



- (51) International Patent Classification:
H01L 31/05 (2006.01) *H01L 31/0224* (2006.01)
- (21) International Application Number:
PCT/SG2012/000214
- (22) International Filing Date:
15 June 2012 (15.06.2012)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
61/497,089 15 June 2011 (15.06.2011) US
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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ,

[Continued on next page]

- (54) Title: PHOTOVOLTAIC MODULE, METHOD OF MANUFACTURING THEREOF, AND PERIPHERAL MEMBER

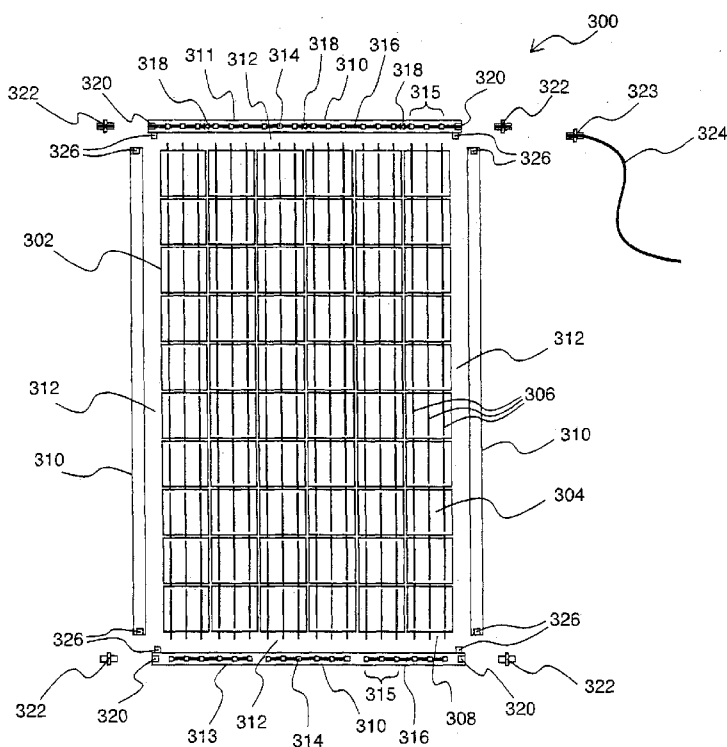


FIGURE 3

(57) Abstract: A method of manufacturing a photovoltaic (PV) module is provided including the steps of: disposing a plurality of peripheral members adjacent respective sides of an array of PV cells; mechanically connecting one or more conductive wires affixed to the array of PV cells to one or more corresponding connector elements in at least one of the peripheral members, thereby forming one or more corresponding electrical connections thereto; and laminating the array of PV cells having said one or more electrical connections formed. There is also provided a photovoltaic module and a peripheral member.



UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

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

PHOTOVOLTAIC MODULE, METHOD OF MANUFACTURING THEREOF, AND PERIPHERAL MEMBER

5 FIELD OF INVENTION

The invention relates to the field of photovoltaic (PV) electricity generation. Particularly, the invention relates to a PV module, a method of manufacturing a PV module, and a peripheral member for interconnecting with an array of PV cells.

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BACKGROUND

Photovoltaic (PV) cells, also known as solar cells, are known devices for converting light or solar energy into electrical energy. This conversion of energy is known as the PV effect. In practice, PV cells are usually electrically connected together to form a PV module, also known as a solar panel. PV modules have many applications. For example, it is common to find PV modules on building roofs functioning as power sources for converting the light energy received into electrical energy to generate electricity for various purposes.

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Conventional methods of manufacturing a PV module are often labour intensive and time consuming. For example, a conventional method typically involves the following steps in order: a tabbing process for connecting a number of PV cells into strings of PV cells, a bussing process for connecting the strings of PV cells in series, a laminating process, a framing process to frame the PV module and finally a process to affix a junction box to complete the PV module. However, the bussing process, the framing process and the process of affixing a junction box are typically labour intensive and add significant production time to produce the PV module. For example, the bussing process is typically performed manually by a person and involves taking small pieces of bussing ribbons and manually soldering them to appropriate ends of the strings of PV cells.

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It is against this background that the present invention has been developed.

SUMMARY

- 5 The present invention seeks to overcome, or at least ameliorate, one or more of the deficiencies of the prior art mentioned above.

According to a first broad aspect of the present invention, there is provided a method of manufacturing a photovoltaic (PV) module, the method comprising the
10 steps of:

disposing a plurality of peripheral members adjacent respective sides of an array of PV cells;

- mechanically connecting one or more conductive wires affixed to the array of PV cells to one or more corresponding connector elements in at least one of the peripheral members, thereby forming one or more corresponding electrical connections thereto;
15 and

laminating the array of PV cells having said one or more electrical connections formed.

- 20 Preferably, one or more sets of the connector elements in the peripheral member are pre-interconnected via one or more conductive elements in the peripheral member.

Preferably, one or more sets of the connector elements in the peripheral member are pre-interconnected with a diode therebetween.

- 25 Preferably, an assembly of one or more of said diode, one or more conductive elements, and a plurality of the connector elements in one of the peripheral members is configured to function as a junction box within said one of the peripheral members.

- 30 The step of disposing a plurality of peripheral members may comprise disposing two peripheral members adjacent respective opposing sides of the array of PV cells.

The step of disposing a plurality of peripheral members may alternatively comprise disposing four peripheral members adjacent respective sides of the array of PV cells and mechanically interconnecting the four peripheral members thereby framing the array of PV cells.

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Preferably, at least one of the peripheral members comprises a connector member, and the method further comprises interconnecting the connector member with a corresponding connector member of a peripheral member of another PV module, thereby electrically interconnecting PV module with said another PV module.

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Preferably, said interconnecting the connector member further comprises mechanically interconnecting the connector member with said corresponding connector member thereby affixing the connector member and said corresponding connector member to each other either directly or through an intermediate member disposed therebetween.

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Said one or more conductive wires affixed to the array of PV cells may be tabbing ribbons for interconnecting a column or a row of the PV cells into a string of PV cells.

Said one or more conductive elements in the peripheral member may be electrical busses for interconnecting a plurality of the strings of PV cells in series.

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According to a second broad aspect of the present invention, there is provided a photovoltaic (PV) module comprising:

an array of PV cells having one or more conductive wires affixed thereto;

a plurality of peripheral members disposed adjacent respective sides of the array of PV cells,

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wherein said one or more conductive wires are mechanically interconnected to one or more corresponding connector elements in at least one of the plurality of peripheral members, thereby forming one or more corresponding electrical connections thereto.

