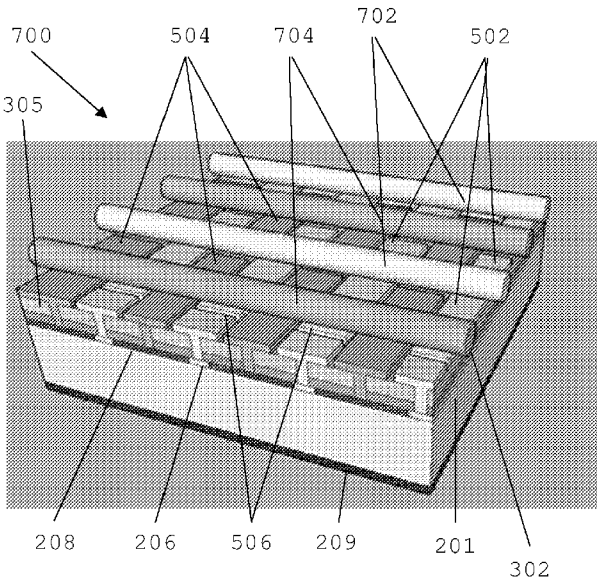


FIGURE 7(a)

(57) Abstract: The present disclosure provides a method for forming a contacting arrangement for a back contact solar cell. The method comprises forming a polymeric layer comprising a plurality of openings on a back portion of the solar cell. Further, the method comprises forming a patterned conductive layer on the polymeric layer. The patterned conductive layer comprises a plurality of conductive regions electrically isolated from each other. At least some of the conductive regions have portions extending into at least one of the openings to form an electric contact with the solar cell. The method also comprises forming a plurality of metallic elements onto the patterned conductive layer, each metallic element being arranged to be in electrical contact with at least some of the plurality of regions of the patterned conductive layer. The plurality of openings and conductive regions are arranged in manner such that each metallic element is in electrical contact with a plurality of regions of the solar cell of the same polarity.

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A METHOD FOR FORMING A CONTACTING STRUCTURE TO A BACK CONTACT SOLAR CELL

Field of the Invention

The present invention generally relates to a method of forming a contacting arrangement for a back contact solar cell and a solar cell manufactured in accordance with the method.

Background of the Invention

Back contact solar cells, such as interdigitated back contact (IBC) silicon solar cells and emitter wrap-through (EWT) silicon solar cells can exceed 25% energy conversion efficiencies. A record efficiency of 25.6% has been reported for hetero-junction IBC cells.

Forming a contacting structure for these solar cells can be challenging. If the metal contact is to be formed directly to the silicon absorber it is important that the area of contact between the metal and the silicon is minimised in order to reduce contact recombination losses. This can be done in a number of ways, each of these requiring a high resolution patterning process. The patterning process generally requires a number of alignment steps and the processing of sacrificial layers used to define the pattern.

The pattern required to metallise the back surface of an IBC solar cell can be quite complex as it has to

accommodate for a number of busbars for reduced resistive loss, and allow to connect each busbar to either the p-type region or the n-type region of the solar cell.

Power loss calculations suggest that copper fingers as thick as 30 µm to 40 µm are required to reduce the series resistance losses to ~1% for 156 mm cells if a single busbar is used for each polarities of contact. An increased conductivity can be achieved using a two-level metallization scheme, however this can significantly increase the complexity of the manufacturing process. Other possible approaches include: reducing the finger length by positioning busbars within the interior of the cell; cleaving cells into strips; forming the bulk of the metallization on the back-sheet and aligning the fingers on the cell with the conductive pattern on the module plate or back-sheet.

However, all of the abovementioned schemes have some disadvantages including: the requirement for accurate alignment, increased electrical shading loss and/or increased edge recombination losses. There is a need for an alternative metallization scheme which can address at least some of these disadvantages.

Summary of the Invention

Embodiments of the present invention provide a method for forming an electrical contacting arrangement for a back contact solar cell, such as an IBC solar cell, which involves patterning of a polymeric layer with optical and

electrical properties that allow the layer to be retained in the final device, therefore eliminating the need to remove it after patterning.

In accordance with the first aspect, the present invention provides a method for forming a contacting arrangement for a back contact solar cell, the method comprising the steps of:

forming a polymeric layer comprising a plurality of openings on a back portion of the solar cell;

forming a patterned conductive layer on the polymeric layer; the patterned conductive layer comprising a plurality of conductive regions electrically isolated from each other, at least some of the conductive regions have portions extending into at least one of the openings to form an electric contact with the solar cell;

forming a plurality of metallic elements onto the patterned conductive layer, each metallic element being arranged to be in electrical contact with at least some of the plurality of regions of the patterned conductive layer;

wherein the plurality of openings and conductive regions are arranged in manner such that each metallic element is in electrical contact with a plurality of regions of the solar cell of the same polarity. The solar cell comprises a plurality of p-type regions and n-type regions disposed at the back of the cell. A first set of the openings may be aligned with the p-type regions and a second set of openings may be aligned with the n-type regions. Further, a first set of conductive regions of the

patterned layer may be disposed in correspondence of the first set of openings and a second set of conductive regions may be disposed in correspondence of the second set of openings. In this way, the conductive regions of the first set are in electrical contact with the p-type regions and the conductive regions of second set are in electrical contact with the n-type regions.

In some embodiments, prior to forming a patterned layer, a portion of a dielectric layer disposed between the solar cell and the polymeric layer is etched using the polymeric layer as an etching mask.

In some embodiments, the patterned polymeric layer is formed by selectively screen-printing a metallic material onto the polymeric material. The polymeric layer may be formed by spinning or spraying a novolac resin or polymide.

The solar cell may have a substantially planar structure with the plurality of p-type regions and n-type regions extending laterally in the same direction along the back of the solar cell. In this case, the openings of the first and second set are aligned along the p-type and n-type regions respectively. The metallic elements may be disposed onto the polymeric layer in a substantially transverse orientation to the plurality of n-type and p-type regions.

The openings of the first set and second set may be arranged in a pattern and define a plurality of polymeric isolation regions, the isolation regions may be arranged to isolate a metallic element from a respective underlying p-type or n-type region.

In some embodiments, a plurality of electrically floating regions of the patterned conductive layer may be disposed onto each isolation region. The electrically floating regions may be arranged to improve adhesion of the metallic elements to the patterned conductive layer by increasing the area of contact.

In embodiments, a first set of isolation regions, disposed on top of n-type regions, is arranged to isolate the n-type regions from a first set of metallic elements; and a second set of isolation regions, disposed on top p-type regions, is arranged to isolate the p-type regions from a second set of metallic elements.

The first set of isolation regions may be spatially offset in respect to the second set of isolation regions along a direction transversal to the n-type regions and p-type regions. The offset may be at least as wide as one of the metallic elements and, in some embodiments, the offset is at least 3 mm. The metallic elements may extend across one side to the other of the solar cell and have a minimum width of 100 µm.

In some embodiments, the step of forming a plurality of metallic elements onto the polymeric layer comprises the steps of:

depositing the metallic elements onto a further polymeric layer;

aligning the further polymeric layer comprising the metallic elements with the patterned conductive layer

overlaying the further polymeric layer comprising the metallic elements onto the patterned conductive layer;

heating the structure comprising the further polymeric layer, the metallic elements and the patterned conductive layer to form an electrical contact between the metallic elements and the patterned conductive layer. The further polymeric layer may then be removed. Alternatively, the further polymeric layer may be left on the solar cell and may be arranged to improve the optical performance of the solar cell. In some instances the further polymeric layer can be arranged to increase the isolation between the cell and the conductive/metallic layers.

Without the polymeric layer, the passivation layer may have defects and may cause shunt.

In some embodiments, the plurality of openings in the polymeric layer comprises a plurality of circle openings closely spaced to each other. The distance between the circle openings and the size of the openings may be selected to minimise carrier recombination at the back surface of the solar cell.

In other embodiments, the plurality of openings in the polymeric layer comprises a plurality of line openings closely spaced to each other. The openings may be formed using a laser beam.

Prior to forming the openings in the polymeric layer, the solar cell may be aligned with the laser beam. The precision required for the alignment is related to the width of the p-type and the n-type regions and the maximum size of the opening. The alignment tolerance may be comprised between 100 μm and 200 μm.

