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(54) **Title**: SOLAR CELL UNIT, SOLAR CELL ARRAY, SOLAR CELL MODULE AND MANUFACTURING METHOD THEREOF

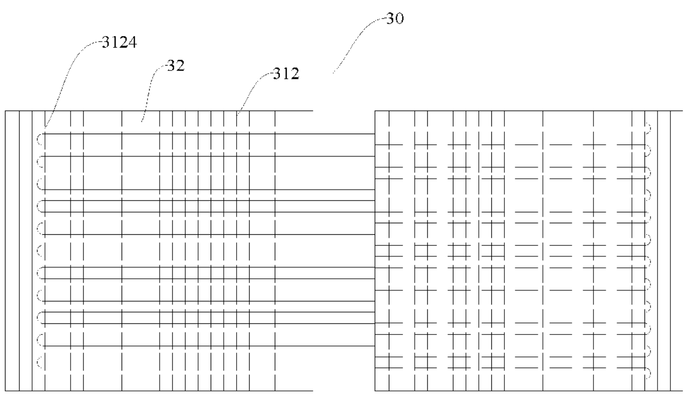

Fig. 13

(57) **Abstract**: A solar cell unit, a solar cell array (30), a solar cell module (100) and a manufacturing method thereof are disclosed. The solar cell unit includes a cell (31) consisting of a cell substrate (311) and a plurality of secondary grid lines (312) disposed on a front surface of the cell substrate (311); and a plurality of conductive wires (32) spaced apart from each other, the plurality of conductive wires (32) intersected and connected with the secondary grid lines (312), in which at least one secondary grid line (312) has at least one gap located between adjacent conductive wires (32)..

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SOLAR CELL UNIT, SOLAR CELL ARRAY, SOLAR CELL MODULE AND MANUFACTURING METHOD THEREOF

FIELD

The present disclosure relates to a field of solar cells, and more particularly, to a solar cell unit, a solar cell array, a solar cell module and a manufacturing method thereof.

BACKGROUND

A solar cell module is one of the most important components of a solar power generation device. Sunlight irradiates onto a cell from its front surface and is converted to electricity within the cell. Primary grid lines and secondary grid lines are disposed on the front surface, and then a welding strip covering and welded on the primary grid lines outputs the current. The welding strip, the primary grid lines and the secondary grid lines cover part of the front surface of the cell, which blocks out part of the sunlight, and the part of sunlight irradiating onto the primary grid lines and the secondary grid lines cannot be converted into electric energy. Thus, the welding strip, the primary grid lines and the secondary grid lines need to be designed as fine as possible in order for the solar cell module to receive more sunlight. However, the welding strip, the primary grid lines and the secondary grid lines serve to conduct current, and in terms of resistivity, the finer the primary grid lines and the secondary grid lines are, the smaller the conductive cross section area thereof is, which causes greater loss of electricity due to increased resistivity. Therefore, the welding strip, the primary grid lines and the secondary grid lines shall be designed to achieve a balance between light blocking and electric conduction, and to take the cost into consideration.

SUMMARY

The present disclosure is based on discoveries and understanding of the applicant to the following facts and problems.

In prior art, the front surface of the solar cell is usually provided with the primary grid lines and the secondary grid lines to output the current generated by the photoelectric effect or chemistry effect. In order to improve the efficiency of the solar cells, solar cell manufacturers conducted extensive researches on how to increase the number of the primary grid lines. In prior art, the number of primary grid lines has been successfully increased from two to three, or even five.

However, in the prior art, the primary grid lines are formed by printing the paste containing expensive silver, so the manufacturing cost is very high, and the increase of the silver primary grid lines absolutely causes an increase in cost. Moreover, the current silver primary grid line has a great width (for example, up to over 2mm), such that the increase of the silver primary grid lines will enlarge the shading area, and make the photoelectric conversion efficiency low.

Consequently, in order to lower the cost and reduce the shading area, in prior art, the silver primary grid lines printed on the cells are replaced with metal wires, such as copper wires which serve as the primary grid lines to output the current. Since the silver primary grid lines are no longer used, the cost can be reduced considerably; the diameter of the copper wire is relatively small, so the shading area can be decreased. Thus, the number of the primary grid lines can be further increased up to 10. this kind of cell may be called a cell without primary grid lines, in which the metal wire replaces the silver primary grid lines and welding strips in the traditional solar cell.