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Preferably, one or more sets of the connector elements in the peripheral member are pre-interconnected via one or more conductive elements in the peripheral member.

Preferably, one or more sets of the connector elements in the peripheral member are pre-interconnected with a diode therebetween.

- 5 Preferably, an assembly of one or more of said diode, one or more conductive elements, and a plurality of the connector elements in one of the peripheral members is configured to function as a junction box within said one of the peripheral members.

- 10 Two peripheral members may be disposed adjacent respective opposing sides of the array of PV cells.

Four peripheral members may be disposed adjacent respective sides of the array of PV cells and interconnected together to form a frame for the array of PV cells.

- 15 Preferably, at least one of the peripheral members comprises a connector member, the connector member configured to be electrically interconnectable with a corresponding connector member of a peripheral member of another PV module for electrically interconnecting the PV module with said another PV module.

- 20 Preferably, the connector member is further configured to be mechanically interconnectable with said corresponding connector member for affixing the connector member and said corresponding connector member to each other either directly or through an intermediate member disposed therebetween.

- 25 Said one or more conductive wires affixed to the array of PV cells may be tabbing ribbons for interconnecting a column or a row of the PV cells into a string of PV cells.

Said one or more conductive elements in the peripheral member may be electrical busses for interconnecting a plurality of the strings of PV cells in series.

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According to a third broad aspect of the present invention, there is provided a peripheral member for interconnecting with one or more conductive wires affixed to an

array of photovoltaic (PV) cells at a side of the array of PV cells, the peripheral member comprising:

one or more connector elements configured to be mechanically interconnectable with said one or more corresponding conductive wires of the array of PV cells for forming one or more corresponding electrical connections therewith.

Preferably, the peripheral member further comprises conductive elements therein, and wherein one or more sets of the connector elements are pre-interconnected via said one or more conductive elements in the peripheral member.

Preferably, one or more sets of the connector elements therein are pre-interconnected with a diode therebetween.

Preferably, an assembly of one or more of said diode, one or more conductive elements, and a plurality of the connector elements therein is configured to function as a junction box within the peripheral member.

Preferably, the peripheral member further comprises first connector members at opposing ends thereof configured to be mechanically interconnectable with one or more other peripheral members together to frame the array of PV cells.

Preferably, the peripheral member further comprises second connector members at opposing ends thereof configured to be electrically interconnectable with a corresponding second connector member of a peripheral member of another PV module for electrically interconnecting said the PV module with said another PV module.

The second connector members may be further configured to be mechanically interconnectable with said second corresponding second connector member for affixing the second connector member and the corresponding second connector element to each other either directly or through an intermediate member disposed therebetween.

Said one or more conductive wires may be tabbing ribbons for interconnecting a column or a row of the PV cells into a string of PV cells.

Said one or more conductive elements therein may be electrical busses for interconnecting a plurality of the strings of PV cells in series.

5 BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

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Figure 1 depicts a schematic back-view of a conventional photovoltaic (PV) module;

Figure 2 depicts an enlarged schematic view of a section of the conventional PV module of Figure 1;

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Figure 3 depicts a schematic back-view of a PV module according to embodiment(s) of the present invention;

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Figure 4 depicts a flow diagram of a method of manufacturing a PV module according to embodiment(s) of the present invention.

DETAILED DESCRIPTION

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Figure 1 depicts a schematic back-view of a conventional photovoltaic (PV) module 100 comprising an array 102 of PV cells 104. As illustrated, columns of the PV cells 104 are respectively interconnected by tabbing ribbons 106 to form strings of PV cells 104. The strings of PV cells 104 are interconnected by bussing ribbons 108 to form a continuous electrical circuit throughout the PV module 100.

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Figure 2 depicts an enlarged schematic view of section A of Figure 1 showing details of the connections of the bussing ribbons 108 to connection points 110 in a junction box 112 (not shown in Figure 1) connected to external cables 114. The junction box 112 is firmly attached onto the backsheet of the PV module 100 for

providing positive and negative output connections 116 to transmit electric current from the PV module to external cables to be used for various purposes. Additionally, the junction box 112 serves as a protective structure to protect the connections therein whereby the junction box 112 is typically filled with a protective sealant (not shown). The junction box 112 comprises bypass diodes 118 between adjacent connection points 110 for purposes known in the art and need not be described herein.

An exemplary conventional method of manufacturing the conventional PV module 100 as depicted in Figures 1 and 2 will now be described below.

1. Stringing

- a. Interconnect columns of PV cells 104 into respective strings of PV cells 104.

For example, as shown in Figure 1, a string of PV cells 104 may be 10 cells long.

In this stringing process, tabbing ribbons 106 are soldered onto the front and back surfaces of a column of PV cells for connecting the column of PV cells into a string. This stringing process may be performed by hand with a soldering iron or by a machine called a stringer.

2. First Lay-up

- a. Place a cover glass onto a lay-up station.
- b. Place a first sheet of encapsulant material, typically Ethylene Vinyl Acetate (EVA), onto the cover glass.
- c. Lay-up the strings of PV cells 104, i.e., placing the strings onto the EVA whereby alternate strings are arranged to face opposite directions to facilitate series interconnection of the strings.

3. Bussing

- a. Solder the strings of PV cells 104 together at ends thereof using bussing ribbons 108 to form a continuous electrical circuit throughout the PV module 100.

This bussing process involves taking small pieces of bussing ribbons 108 and soldering them to the ends of the tabbing ribbons 106. This bussing process is

typically done by hand using a soldering iron and represents a labour intensive process when manufacturing the PV module 100. Bussing ribbons 108 are also soldered onto the PV module at this stage to provide electrical connections to the junction box 112. The 90-degree bend 120 of the bussing ribbon 108 shown in Figure 2 is made by either folding the bussing ribbon 108 or soldering two pieces of bussing ribbons 108 at right angle to each other.

In this bussing process, care must be taken while performing the soldering to avoid melting the first sheet of encapsulant material. In addition, care must also be taken not to create an electrical short where the bussing wires 108 cross-over or intersect 122 as shown in Figure 2. This is achieved by placing a small piece of EVA or backsheet between the bussing ribbons 108 at each location 122 where there is an intersection. Such delicate steps typically add considerable time and risk to the manufacturing process.