In accordance with the second aspect, the present invention provides a back contact solar cell comprising:

a polymeric layer disposed on a back surface of the solar cell and comprising a plurality of openings;

a patterned conductive layer comprising a plurality of conductive regions electrically isolated from each other;

a plurality of metallic elements disposed onto the patterned layer, each metallic element being arranged to be in electrical contact with at least some of the plurality of regions of the patterned conductive layer;

wherein the plurality of openings and conductive regions are arranged in manner such that each metallic element is in electrical contact with a plurality of regions of the solar cell of the same polarity.

Advantageous embodiments of the present invention provide a method for forming a contacting structure to a IBC solar cell using a patterned polymeric layer. The layer can be patterned using a low-cost inkjet patterning method to form point openings as small as 20 µm in a novolac resin layer or a laser pattering method. The optical and electrical properties of the patterned novolac resin layer enable the layer to be retained in the final device thus eliminating the need to remove it after patterning.

The metallization scheme proposed can avoid the use of thick plated metal layers without significantly increasing the cell series resistance. It can rely on the use of pre-formed solder-coated Cu wires to extract current from the

cell. The Cu wire busbars can be aligned perpendicular to the fingers (on the either the cell or the back-sheet) with the solder coating enabling low-resistance bonding to the metal fingers during tabbing/lamination. The described approach enables the cell metallization process to be largely decoupled from the cell design thereby enabling it to be adapted for use with different IBC cell types, including heterojunction IBC cells.

Brief Description of the Drawings

Features and advantages of the present invention will become apparent from the following description of embodiments thereof, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a flow diagram outlining a series of steps for forming a contacting arrangement for a back contact solar cell in accordance with embodiments;

Figures 2 to 7 are schematic illustrations of a back contact solar cell during different fabrication steps of the contacting arrangement in accordance with embodiments; and

Figure 8 shows the calculated fractional power loss due to resistance in the Cu busbars for IBC solar cells manufactured in accordance with embodiments.

Figure 9 shows the calculated fractional power loss due to resistance in the patterned conductive layer assuming the conductive layer is made by aluminium.

Detailed Description of Embodiments

Embodiments of the present disclosure relate to a method for forming a contacting arrangement for a back contact solar cell, such as an IBC solar cell. IBC solar cells generally have a series of n-type and p-type regions at the back portion which need to be electrically contacted to deliver electrical carriers to an external circuit.

Generally the n-type and p-type regions extend from one side to the other of the solar cell along one direction at the back of the solar cell and are interleaved. A convenient way to contact all of these regions is to have metallic elements, for example busbars, extending on top of these regions in a transversal direction, so that each busbar extends across all of the n-type and p-type regions. However, each of the busbars must be placed in electrical contact with either the n-type regions or the p-type regions. Ideally, to optimise the electrical properties of the solar cell, each busbar would be placed in electrical contact with all the n-type regions or all the p-type regions so that the final contacting arrangement has two sets of busbars which can be used to connect to an external electrical circuit.

Referring now to figure 1, there is shown a flow diagram 100 outlining a series of steps for forming a contacting arrangement for a back contact solar cell in accordance with embodiments of the method disclosed herein.

At step 102, a polymeric layer is formed on the back portion of the solar cell. The polymeric layer can be formed by spinning or spraying a novolac resin or

polymide. An alternative solution is to apply a sheet-like polymer, such as a dry film.

A plurality of openings is then formed in the polymeric layer. The openings can be formed using inkjet printing, aerosol jet printing, screen printing or laser patterning. Preferably, point openings as small as 20 µm can be formed. Alternatively a pre-patterned polymeric layer may be used, such as screen printed resist or inkjet printed hot melt wax.

In some instances a dielectric layer may be present at the back portion of the solar cell, the dielectric layer acting to reduce recombination of light-generated carriers and at the silicon surface. The dielectric layer can be etched through the formed openings using the polymeric layer as an etching mask to gain access to the n-type and p-type regions of the solar cell. Alternatively, the dielectric layer can be ablated using a laser while the openings are formed.

A first set of the point openings is aligned with the p-type regions of the solar cell and a second set of openings is aligned with the n-type regions. The openings are closely spaced to each other along the directions of the p-type and n-type regions. However, a series of larger gaps is left between some openings to form a plurality of polymeric isolation regions between the openings. These isolation regions are suitable to isolate a metallic element, such as a busbar, from a respective underlying p-type or n-type region of the solar cell. The distance between the point openings and the size of the openings

are selected to minimise carrier recombination at the back surface of the solar cell.

In an alternative embodiment, closely spaced line openings can be used instead of point openings.

A first set of isolation regions is positioned to isolate the n-type regions from a first set of metallic elements; and a second set of isolation regions is positioned to isolate the p-type regions from a second set of metallic elements. The regions of the first set are spatially offset in respect to the regions of the second set.

At step 104, a patterned conductive layer comprising a plurality of conductive regions is formed on the polymeric layer. The regions are electrically isolated from each other and each region extends into at least one of the openings to form an electric contact with an n-type or p-type region of the solar cell. The patterned conductive layer can be formed by selectively screen-printing, inkjet printing or aerosol printing a metallic material onto the polymeric layer. Alternatively the conductive layer can be formed by metal plating onto the polymer and the silicon surface exposed through the openings. The latter process would require the polymer to be first sensitised for plating using a low-power laser. In a further variation, the patterning conductive layer can be formed by first depositing a layer of metal over the entire back surface of the solar cell and then forming isolation lines that electrically isolate different regions on the conductive layer.

A first set of the conductive regions is disposed in correspondence of the first set of openings and is in

electrical contact with the p-type regions of the solar cell. In a similar manner, a second set of the conductive regions is disposed in correspondence of the second set of openings and is in electrical contact with the n-type regions. A number of conductive regions, aligned with the polymeric isolation regions, are left electrically floating.

At step 106, a plurality of metallic elements, provided in the form of busbars, are formed onto the patterned layer, each metallic element is arranged to be in electrical contact with a plurality of regions of the patterned layer which are in turn in electrical contact with a plurality of regions of the solar cell of the same polarity.

Figures 2 to 7 are schematic illustrations of a back contact solar cell during different fabrication steps of the contacting arrangement.

Referring now to figure 2, there is shown a back contact solar cell 200 formed on a semiconductor substrate 201 having a rear surface 202 and an opposing front surface 204. The back portion of solar cell 200 includes several p-type regions 208 and n-type regions 206. In the embodiment of figure 2, the semiconductor substrate 201 is a silicon n-type monocrystalline wafer with a resistivity between 0.1 and 1000 Ω cm, but other type semiconductor materials such as p-type monocrystalline silicon wafers, and n-type or p-type multi-crystalline silicon wafers, gallium arsenide and other thin film materials can also be used.

Similarly to conventional IBC solar cells, this back contact solar cell structure includes multiple

interdigitated p-type 208 and n-type 206 regions that are formed through the rear surface 202. These n-type 206 and p-type 208 regions can be doped regions. Doping can be performed by diffusion or ion implantation amongst other techniques. Alternatively, regions 206 and 208 can be portions of a hetero-junction structure with doped n+ and p+ amorphous silicon or poly silicon.

Region 209 at the front surface 204 can be of the opposite polarity to the substrate 201 (floating junction) or the same polarity to the substrate 201 (front surface field). Region 209 is used to reduce the front surface recombination velocity. However, region 209 can be avoided if other methods for reducing carrier recombination at the front surface are used. In one embodiment, the front region 209 can be an n-type doped region with a sheet resistance between 50 Ω/□ to 1000 Ω/□ on an n-type substrate 201.

The rear n-type 206 and p-type 208 regions have a sheet resistance between 20 Ω/□ to 200 Ω/□ and the distance between two adjacent n-type 206 or p-type 208 regions (pitch size) is between 100 µm to 5000 µm. In the embodiment of figure 2, where an n-type substrate 201 is used, the rear p-type regions 208 cover 10% to 95% of the rear surface area (or the pitch size) and the rear n-type regions 206 cover 5% to 50 % of the rear surface area (or the pitch size).