After extensive researches, the inventor of the present disclosure finds if a cell is manufacture in a way that multiple parallel metal wires are drawn simultaneously, cut off, and then welded to the cell simultaneously, due to limit of sophistication of equipment and process, for example, the influence of stress, the solar cell is bent to some extent when disposed at a free state, so the metal wire needs to remain strained to flatten the cell (a test proves that the minimum strain is at least 2N for a copper wire with a diameter of 0.2mm). In order to keep the strain, each metal wire needs to be provided with clips or similar equipment at the two ends thereof, and the equipment occupies certain space, but the space in the cell is limited. Thus, in the prior art, at most ten metal wires can be drawn, fixed and welded to a single cell, and it will be difficult to increase the number of the metal wires. The larger the number of the metal wires is, the more free ends there are, such that the equipment needs to control more metal wires at the same time, which is demanding as for the wiredrawing equipment. Moreover, the space of the solar cells is limited. For example, the dimension of a single cell is 156mm×156mm. In such limited space, the multiple metal wires need to be controlled accurately at the same time, which is demanding as for the equipment, especially as for the accuracy. Currently, it is still hard to control and weld multiple metal wires simultaneously in actual production, so the number of the conductive wires is limited, usually at most ten around, which is difficult to realize.

In order to solve the above problem, relevant patents (US20100275976 and US20100043863) provide a technical solution that multiple metal wires are fixed on a transparent film. That's to say, multiple parallel metal wires are fixed on the transparent film by adhesion; then, the transparent film bound with the multiple parallel metal wires is attached to the cell; finally the metal wires contact with the secondary grid lines on the cell by lamination. By this method, the multiple metal wires are fixed via the transparent film, which solves the problem of controlling the multiple metal wires simultaneously, and further increases the number of the metal wires. However, the technical solution almost abandons the welding process. That's to say, the metal wires are not connected with the secondary grid lines by the welding process; instead, the metal wires contact with the secondary grid lines by the laminating process, so as to output the current.

The above technical solution can further increase the number of the metal wires, but the transparent film may affect the light absorption, which causes certain degree of shading, and thus lowers the photoelectric conversion efficiency.

Furthermore, the above technical solution cannot connect the metal wires with the secondary grid lines by the welding process, because the melting temperature of the transparent film must be higher than the welding temperature (usually around 140°C), otherwise the transparent film will melt in the process of welding, which may lose the function of fixing the metal wires, and then the metal wires drift, resulting in poor welding effects.

Moreover, it is known to those skilled in the art that the solar cells in use are sealed to prevent moisture and air from penetrating the cells, which may cause corrosion and short circuit. The encapsulating material at present is EVA whose melting point is 70°C to 80°C, much lower than the welding temperature. If the welding process is employed, as said above, the melting temperature of the transparent film must be higher than the welding temperature, which is higher than the melting point of the encapsulating material. Thus, in the encapsulating process, the encapsulating material (EVA) will melt at the encapsulating temperature, but the transparent film will not, such that the melting encapsulating material cannot penetrate the solid transparent film to completely seal the cells. Hence, the sealing effect is poor, and the actual product tends to fail. In terms of encapsulating, the melting temperature of the transparent film needs to be lower than the welding temperature, which is an evident paradox.

Therefore, the technical solution of fixing the metal wires via the transparent film cannot adopt the welding process to weld the metal wires with the secondary grid lines, or the metal wires are merely in contact with the secondary grid lines on the cells, i.e. the metal wires are only placed on the secondary grid lines. Thus, the connection strength of the metal wires and the secondary grid lines is so low that the metal wires tend to separate from the secondary grid lines in the laminating process or in use, which causes bad contact, low efficiency of the cells, or even failure thereof. Consequently, the product in this technical solution is not promoted and commercialized. There is no relatively mature solar cell without primary grid lines.

Moreover, in the current solar cells, the secondary grid lines at the front surface of the cell are usually printed at the surface thereof by silver paste, and then sintered. The secondary grid lines of this structure are continuous and have an even dimension, which consumes more silver and results in higher cost.

The present disclosure seeks to solve at least one of the problems existing in the related art to at least some extent.

The solar cell with multiple primary grid lines provided in the present disclosure can be commercialized for mass production, and easy to manufacture with simple equipment, especially in low cost.

Thus, the present disclosure provides a solar cell unit that is easy to manufacture in low cost, and improves the photoelectric conversion efficiency.

Thus, the present disclosure provides a solar cell array that is easy to manufacture in low cost, and improves the photoelectric conversion efficiency.

Thus, the present disclosure provides a solar cell module with the above solar cell array, and the solar cell module is easy to manufacture in low cost, and improves the photoelectric conversion efficiency.

The present disclosure further provides a method for manufacturing the solar cell module.