4. Second Lay-up

- a. Place a second sheet of encapsulant material (e.g. EVA) over the laid-up PV cells 104. This step is usually performed by hand where extra care must be taken not to inadvertently move the laid PV cells 104. In addition, bussing ribbons 108 for connections to the junction box 400 are arranged to pass through a slit 124 made in the second sheet of encapsulant material.
- b. Place a backsheet (e.g., made under the trademark Tedlar or similar) onto the back of the second sheet of encapsulant material. Again extra care must be taken not to inadvertently move the laid PV cells 104. Additionally, bussing ribbons 108 for connections to the junction box 112 are arranged to pass through the slit 124 made in the backsheet.

5. Lamination

- a. Laminate the PV module 100. This laminating process includes melting and cross-linking the encapsulant and bonding all the components together (i.e., glass, encapsulant, PV cells, ribbons and backsheet).

6. Framing

- a. Trim the excess encapsulant and backsheet around the edge of the PV laminate with a knife.
- b. Obtain four frame elements and dispense potting agent (typically silicone rubber) into channels of the four frame elements.
- 5 c. Position corner clips in corners of the frame elements.
- d. Place the four frame elements and the PV laminate into a framing press.
- e. Activate the framing press to secure the frame elements around the PV laminate.
- f. Wipe off any excess potting agent that has been squeezed out from between the frame channel and the PV laminate.
- 10 7. Junction box
- a. Dispense potting agent around edges of the junction box 112 and affixing the junction box 112 to the backsheet of the PV module 100.
- b. Connect junction box ribbons to the junction box (either by soldering or specially
15 used).

Therefore, it can be seen that the conventional method of manufacturing the PV module 100 described above involves a number of labour intensive and delicate steps, such as the bussing and framing steps. The need to affix a junction box 112
20 to the backsheet of the PV module 100 after the PV laminate has been framed adds further production time to the manufacturing process. In addition to being labour intensive, such steps also introduce certain risks to the manufacturing process as they are prone to human errors (e.g., when soldering bussing ribbons) which may result in production delays or reduced production yield. Although a number of the
25 above steps can be automated to reduce the production time, however, this can be prohibitive due to the large capital investment required and the additional continued costs associated with maintaining the machineries.

Embodiments of the present invention seek to overcome, or at least ameliorate, one
30 or more of the above-mentioned problems.

Figure 3 illustrates an exploded schematic back-view of a photovoltaic (PV) module (or a solar panel) 300 according to a first exemplary embodiment of the present invention. The PV module 300 comprises an array 302 of PV cells 304 for converting light or solar energy into electrical energy through the photovoltaic effect. In the PV module 300, each column of the PV cells 304 are interconnected by one or more conductive wires 306 thereby forming a corresponding string 308 of PV cells 304. It will be appreciated to a person skilled in the art that the columns of the PV cells 304 in Figure 3 can instead be rows of the PV cells 304 depending on the orientation of the PV module 300. Therefore, the array 302 of PV cells has one or more conductive wires 306 affixed thereto. In a preferred embodiment, the conductive wires 306 are tabbing ribbons (also known as stringing ribbons). In the exemplary PV module 300, three strings of conductive wires 306 are shown affixed to a column of PV cells 304 for illustration purposes only. It is apparent to a person skilled in the art that more or less strings of conductive wires 306 can be affixed to a column of PV cells 304 as desired for various reasons.

The exemplary PV module 300 comprises a plurality of peripheral members 310 disposed adjacent respective sides 312 of the array 302 of PV cells 304. In the first exemplary embodiment, the PV module 300 comprises four peripheral members 310 disposed adjacent four respective sides 312 of the array 302 of PV cells 304, such as a top, a bottom, a left and a right peripheral members 310. In a completed PV module 300, the four peripheral members 310 are interconnected together, preferably mechanically, at respective ends thereof for framing the array 302 of PV cells 304. In this regard, the peripheral members 310 can be referred to as frame members for framing the PV module 300. However, it is apparent to a person skilled in the art that fewer than four peripheral members 310 may be provided depending on the type of PV module to be manufactured. For example, for a glass-glass type PV module (not shown), only two peripheral members 310 (e.g., the top and bottom peripheral members 311, 313) may be provided adjacent opposing sides 312 of the PV module 300. In a preferred embodiment, the peripheral member 310 is an electrically insulating material. For example, the peripheral member 310 may be injection moulded.

In the exemplary PV module 300 shown in Figure 3, two opposing peripheral members 310 (e.g., the top and bottom peripheral members 311, 313) comprise a plurality of connector elements 314 formed therein, each configured or adapted to be mechanically interconnectable to a conductive wire 306 affixed to the array 302 of PV cells 304 to form an electrical connection. The connector elements 314 are affixed or integrated in the peripheral member 310, that is, they are pre-made in the peripheral member 310. For example, the connector element 314 may be a connection clip or any device capable of holding a wire placed therein to form an electrical connection. In the exemplary PV module 300, a set 315 of connector elements 314 in the peripheral member 310 corresponds to a string 308 of PV cells 304. By way of example only, as illustrated in Figure 3, a set 315 includes three connector elements 314 configured for receiving three corresponding conductive wires 306 affixed to the corresponding string 308 of PV cells 304. In the peripheral member 310, predetermined adjacent sets 315 of the connector elements 314 are pre-interconnected together via conductive elements 316. For example, the conductive element 316 can be a conductive wire or a stamped metal part. In a preferred embodiment, the conductive elements 316 in the peripheral member 310 are electrical busses. Therefore, by pre-interconnecting (i.e., prior to assembling or making the PV module 300) appropriate sets 315 of the connector elements 314 via electrical busses 316, the peripheral member 310 advantageously has integrated busses. Accordingly, the bussing process involving soldering for connecting strings of PV cells together required in a typical conventional method can be eliminated.

In the exemplary PV module 300, sets 315 of the connector elements 314 are interconnected by the conductive elements 316 such that, when ends of the conductive wires 306 of the array 302 of PV cells 304 are attached or clipped thereto, adjacent strings 308 of PV cells 304 are connected in series thereby allowing electric current generated in each string of PV cells to flow to an electrical output of the PV module 300. Therefore, predetermined adjacent sets of the connector elements 314 are not interconnected by conductive elements 316 to achieve such electric current flow. By way of example, as illustrated in Figure 3, alternate adjacent pair sets 315 of connector elements 314 in the peripheral

members 310 are not interconnected by the conductive elements 316. Furthermore, the alternate adjacent pair sets 315 are arranged such that adjacent pair sets 315 of connector elements 314 in one peripheral member 310 (corresponding to adjacent pair strings 308 of PV cells 304) are not interconnected by the conductive elements 316 but an opposing adjacent pair sets 315 of connector elements 314 in an opposing peripheral member 310 (corresponding to the same adjacent pair strings 308 of PV cells 304) are interconnected by the conductive elements 316. In one of the above-mentioned two opposing peripheral members 310 (e.g., the top peripheral member 311), there is provided one or more diodes 318 pre-interconnected between one or more predetermined sets 315 of the connector elements 314. For example, a diode 318 is provided between adjacent sets 315 of the connector elements 314 not interconnected by the conductive elements 316 as explained above. Preferably, the diode 318 is a bypass diode for allowing current to pass around a string 308 of PV cells 304 not generating sufficient electric current (e.g., the string of PV cells may be a shaded area).