Referring to figure 3, there is shown a schematic representation 300 of cell 200 with additional layers. A surface passivation layer 302 (e.g., one of silicon nitride, silicon carbide, silicon oxide, silicon oxi-

nitride, amorphous silicon, poly-silicon or any other suitable dielectric materials and/or stacks) is formed over the rear surface and an anti-reflection and passivation layer (e.g., SiNx, TiO2, amorphous silicon, poly silicon with ITO or any other suitable dielectric materials and stacks) is formed over front surface. The thickness of the rear passivation layer 302 (or stack) is between 5 nm to 2000 nm and the thickness of the front anti-reflection and passivation layer (or stack) is between 5 nm to 200 nm.

On the top of the rear surface passivation layer 302, a masking layer, provided in the form of polymeric layer 304 (e.g. resin including novolac resin, polyimide, photoresist, hot melt wax or other suitable polymer layer can be patterned in the following process) is coated by spin coating. Layer 304 could be also coated by spray coating, dip coating or any other coating or deposition technique. The thickness of polymeric layer 304 is comprised between 0.1 µm to 50 µm. The polymeric layer 304 can alternatively be formed using a dry film polymer material that is overlaid on the surface passivation layer 302. Alternatively, a patterned masking layer can be printed by screen printing, inkjet printing or any other printing technique.

Referring to figure 4, there is shown a schematic representation 400 of device 300 with a patterned polymeric layer 304. Layer 304 can be patterned by inkjet or other printing methods, laser ablation or photolithography. A plurality of point openings 402, 404 are opened in the polymeric layer 304. A first set of the openings 402 is aligned to the p-type regions 208 and a

second set of the openings 404 is aligned to the n-type region 206 In alternative embodiments, the shape of the patterned openings can be different, for example the openings may have an elongated shape, such as line openings. The diameter of the point openings 402, 404 is between 1 µm to 300 µm. The distance between two adjacent openings is between 1 µm to 300 µm. The polymeric layer 304 together with the passivation layer can act as an insulator.

A series of larger gaps 405 is left between some openings 402 to form a plurality of polymeric isolation regions 305 between the openings. Isolation regions 305 will prevent busbars in electrically in contact with regions of one polarity of the solar cell from forming electrical contact to underlying regions of the other polarity n-type region 206.

A first set of isolation regions 305 is positioned to isolate the n-type regions 206 from a first set of busbars. A second set of isolation regions 305 is positioned to isolate the p-type regions 208 from a second set of busbars. The regions of the first set are spatially offset in respect to the regions of the second set by at least the width of the busbars. In the majority of embodiment, this offset is at least 3 mm.

The patterned polymeric layer 304 can be used as a mask to etch portions of the underlying dielectric passivation layer 302 in correspondence of the openings by wet chemical etching or dry etching, such as plasma etching.

Referring to figure 5, there is shown a schematic representation 500 of device 400 with a patterned

conductive layer which defines a plurality of conductive regions electrically isolated from each other. A first set of conductive regions 502 is disposed in correspondence of the first set of openings 402 and a second set of the conductive regions 502 is disposed in correspondence of the second set of openings 404 so that the first set of conductive regions 504 are in electrical contact with the p-type regions 208 and the second set of conductive regions 502 are in electrical contact with the n-type regions 206.

The conductive regions can be formed by one or a stack of metal layers with a thickness ranging from 0.1 μm to 40 μm. For example, the conductive regions can be formed by one or a stack of Ti/Pd/Ag, Al/Ti/Pd/Ag, Tungsten Titanium (WTi), Cr/Cu or Ag/Sn or Al/W/Cu/Sn/. The patterned conductive layer used to form the conductive regions can be screen printed, inkjet printed, plated or deposited through a mask. Alternatively, a conductive layer covering the entire back portion can be deposited and then patterned after a full area deposition.

A number of conductive regions 506, aligned with the polymeric isolation regions 304, are left electrically floating. The width of conductive regions 506 is between 50 μm to 2000 μm. The length of conductive regions 506 is between 300 μm to 50 mm. The conductive regions 506 are electrically isolated from the p-type regions 208 and the n-type regions 206.

Referring now to figure 6, there is shown a schematic diagram 600 of the device without the floating conductive regions 506. Diagram 600 shows that the polymeric layer

exposed between adjacent conductive region elements 504 and 502 does not have any openings, keeping these regions electrically disconnected.

Referring now to figure 7, there are shown schematic illustrations of devices 700 (figure 7(a)) and 750 (figure 7(b)) with a plurality of metallic elements, provided as busbars 702, 704 aligned on the conductive layer.

Referring now to figure 7(a), there is shown a device which comprises floating regions 506. One type of the busbars 704 is in contact with the conductive regions 504 which are connected to the p-type region 208 and the floating regions 506. The other type of the busbars 702 is in contact with the conductive regions 502 which are connected to the n-type region 206 and the floating regions 506. The busbars extend across one side to the other of the solar cell and have a minimum width of 100 µm and their thickness is between 5 µm to 1 mm. The distance between two adjunct busbars is between 300 µm to 50 mm.

The polymeric isolation regions 305 insulate each set of busbars 702 or 704 from all the regions of the solar cell of one polarity (n-type or p-type), so that each busbar can be electrically connected to only regions of the solar cell of the other polarity. The electrically floating metallic regions 506 in device 700 improve the adhesion of the busbars 702 and 704 to the patterned conductive layer by increasing the area of contact.

The busbars 702 and 704 can be directly formed on the conductive layer by screen printing. Alternatively, they can be deposited by performing the following steps: depositing the busbars 702 and 704 onto another polymeric

layer; aligning the other polymeric layer with the busbars 702 and 704 with the patterned conductive layer; overlaying polymeric layer with the busbars 702 and 704 onto the patterned conductive layer; and heating the polymeric layer and the busbars 702 and 704 to form an electrical contact between the busbars 702 and 704 and the respective conductive regions 502 and 504 of the patterned conductive layer. The additional polymeric layer can then be removed or left at the back of the cell to improve the optical performance. The alignment step tolerance is comprised between 100 µm and 200 µm.

Figure 7(b) shows a schematic illustration of a device 750 which is similar device to 700 but does not have any floating regions 506.

Referring now to figure 8, there is shown a plot 800 of the calculated fractional power loss (due to resistance in the Cu busbars) as a function of the busbar diameter and total number of busbars (including n-type and p-type busbars).

The calculations assumed a pitch of 2000 µm and circular Cu wire busbars. It can be seen that to achieve a 1% resistive loss, the diameter of the busbars is preferably > 500 um and the total number of busbars is > 32 (i.e., spaced ~ 5 mm apart).

The solder-coated Cu wire busbars can be aligned on a polymer substantially as in the known SmartWire Connection Technology (SWCT) or on a module back-sheet. The alignment of the cell on the wire-coated polymer or back-sheet is performed during the tabbing/lamination process.

Referring now to figure 9, there is shown a plot 900 of the calculated fractional power loss due to resistance in the aluminium fingers as a function of the fingers height and total number of busbar (including n-type and p-type fingers). Using a design with 36 Cu busbars of 500 µm diameter and 0.5 µm Al finger height, the total power loss due to series resistance in the metal is 0.9%.

The Applicants have calculated the influence of the series resistance under the non-contact fingers for a structure as in figure 7(a) using the 3D modelling software Quokka 2. The following parameters were varied: (a) finger alignment; (b) busbar placement; and (c) sheet resistance for the n+ and p+ regions. The Applicants have found that with a 300 µm alignment tolerance for the finger and busbar and sheet resistances of 30 Ω/□ for the n+ and 60 Ω/□ for p+ regions, the introduced series resistance loss was only 0.2%.

It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

Claims:

1. A method for forming a contacting arrangement for a back contact solar cell, the method comprising the steps of:

forming a polymeric layer comprising a plurality of openings on a back portion of the solar cell;

forming a patterned conductive layer on the polymeric layer; the patterned conductive layer comprising a plurality of conductive regions electrically isolated from each other, at least some of the conductive regions have portions extending into at least one of the openings to form an electric contact with the solar cell;

forming a plurality of metallic elements onto the patterned conductive layer, each metallic element being arranged to be in electrical contact with at least some of the plurality of regions of the patterned conductive layer;

wherein the plurality of openings and conductive regions are arranged in manner such that each metallic element is in electrical contact with a plurality of regions of the solar cell of the same polarity.

2. The method of claim 1 wherein the solar cell comprises a plurality of p-type regions and n-type regions at the back portion and wherein the step of forming a polymeric layer comprising a plurality of openings comprises the step of forming a first set of openings aligned with the p-type regions and a second set of openings aligned with the n-type regions.

3. The method of claim 2 wherein the step of forming a plurality of metallic elements onto the patterned conductive layer comprises forming a first set of conductive regions, disposed in correspondence of the first set of openings, and a second set of conductive regions, disposed in correspondence of the second set of openings, so that the conductive regions of the first set are in electrical contact with the p-type regions and the conductive regions of the second set are in electrical contact with the n-type regions.

4. The method of claim 2 or claim 3 wherein the solar cell has a substantially planar structure and the plurality of p-type regions and n-type regions extend laterally in the same direction along the rear of the solar cell; and the step of forming a polymeric layer comprising a plurality of openings comprises the step of aligning the openings of the first and second set along the plurality of p-type regions and n-type regions respectively.

5. The method of claim 4 wherein the step of forming a plurality of metallic elements onto the patterned conductive layer comprises arranging each metallic element onto the polymeric layer in a substantially transverse orientation to the plurality of n-type regions and p-type regions.

6. The method of claim 4 or claim 5 wherein the step of forming a polymeric layer comprising a plurality of openings comprises arranging the openings of the first set and second set in a pattern that defines a plurality of polymeric isolation regions between the openings, the

isolation regions being arranged to isolate a metallic element from a respective underlying p-type or n-type region.

7. The method of claim 6 wherein the step of forming a plurality of metallic elements onto the patterned conductive layer comprises forming a plurality of electrically floating regions disposed onto each isolation region.

8. The method of any one of claim 6 or claim 7 wherein a first set of isolation regions, disposed on top of n-type regions, is arranged to isolate the n-type regions from a first set of metallic elements; and a second set of isolation regions, disposed on top of p-type regions, is arranged to isolate the p-type regions from a second set of metallic elements.

9. The method of any one of the preceding claims wherein the method further comprises the step of, prior to forming a patterned layer, etching a portion of a dielectric layer disposed between the solar cell and the polymeric layer using the polymeric layer as an etching mask.

10. The method of any one of the preceding claims wherein the method further comprises the step of selectively screen-printing a metallic material onto the polymeric layer to form the patterned layer.

11. The method of any one of the preceding claims wherein the step of forming a plurality of metallic elements onto the polymeric layer comprises the steps of:

depositing the metallic elements onto a further polymeric layer;

aligning the further polymeric layer comprising the metallic elements with the patterned conductive layer;

overlaying the further polymeric layer comprising the metallic elements onto the patterned conductive layer;

heating the structure comprising the further polymeric layer, the metallic elements and the patterned conductive layer to form an electrical contact between the metallic elements and the patterned conductive layer.

12. The method of claim 11 wherein the further polymeric layer is arranged to improve the optical performance of the solar cell.

13. The method of any one of the preceding claims wherein the step of forming a polymeric layer comprising a plurality of openings comprises the step of forming a plurality of circle openings closely spaced to each other.

14. The method of claim 13 wherein the method further comprises the step of selecting a distance between the circle openings and a size of the circle openings to minimise carrier recombination at the rear surface of the solar cell.

15. A back contact solar cell comprising:

a polymeric layer disposed on a back surface of the solar cell and comprising a plurality of openings;

a patterned conductive layer comprising a plurality of conductive regions electrically isolated from each other;

a plurality of metallic elements disposed onto the patterned layer, each metallic element being arranged to be in electrical contact with at least some of the plurality of regions of the patterned conductive layer;

wherein the plurality of openings and conductive regions are arranged in manner such that each metallic element is in electrical contact with a plurality of regions of the solar cell of the same polarity.

16. The solar cell of claim 15 wherein the solar cells comprises a plurality of p-type regions and n-type regions at the back portion and a first set of the openings is aligned with the p-type regions and a second set of openings is aligned with the n-type regions.

17. The solar cell of claim 16 wherein the a first set of the conductive regions is disposed in correspondence of the first set of openings and a second set of the conductive regions is disposed in correspondence of the second set of openings so that the first set of conductive regions are in electrical contact with the p-type regions and the second set of conductive regions are in electrical contact with the n-type regions.

18. The solar cell of any one of claims 15 to 17 wherein:

the solar cell has a substantially planar structure and the plurality of p-type regions and n-type regions

extend laterally in the same direction along the back of the solar cell; and

the openings of the first and second set are respectively aligned along the plurality of p-type regions and n-type regions.

19. The solar cell of claim 18 wherein each metallic element is disposed onto the polymeric layer in a substantially transverse orientation to the plurality of n-type regions and p-type regions.

20. The solar cell of claim 18 or claim 19 wherein the openings of the first set and second set are arranged in a pattern and define a plurality of polymeric isolation regions between the openings, the isolation regions being arranged to isolate a metallic element from a respective underlying p-type or n-type region.

21. The solar cell of any one of claims 18 to 20 wherein a plurality of electrically floating regions of the patterned conductive layer are disposed onto each isolation region and are arranged to improve adhesion of the metallic elements to the patterned conductive layer by increasing the area of contact

22. The solar cell of any one of claims 20 or claim 21 wherein a first set of isolation regions, disposed on top of n-type regions, is arranged to isolate the n-type regions from a first set of metallic elements; and a second set of isolation regions, disposed on top p-type regions, is arranged to isolate the p-type regions from a second set of metallic elements.

23. The solar cell of any one of claims 20 to 22 wherein the first set of isolation regions is spatially offset in respect to the second set of isolation regions along a direction transversal to the n-type regions and p-type regions.

24. The solar cell of any one of claims 15 to 23 wherein the metallic elements extend across one side to the other of the solar cell and have a minimum width of 100 µm.