In a preferred embodiment, the interconnection of the connector elements 314, the conductive elements 316 and diodes 318 provided or integrated in one of the peripheral members 310 as shown in Figure 3 is configured to function as a junction box in the peripheral member 310. Therefore, advantageously, it is no longer necessary to affix a junction box to a PV module required as a last step in a typical conventional method. That is, the peripheral member 310 (e.g., the top peripheral member 311) can be considered as having integrated busses and as having an integrated junction box.

It will be appreciated to a person skilled in the art that an exploded view of the PV module 300 is shown in Figure 3. Therefore, the conductive wires 306 are not shown connected to the corresponding connector elements 314. It will be appreciated to a person skilled in the art that, as described hereinbefore, the conductive wires 306 are connected to corresponding connector elements 314 in the two opposing peripheral members 310 for forming corresponding electrical connections thereto.

In the first exemplary PV module 300, each peripheral member 310 further comprises first connector members 326 at opposing ends thereof for connecting or affixing the peripheral members 310 to each other. For example, the first connector members 326 can be in the form of male/female connector pairs whereby a male connector is disposed at one end of a peripheral member 310 and a female connector is disposed at one end of an adjacent peripheral member 310 to be affixed to each other when interconnecting the peripheral members 310 together. In a preferred embodiment, the first connector members 326 are of clip-type thereby allowing corresponding connector members 326 to be mechanically interconnected to each other through the application of a pushing force. As a result, the peripheral members 310 can be interconnected together relatively quickly and easily by "clicking" them together at appropriate ends thereof.

In a preferred embodiment, two opposing peripheral members 310 (e.g., the top and bottom peripheral members 311, 313) each further comprises second connector members 320 at opposing ends thereof. The second connector member 320 is configured to be interconnectable with a corresponding connector member of a peripheral members of another (e.g., adjacent) PV modules (not shown). Therefore, this enables PV modules 300 according to the embodiment to be interconnected to each other to form a PV system. The second connector members 320 can be of any type capable of being mechanically interconnected to a corresponding connector member of another peripheral member (not shown) either directly or via an intermediate connector member 322. For example, adjacent PV modules 300 can be affixed to each other by mechanically interconnecting respective opposing peripheral members 310 of the adjacent PV modules with intermediate connector members 322. For example, the second connector members 320 can be female-type connectors and the intermediate connector members 322 can be male-type connectors configured to be mechanically interconnected together. Furthermore, the second connector members 320 of one of the two opposing peripheral members 310 (e.g., the top peripheral member 311) are further electrically interconnected with the connector elements 314 in the peripheral member 310 so as to be electrically interconnected with the array 302 of PV cells 304. Therefore, the second connector members 320 of, e.g., the top peripheral member 311 further function to electrically interconnect the array 302 of PV cells 304 or the PV module 300 with an adjacent

PV module to form an electrically interconnected PV system. In this regard, for example, the intermediate connector member 322 is electrically conductive. It will be appreciated to a person skilled in the art that one or more of the second connector members 320 may also function as an electrical output of the PV module or system (e.g., a last PV module in the PV system). For example, the second connector member 320 may be connected to a connector end 323 of an electric cable 324 to connect to an output circuit such as an inverter (not shown), or another string of PV modules (not shown).

According to a second exemplary embodiment of the present invention, there is provided a peripheral member 310 for interconnecting with one or more conductive wires affixed to an array 302 of photovoltaic (PV) cells 304 at a side 312 of the array 302 of PV cells 304. The peripheral member 310 is the same as that described hereinbefore in the first embodiment and thus will not be repeated for conciseness. For example, when manufacturing a glass-encapsulant-backsheet type PV module, four peripheral members 310 may be disposed adjacent respective four sides 312 of the array 302 of PV cells 304 and then mechanically interconnected together thereby forming a rigid rectangle structure for framing the array 302 of PV cells 304. In this regard, the peripheral members 310 can be regarded as frame members for framing the PV module 300. Alternatively, when manufacturing a glass-glass type PV module, two opposing peripheral members 311, 313 may be placed adjacent respective opposing two sides of an array 302 of PV cells 304. As described hereinbefore, the top peripheral member 311 comprises connector members 320 for electrically and mechanically interconnecting adjacent PV modules together.

As described hereinbefore with reference to Figures 1 and 2, a typical conventional method of manufacturing a PV module requires a bussing process of soldering strings of PV cells together at ends thereof using bussing ribbons, and then followed by a lay-up process and a laminating process to laminate the PV module. The PV laminate is subsequently framed and then finished off by affixing a junction box thereto to completed the PV module. As explained, the above steps are labour intensive and time consuming. Embodiments of the present invention seek to address such problems by providing a plurality of peripheral members 310 as described in the first and second embodiments of

the present invention having integrated busses. Furthermore, at least one of the peripheral members 310 further has functions of a junction box integrated therein. Accordingly, the peripheral member 310 according to embodiments of the present invention has integrated busses and junction box. As a result, both the bussing step and the step of affixing a junction box to the PV module can be eliminated from the manufacturing process thereby greatly simplifying the manufacturing process as well as resulting in significant saving in manual labour.

An exemplary method of manufacturing the PV module 300 illustrated in Figure 3 according to a third embodiment of the present invention will now be described with reference to Figure 4. The method comprises an initial step 400 of disposing a plurality of peripheral members 310 adjacent respective sides of an array 302 of PV cells 304. For example, when manufacturing a glass-encapsulant-backsheet type PV module such as that shown in Figure 3, four peripheral members 310 may be disposed adjacent respective four sides of the array 302 of PV cells 304. Alternatively, when manufacturing a glass-glass type PV module (not shown), two opposing peripheral members 310 may be disposed adjacent respective opposing two sides of an array 302 of PV cells 304. Subsequently, in step 402, conductive wires affixed to the array 302 of PV cells 304 are connected to corresponding connector elements 314 of the peripheral members 310, thereby forming corresponding electrical connections thereto. Thereafter, in step 404, the array of PV cells, with the conductive wires 306 connected to the corresponding connector elements 314 of the peripheral members, are laminated. The laminating process is known in the art and thus will not be described herein for conciseness.