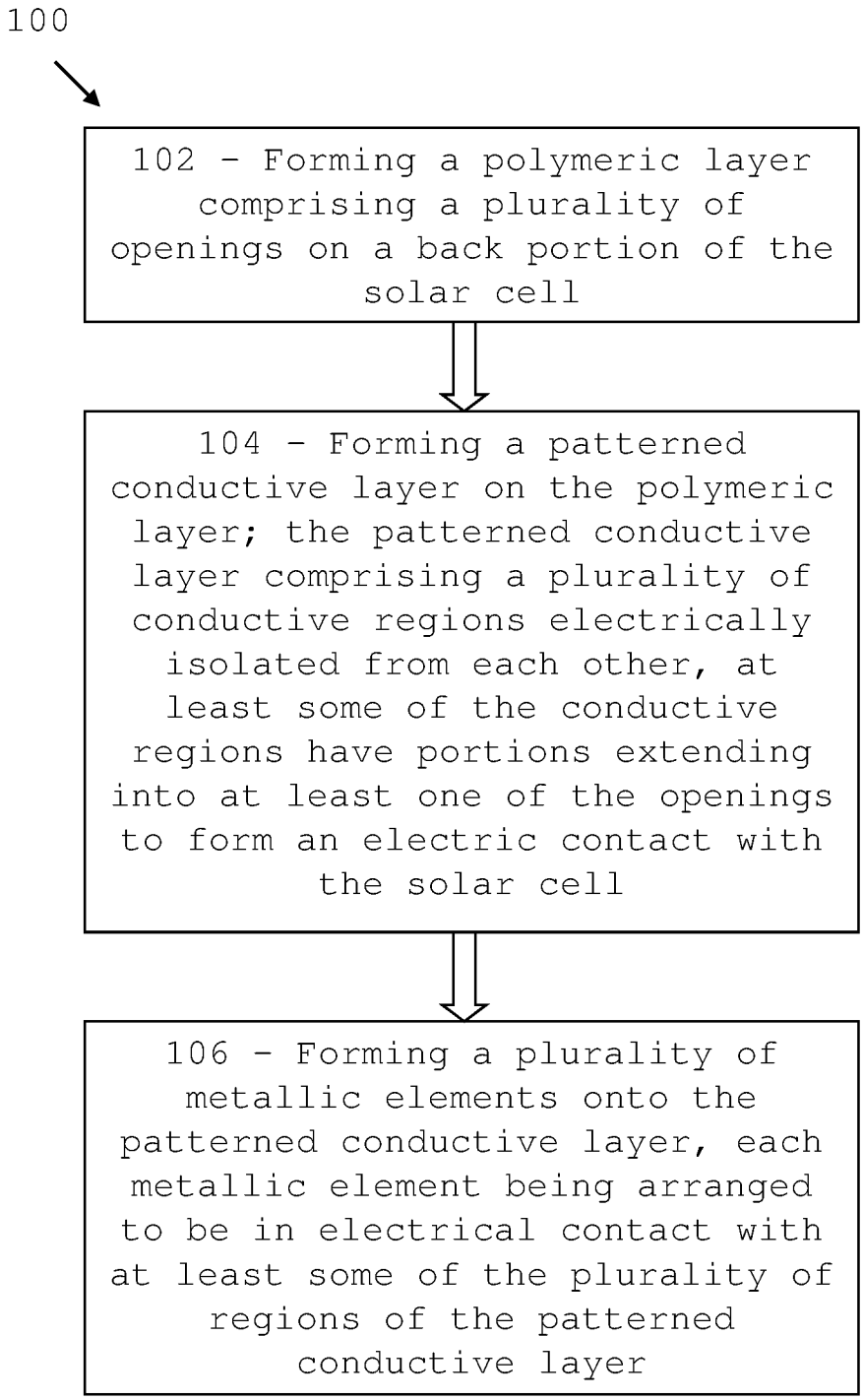

100
102 - Forming a polymeric layer comprising a plurality of openings on a back portion of the solar cell
104 - Forming a patterned conductive layer on the polymeric layer; the patterned conductive layer comprising a plurality of conductive regions electrically isolated from each other, at least some of the conductive regions have portions extending into at least one of the openings to form an electric contact with the solar cell
106 - Forming a plurality of metallic elements onto the patterned conductive layer, each metallic element being arranged to be in electrical contact with at least some of the plurality of regions of the patterned conductive layer

FIGURE 1

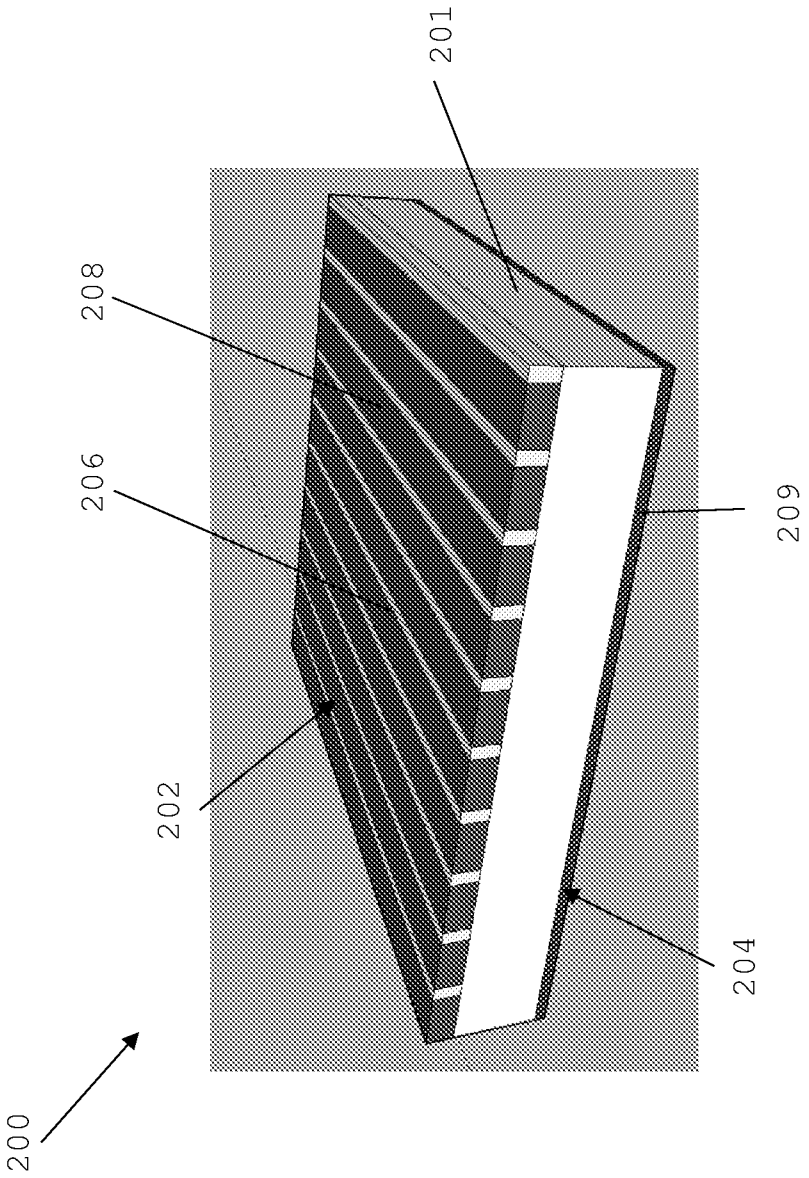


FIGURE 2

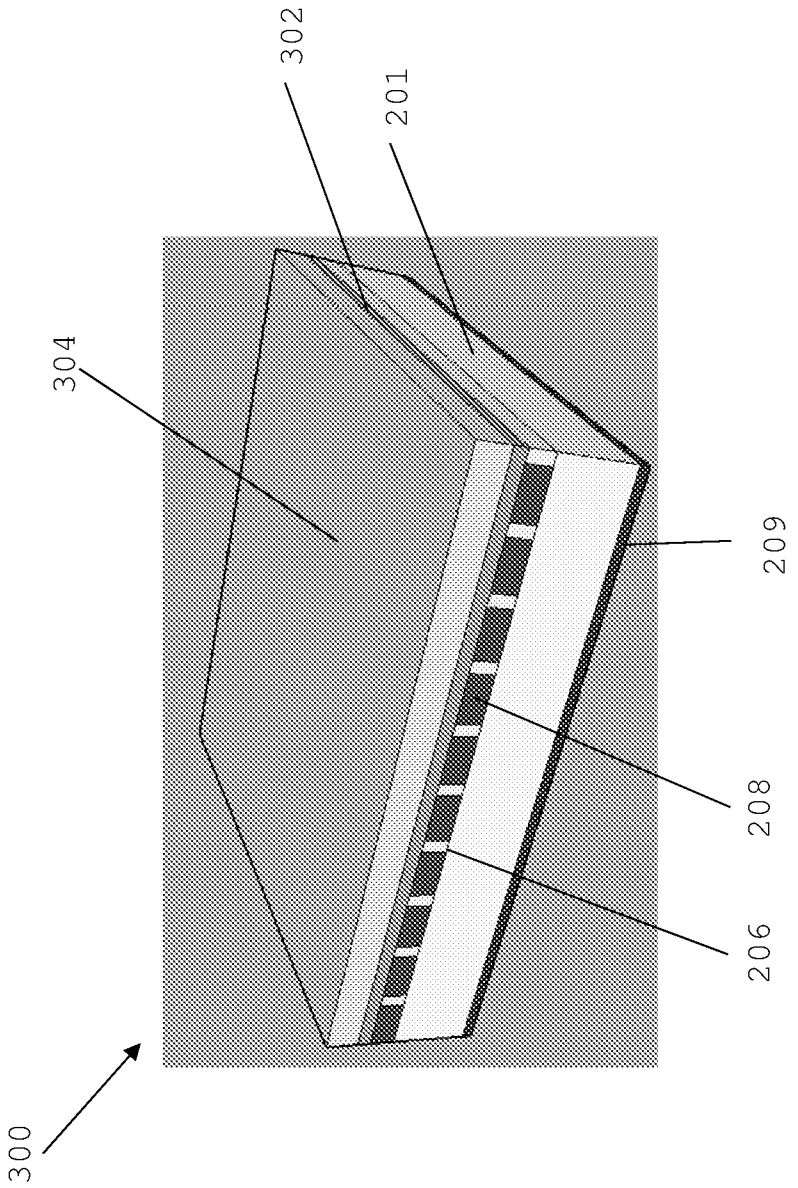


FIGURE 3

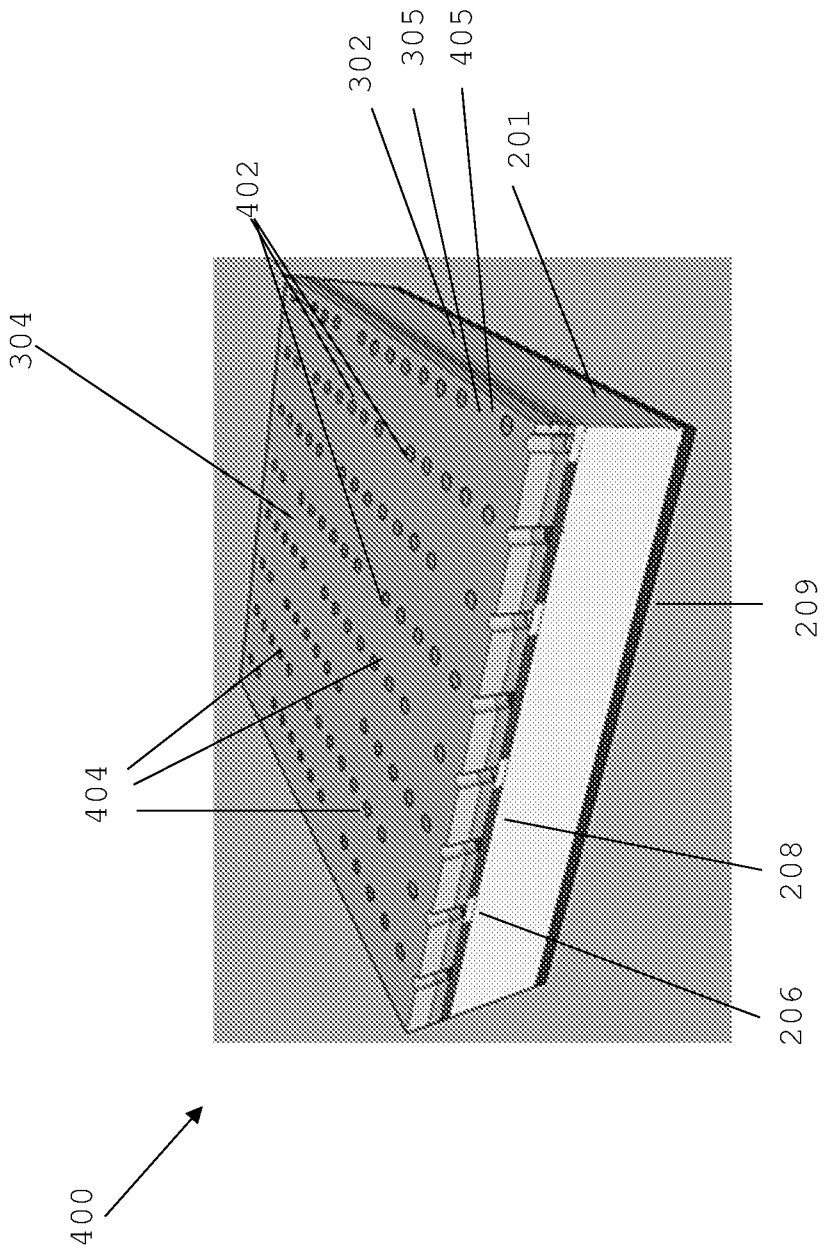


FIGURE 4

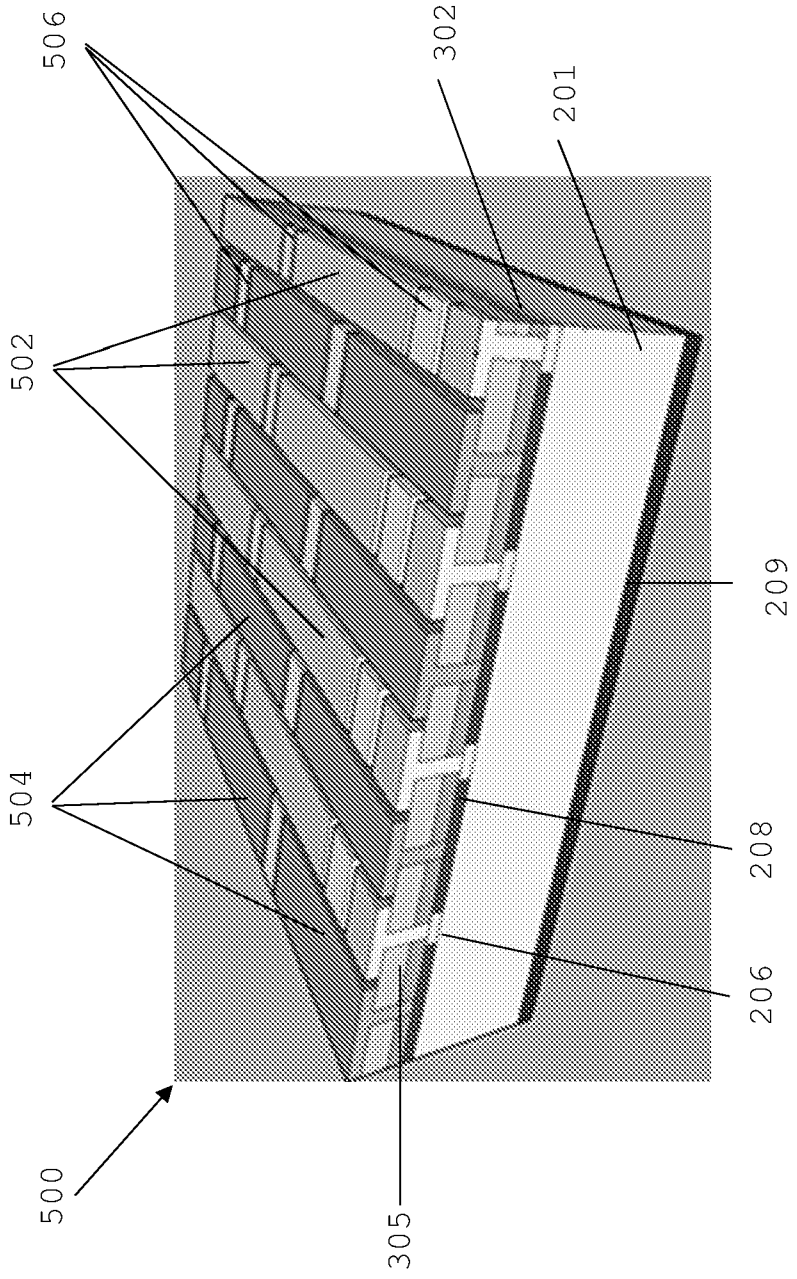