Specific non-limiting examples of the method of manufacturing the PV module 300 will be described below for illustration purposes only. It will be apparent to a person skilled in the art that the method is not limited to such specific examples. For example, specific elements may be used in the examples below for illustration purposes but the present invention is not limited to such specific elements.

A non-limiting example of manufacturing a glass-encapsulant-backsheet type PV module will now be described below according to an embodiment of the present invention.

1. Stringing

- a. Interconnecting columns of PV cells 304 into respective strings 308 of PV cells 304. The stringing (also known as tabbing) process is known in the art and thus need not be described herein.

5 However, since the peripheral member 310 has built-in or integrated busses 316 therein, this advantageously enables the length of the tabbing ribbons 306 extending from the first and last PV cell 304 in each string 308 to be the same for all strings 308 as illustrated in Figure 3. This is not the case in conventional art as for example illustrated in Figure 1. This means that no manual trimming of
10 tabbing ribbons 306 is required according to the exemplary embodiments of the present invention

2. Framing

- a. Providing four peripheral members 310 for framing the array 302 of PV cells 304. As described hereinbefore, two opposing peripheral members (e.g., top and
15 bottom peripheral members 311, 313) have integrated busses and one peripheral member (e.g., top peripheral member 311) has functions of a junction box integrated therein.
- b. Mechanically interconnecting (e.g., "clicking") ends of the four peripheral members 310 together forming a rigid rectangular structure.

20 3. Lay-up

- a. Place a cover glass onto a lay-up station
- b. Place a first encapsulant sheet onto the cover glass
- c. Place the interconnected peripheral members 310 around the cover glass.
- d. Place the array 302 of PV cells 306 onto the first encapsulant sheet
- 25 e. Attach ends of the tabbing ribbons 306 of the strings 308 to the corresponding connector elements 314 to the top and bottom peripheral members 311, 313.
- f. Place a second encapsulant sheet onto the array 302 of PV cells 304.
- g. Place a backsheet over the second encapsulant sheet.

- h. Clip covers for the connector elements 314 of the top and bottom peripheral member 311, 313 into place to cover the electrical connections.

4. Lamination

- a. Laminate the PV module 300. This step includes melting and cross-linking the encapsulant and bonding all the components together (i.e., glass, encapsulant, PV cells, ribbons, frame and backsheet). The laminating process is known in the art and thus need not be described in detail herein.

A non-limiting example of manufacturing a glass-glass type PV module, either with or without encapsulant between the glass layers, will now be described below according to an embodiment of the present invention.

1. Stringing

- a. Interconnecting columns of PV cells 304 into respective strings 308 of PV cells 304. This step is the same as the stringing step described hereinbefore for the glass-encapsulant-backsheet type PV module.

2. Lay-up

- a. Lay-up a first glass sheet
- b. Either
 - i. Lay-up a first encapsulant sheet or
 - ii. Dispense sealant around edges of the first glass sheet
- c. Dispose peripheral members 310 adjacent respective sides of the glass sheet, and place the array 302 of PV cells 304 on the first encapsulant sheet or the first glass sheet. For example, two peripheral members 310 may be provided on respective opposite sides of the array 302 of PV cells 304. Alternatively, four peripheral members 310 may be provided on four respective sides 312 of the array 302 of PV cells 304.
- d. Attach ends of the tabbing ribbons 306 of the strings 308 to the corresponding connector elements 314 in two opposing peripheral members 311, 313.

e. Either

i. Lay-up a second encapsulant sheet, or

ii. Dispense additional sealant around the edges of the first glass sheet

f. Lay-up a second glass sheet on the second encapsulant sheet or the array 302 of PV cells 304.

3. Lamination

a. Laminating the PV module 300. For example, this can be achieved by thermal lamination or UV curing. The laminating process is known in the art and thus need not be described in detail herein.

Therefore, according to embodiments of the present invention described hereinbefore, the most labour intensive steps of the PV module manufacturing process, i.e., bussing, framing and affixing of a junction box, have either been eliminated completely or greatly simplified resulting in significant savings in both costs and time.

Additional advantages of or improvements to the PV module 300 or peripheral member 310 according to embodiments of the present invention will now be described.

In an embodiment, the peripheral member 310 may have a rebate configured to fit snugly around the glass sheet. As a result, the peripheral member 310 does not wrap around the edges and onto a front surface of the glass sheet (which is a design feature of a typical conventional PV module) causing soiling of the cover glass by allowing water to pool at the lower edge of the PV module surface once the PV module has been installed. This type of soiling would be completely eliminated with this embodiment because the water on the PV module surface could run off the edges without being trapped.

As described hereinbefore, since there is no junction box affixed on the back of the PV module 300, the module frame (peripheral member 310) can be made with a lower profile, allowing stacked modules to occupy less space. In addition, the peripheral members 310 or frame may have corners configured for easy and safe stacking of

modules for transportation, such as interlocking tabs. This removes the need for special stacking clips which are used in conventional PV modules with aluminium profile frames. Furthermore, the peripheral member or frame may additionally have holes therein at predetermined locations to facilitate easy mounting of the modules.

5

As described hereinbefore, embodiments of the present invention also provide means of interconnecting adjacent PV modules together in a PV installation, for example, including:

- 10 • Double-ended active male connectors 322 clip into the active female connectors 320 in the top peripheral member 311 to provide both electrical and mechanical interconnection between adjacent PV modules in a PV system;
- 15 • Double-ended passive male connectors 322 clip into the passive female connectors 320 in the bottom peripheral member 313 to provide mechanical interconnection between adjacent PV modules in a PV system; and
- 20 • Single-ended active male connectors 323 clip into the active female connectors in the top peripheral member 311 to provide connection from the PV module to a electric cable 324 for subsequent connection to an inverter.

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

30

CLAIMS

1. A method of manufacturing a photovoltaic (PV) module, the method comprising the steps of:

5 disposing a plurality of peripheral members adjacent respective sides of an array of PV cells;

mechanically connecting one or more conductive wires affixed to the array of PV cells to one or more corresponding connector elements in at least one of the peripheral members, thereby forming one or more corresponding electrical connections thereto;
10 and

laminating the array of PV cells having said one or more electrical connections formed.

2. A method according to claim 1, wherein one or more sets of the connector elements in the peripheral member are pre-interconnected via one or more conductive
15 elements in the peripheral member.

3. A method according to claim 1 or 2, wherein one or more sets of the connector elements in the peripheral member are pre-interconnected with a diode therebetween.
20

4. A method according to claim 3, wherein an assembly of one or more of said diode, one or more conductive elements, and a plurality of the connector elements in one of the peripheral members is configured to function as a junction box within said one of the peripheral members.
25

5. A method according to any one of claims 1 to 4, wherein said step of disposing a plurality of peripheral members comprises disposing two peripheral members adjacent respective opposing sides of the array of PV cells.

6. A method according to any one of claims 1 to 4, wherein said step of disposing a plurality of peripheral members comprises disposing four peripheral members adjacent respective sides of the array of PV cells and mechanically interconnecting the four peripheral members thereby framing the array of PV cells.
30

7. A method according to any one of claims 1 to 6, wherein at least one of the peripheral members comprises a connector member, and the method further comprises interconnecting the connector member with a corresponding connector member of a peripheral member of another PV module, thereby electrically interconnecting PV module with said another PV module.

8. A method according to claim 7, wherein said interconnecting the connector member further comprises mechanically interconnecting the connector member with said corresponding connector member thereby affixing the connector member and said corresponding connector member to each other either directly or through an intermediate member disposed therebetween.

9. A method according to any one of claims 1 to 8, wherein said one or more conductive wires affixed to the array of PV cells are tabbing ribbons for interconnecting a column or a row of the PV cells into a string of PV cells.

10. A method according to claim 9, wherein said one or more conductive elements in the peripheral member are electrical busses for interconnecting a plurality of the strings of PV cells in series.

11. A photovoltaic (PV) module comprising:
an array of PV cells having one or more conductive wires affixed thereto;
a plurality of peripheral members disposed adjacent respective sides of the array of PV cells,

wherein said one or more conductive wires are mechanically interconnected to one or more corresponding connector elements in at least one of the plurality of peripheral members, thereby forming one or more corresponding electrical connections thereto.

12. The PV module according to claim 11, wherein one or more sets of the connector elements in the peripheral member are pre-interconnected via one or more conductive elements in the peripheral member.

13. The PV module according to claim 11 or 12, wherein one or more sets of the connector elements in the peripheral member are pre-interconnected with a diode therebetween.

5

14. The PV module according to claim 13, wherein an assembly of one or more of said diode, one or more conductive elements, and a plurality of the connector elements in one of the peripheral members is configured to function as a junction box within said one of the peripheral members.

10

15. The PV module according to any one of claims 11 to 14, wherein two peripheral members are disposed adjacent respective opposing sides of the array of PV cells.

15

16. The PV module according to any one of claims 11 to 14, wherein four peripheral members are disposed adjacent respective sides of the array of PV cells and interconnected together to form a frame for the array of PV cells.

20

17. The PV module according to any one of claims 11 to 16, wherein at least one of the peripheral members comprises a connector member, the connector member configured to be electrically interconnectable with a corresponding connector member of a peripheral member of another PV module for electrically interconnecting the PV module with said another PV module.

25

18. The PV module according to claim 17, wherein the connector member is further configured to be mechanically interconnectable with said corresponding connector member for affixing the connector member and said corresponding connector member to each other either directly or through an intermediate member disposed therebetween.

30

19. The PV module according to any one of claims 11 to 18, wherein said one or more conductive wires affixed to the array of PV cells are tabbing ribbons for interconnecting a column or a row of the PV cells into a string of PV cells.

20. The PV module according to claim 19, wherein said one or more conductive elements in the peripheral member are electrical busses for interconnecting a plurality of the strings of PV cells in series.

5 21. A peripheral member for interconnecting with one or more conductive wires affixed to an array of photovoltaic (PV) cells at a side of the array of PV cells, the peripheral member comprising:

one or more connector elements configured to be mechanically interconnectable with said one or more corresponding conductive wires of the array of PV cells for forming
10 one or more corresponding electrical connections therewith.

22. The peripheral member according to claim 21, wherein the peripheral member further comprises conductive elements therein, and wherein one or more sets of the connector elements are pre-interconnected via said one or more conductive elements in
15 the peripheral member.

23. The peripheral member according to claim 21 or 22, wherein one or more sets of the connector elements therein are pre-interconnected with a diode therebetween.

20 24. The peripheral member according to claim 25 or 26, wherein an assembly of one or more of said diode, one or more conductive elements, and a plurality of the connector elements therein is configured to function as a junction box within the peripheral member.

25 25. The peripheral member according to any one of claims 21 to 24, further comprising first connector members at opposing ends thereof configured to be mechanically interconnectable with one or more other peripheral members together to frame the array of PV cells.

30 26. The peripheral member according to any one of claims 21 to 25, further comprising second connector members at opposing ends thereof configured to be electrically interconnectable with a corresponding second connector member of a

peripheral member of another PV module for electrically interconnecting said the PV module with said another PV module.

27. The peripheral member according to claim 26, wherein the second connector members are further configured to be mechanically interconnectable with said second corresponding second connector member for affixing the second connector member and the corresponding second connector element to each other either directly or through an intermediate member disposed therebetween.

28. The peripheral member according to any one of claims 21 to 27, wherein said one or more conductive wires are tabbing ribbons for interconnecting a column or a row of the PV cells into a string of PV cells.

29. The peripheral member according to claim 28, wherein said one or more conductive elements therein are electrical busses for interconnecting a plurality of the strings of PV cells in series.