FIGURE 5

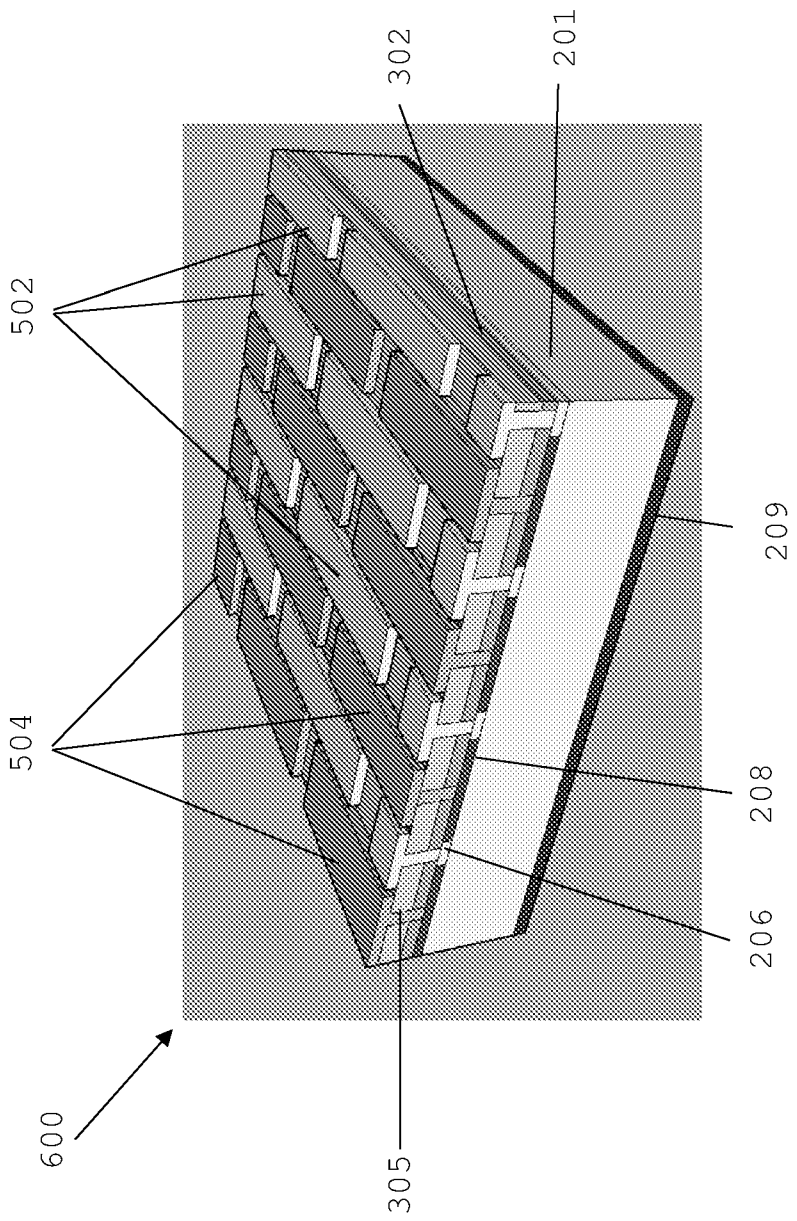


FIGURE 6

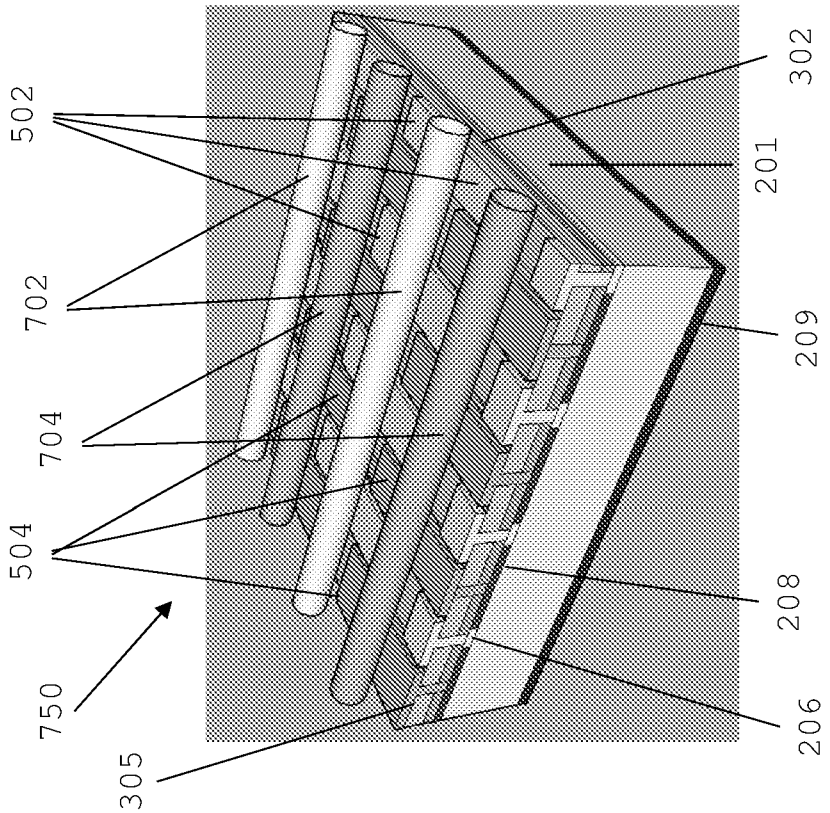


FIGURE 7(b)

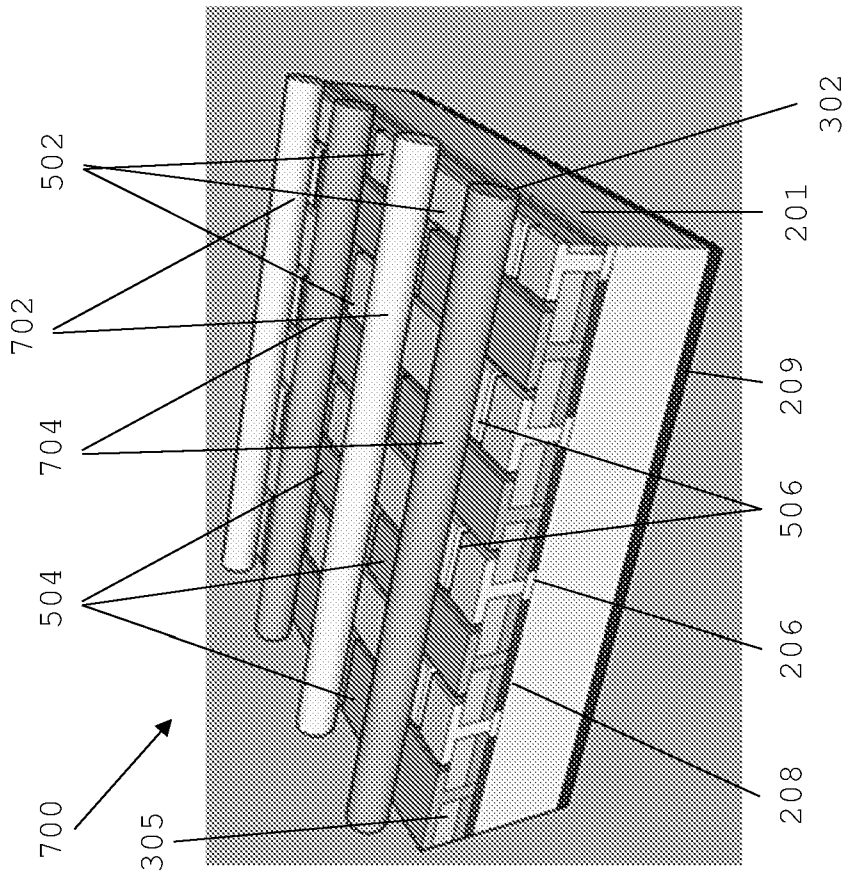


FIGURE 7(a)

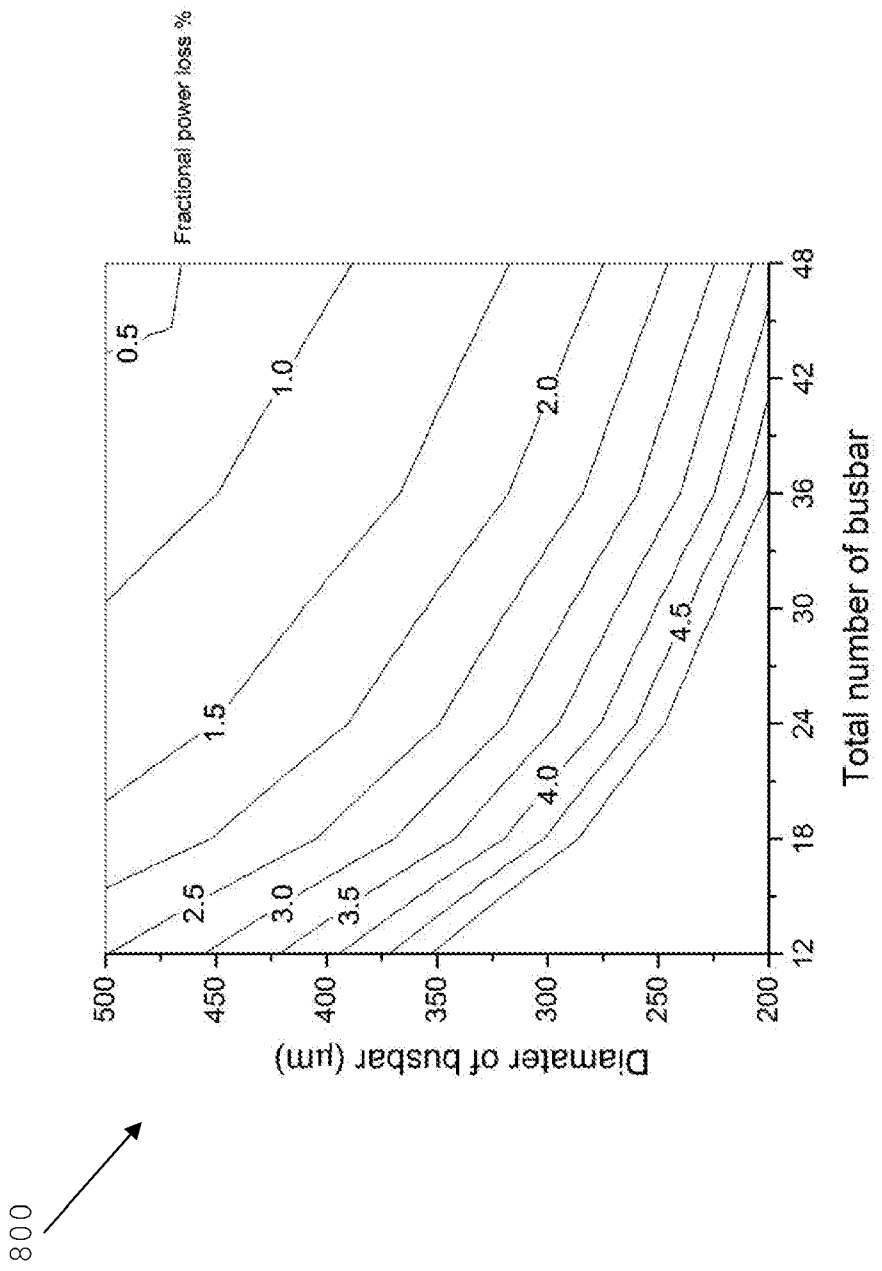

800
Diameter of busbar (μm)
500
450
400
350
300
250
200
Total number of busbar
12
18
24
30
36
42
48
Fractional power loss %
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5

FIGURE 8

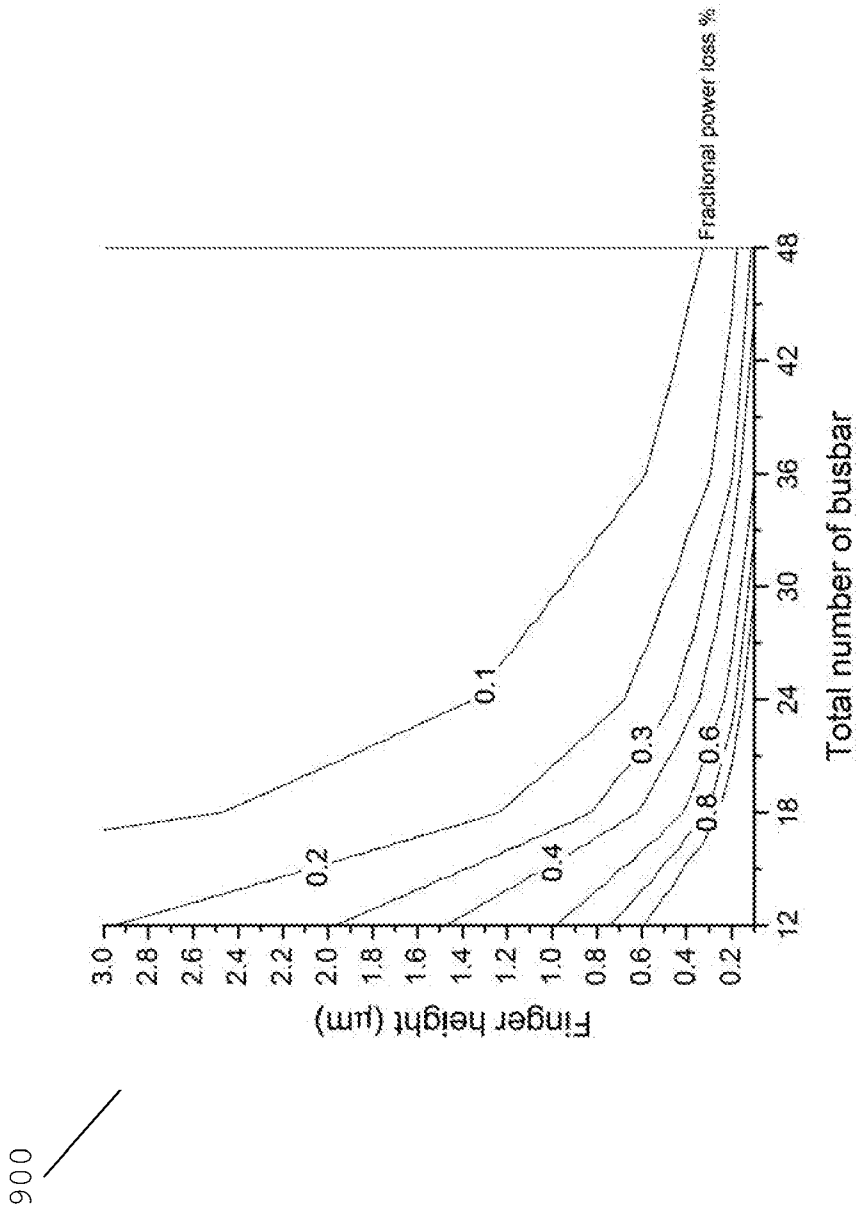

900
Finger height (μm)
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.1
0.2
0.3
0.4
0.6
0.8
Fractional power loss %
12
18
24
30
36
42
48
Total number of busbar

FIGURE 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2016/050618

A. CLASSIFICATION OF SUBJECT MATTER

H01L 31/0224 (2006.01) H01L 31/18 (2006.01) H01L 31/00 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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)

Databases: WPIAP, EPODOC, INSPEC, Google Patents, Google Scholar, Espacenet

IPC/CPC: H01L

Keywords: Solar Cell, PV, Back contact, Polymer+, Dielectric, Conduct+, Metal+, Layer, Isolat+, Region, Polarity etc.

Applicant and Inventor Search: Applicant(s) - NEWSOUTH INNOVATIONS PTY LIMITED; MEYER BURGER AG; CHANZHOU TRINA SOLAR ENERGY CO. LTD. Inventor(s) - LI, Zhongtian; LENNON, Alison Joan; HSIAO, Pei-Chieh; SOEDERSTROEM, Thomas; YAO, Yu; JIANG, Yu.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] 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

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"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	Date of mailing of the international search report
18 October 2016	18 October 2016
Name and mailing address of the ISA/AU	**Authorised officer**
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au	Steven Howell AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262837996

INTERNATIONAL SEARCH REPORT C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		International application No. **PCT/AU2016/050618**
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2013/000025 A1 (NEWSOUTH INNOVATIONS PTY LIMITED) 03 January 2013 Abstract, Page 1, Lines 11-12, Page 2, Lines 16-22, Page 3, Lines 2-4, Page 8, Lines 10-12, Page 16, Lines 4-29, Page 18, Lines 22-35, Page 23, Line 10 to Page 24, Line 12, Page 27, Line 4, Page 29, Lines 28-32, Figure 3	1-24
X	WO 2013/017616 A1 (IMEC) 07 February 2013 Page 1, Lines 3-5, Page 2, Lines 20-30, Page 2, Line 33 to Page 3, Line 12.	1-24
X	US 2010/0012172 A1 (MEAKIN et al.) 21 January 2010 Abstract, Paragraphs [0015], [0026]-[0028]	1-24
X	US 2013/0000715 A1 (SOLEXEL, INC.) 03 January 2013 Abstract, Paragraph [0014]-[0015], [0137], [0142]	1-24
A	WO 2013/181298 A1 (SOLEXEL, INC et al.) 05 December 2013 Whole Document	1-24
A	US 2010/0051085 A1 (WEIDMAN et al.) 04 March 2010 Whole Document	1-24
A	US 2013/0228221 A1 (SOLEXEL, INC.) 05 September 2013 Whole Document	1-24
A	US 2015/0136227 A1 (SOLEXEL et al.) 21 May 2015 Whole Document	1-24

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INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2016/050618**

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		US 2012028399 A1	02 Feb 2012
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		US 2010304522 A1	02 Dec 2010
		US 8420435 B2	16 Apr 2013
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INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2016/050618**

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Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
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Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2016/050618**

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Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
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