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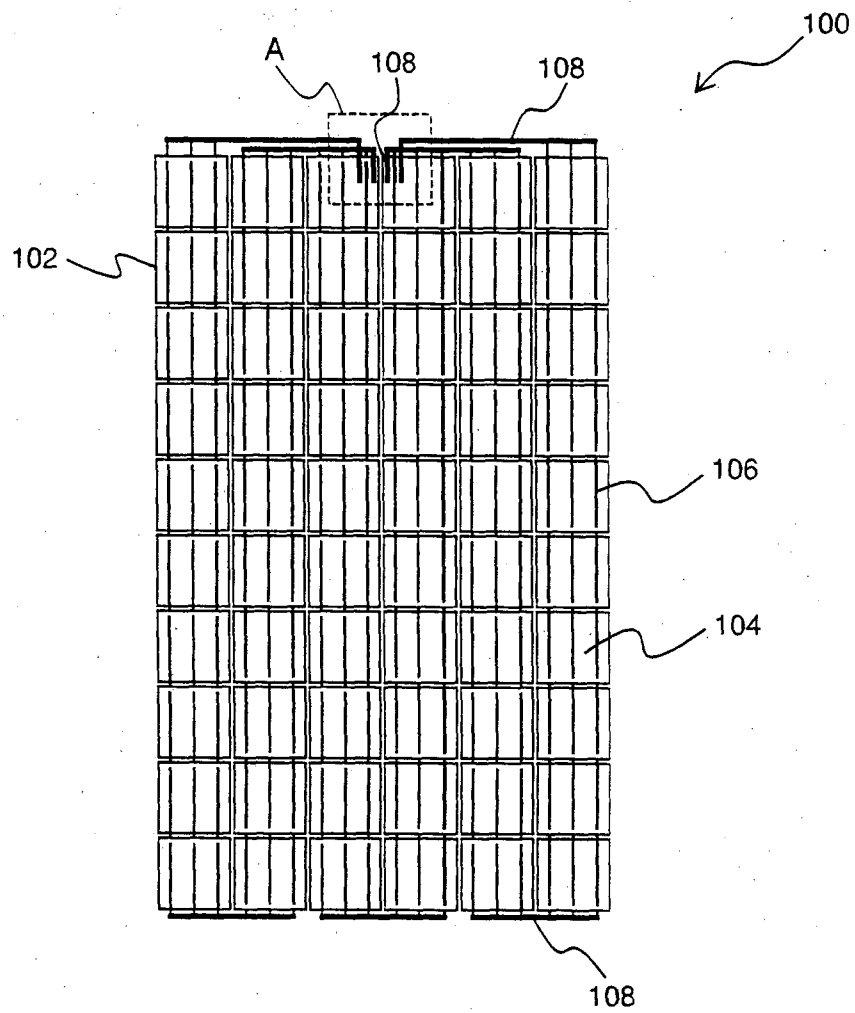


FIGURE 1

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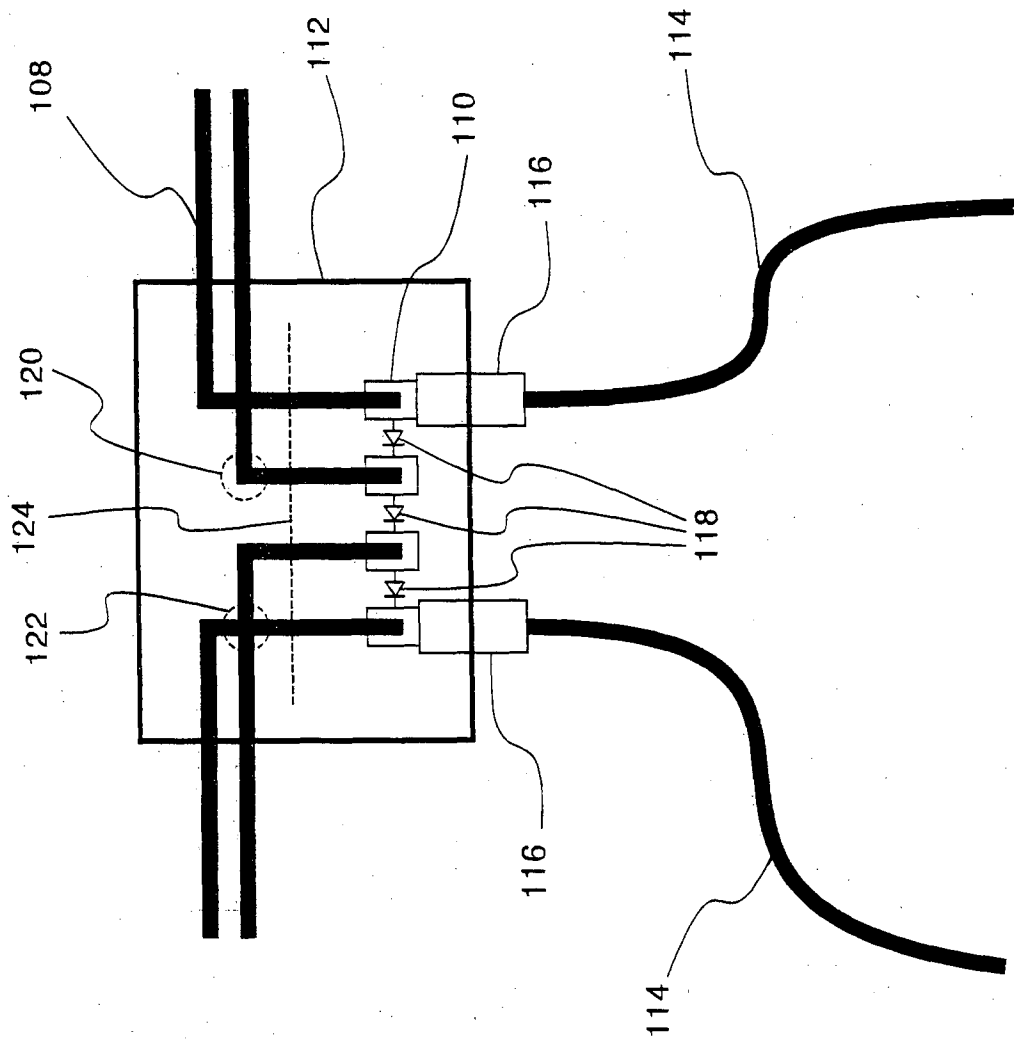


FIGURE 2

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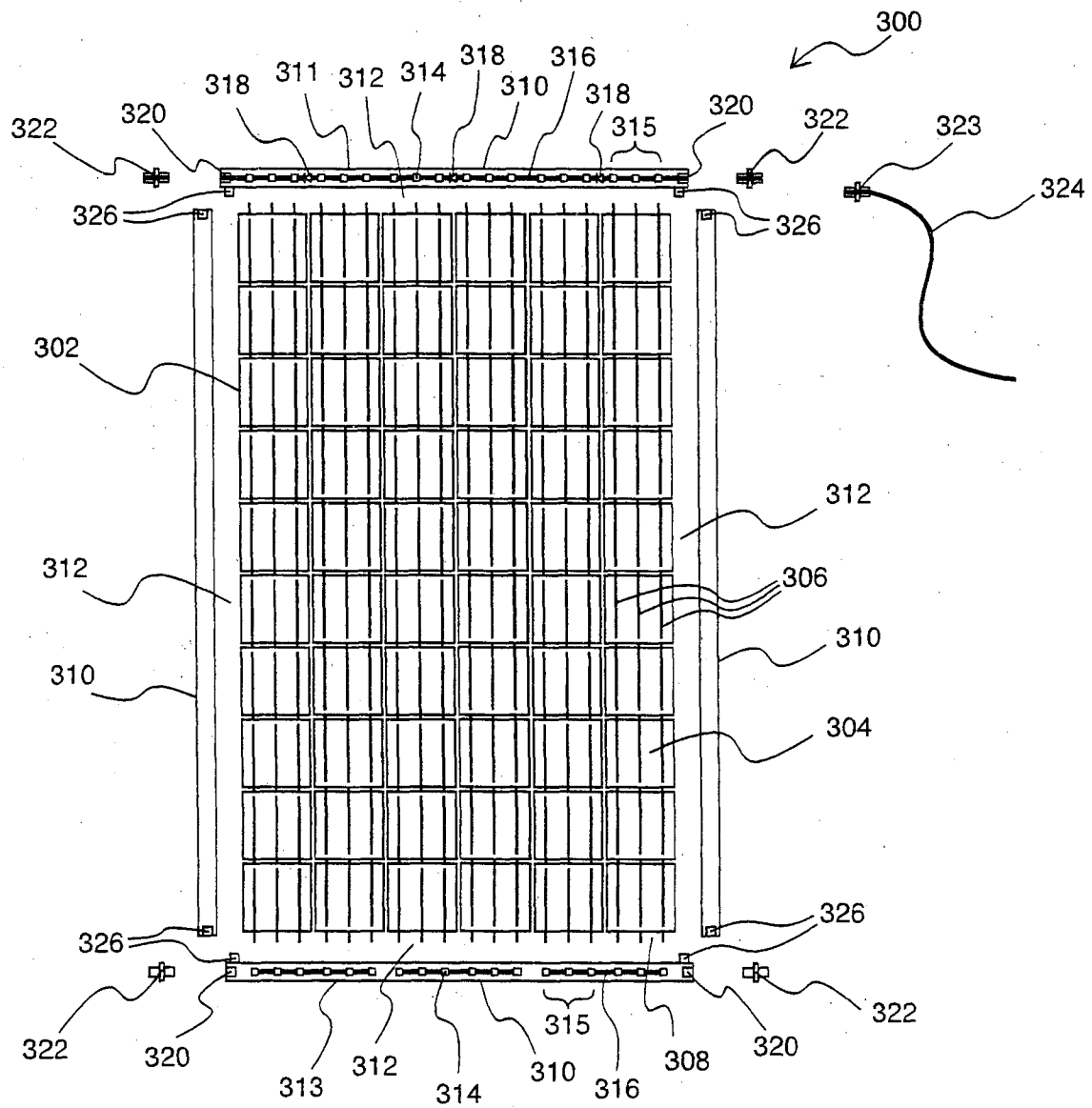


FIGURE 3

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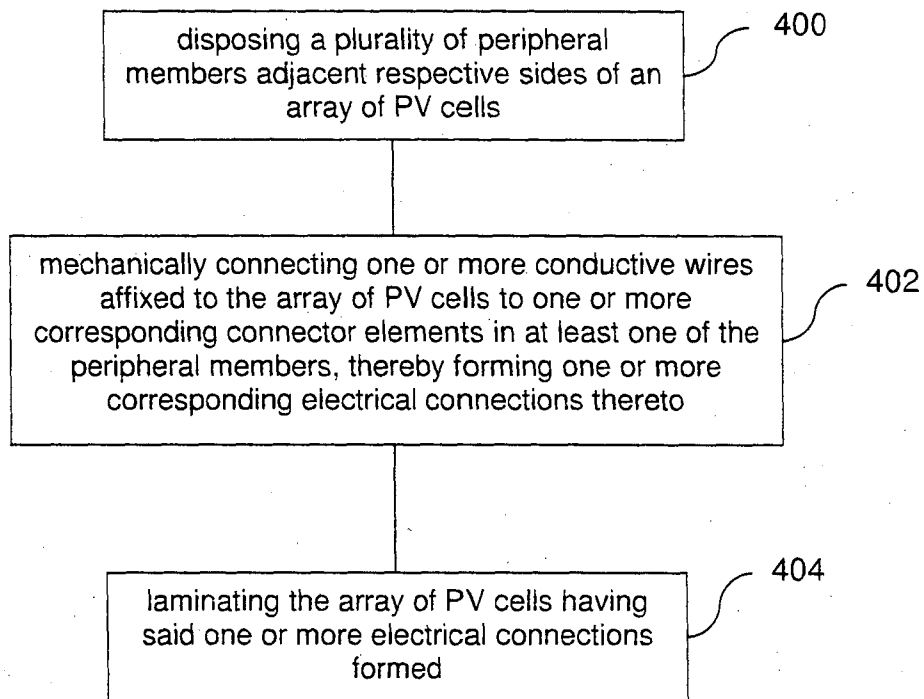


FIGURE 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SG2012/000214

A. CLASSIFICATION OF SUBJECT MATTER

H01L 31/05 (2006.01) H01L 31/0224 (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)

WPI,EPODOC: SOLAR, PV, PHOTOVOLTAIC, CELL, MODULE, COLLECTOR, PANEL, H01L31/042, H01L31/0224, WIRE, STRAND, RIBBON, CONNECT, CONDUCT, ELECTRIC, BUS, BAR, LENGTH, MEMBER, ELEMENT, ARRAY, ROW, MATRIX, SERIES, STRING, PLURAL, LUTIPLE, MANY, TOP, BOTTOM, SIDE, PERIPHERY AND SIMILIAR KEYWORDS.

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	

☒ 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	"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
"E" earlier application or patent but published on or after the international filing date	"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
"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)	"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
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search
03 August 2012

Date of mailing of the international search report
08 August 2012

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INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/SG2012/000214
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,A	US 2012/0073623 A1 (JONES et al) 29 March 2012 Fig 2, Para 47	1,11,21
A	GB 2391704 B (ICP GLOBAL TECHNOLOGIES) 11 January 2006 Figs 5,8, page 8 para 2, page 4 para 3, page 5 last para.	
A	WO 2009/029111 A2 (TENKSOLAR INC) 23 July 2009 Figs 2c, 5a,b, page 33 line 19-page 34 line 25, page 28 line 5-11.	
P,A	US 2011/0146750 A1 (NASUNO et al) 23 June 2011 Abstract, fig 3.	1,11,21

INTERNATIONAL SEARCH REPORT Information on patent family members		International application No. PCT/SG2012/000214	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
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		WO 2010026849 A1	11 Mar 2010
End of Annex			