According to a first aspect of embodiments of the present disclosure, a solar cell unit includes a cell consisting of a cell substrate and a plurality of secondary grid lines disposed on a front surface of the cell substrate; and a plurality of conductive wires spaced apart from each other, the plurality of conductive wires intersected and connected with the secondary grid lines, in which at least one secondary grid line has at least one gap located between adjacent conductive wires.

As for the solar cell unit according to embodiments of the present disclosure, at least one secondary grid line between adjacent conductive wires is provided with a gap, i.e. the at least one secondary grid line between the adjacent conductive wires breaks off in a position where there is no need to print silver paste or other materials for manufacturing the secondary grid lines, so as to save the amount of the material for manufacturing the secondary grid lines to lower the cost. Moreover, the inventor of the present disclosure finds out that the gaps disposed on the secondary grid lines will not affect the photoelectric conversion efficiency of the solar cell greatly. The solar cell unit according to the embodiments of the present disclosure still can obtain relatively high photoelectric conversion efficiency.

According to a second aspect of embodiments of the present disclosure, a solar cell array includes a plurality of solar cell units which are the solar cell units according to the above embodiments, and cells of the adjacent cell units are connected by the conductive wires.

According to a third aspect of embodiments of the present disclosure, a solar cell module includes an upper cover plate, a front adhesive layer, a cell array, a back adhesive layer and a lower cover plate superposed in sequence, the cell array being a solar cell array according to the above embodiments.

According to a fourth aspect of embodiments of the present disclosure, a method for manufacturing a solar cell module includes: providing a cell which includes a cell substrate and a plurality of secondary grid lines disposed on a front surface of the cell substrate; intersecting and connecting conductive wires constituted by a metal wire with the secondary grid lines to obtain a solar cell unit, in which at least one secondary grid line has at least one gap located between adjacent conductive wires; superposing an upper cover plate, a front adhesive layer, the solar cell unit, a back adhesive layer and a lower cover plate in sequence, in which a front surface of the solar cell faces the front adhesive layer, a back surface thereof facing the back adhesive layer, and laminating them to obtain the solar cell module.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a plan view of a solar cell array according to an embodiment of the present disclosure;

Fig. 2 is a sectional view of a solar cell array according to an embodiment of the present disclosure;

Fig. 3 is a sectional view of a solar cell array according to embodiments of the present disclosure;

Fig. 4 is a schematic diagram of a metal wire for forming a conductive wire according to embodiments of the present disclosure;

Fig. 5 is a plan view of a solar cell array according to another embodiment of the present disclosure;

Fig. 6 is a plan view of a solar cell array according to another embodiment of the present disclosure;

Fig. 7 is a schematic diagram of a metal wire extending reciprocally according to embodiments of the present disclosure;

Fig. 8 is a schematic diagram of two cells of a solar cell array according to embodiments of the present disclosure;

Fig. 9 is a sectional view of a solar cell array formed by connecting, by a metal wire, the two cells according to Fig. 8;

Fig. 10 is a schematic diagram of a solar cell module according to embodiments of the present disclosure;

Fig. 11 is a sectional view of part of the solar cell module according to Fig. 10;

Fig. 12 is a schematic diagram of a solar cell array according to another embodiment of the present disclosure;

Fig. 13 is a schematic diagram of a secondary grid line of a solar cell according to an embodiment of the present disclosure;

Fig. 14 is a schematic diagram of a secondary grid line of a solar cell according to another embodiment of the present disclosure.

Reference numerals:

100	cell module
10	upper cover plate
20	front adhesive layer
30	cell array
31	cell
31A	first cell
31B	second cell
311	cell substrate
312	secondary grid line

312A front secondary grid line

312B back secondary grid line

3121 edge secondary grid line

3122 middle secondary grid line

3123 welding portion

3124 gap

313 back electric field

314 back electrode

32 conductive wire

32A front conductive wire

32B back conductive wire

321 metal wire body

322 connection material layer

33 short grid line

40 back adhesive layer

50 lower cover plate

51 reflective coating

60 U-shape frame

70 junction box

80 mounting block

DETAILED DESCRIPTION

Embodiments of the present disclosure will be described in detail and examples of the embodiments will be illustrated in the drawings, where same or similar reference numerals are used to indicate same or similar members or members with same or similar functions. The embodiments described herein with reference to the drawings are explanatory, which are used to illustrate the present disclosure, but shall not be construed to limit the present disclosure.

Part of technical terms in the present disclosure will be elaborated herein for clarity and convenience of description.

According to one embodiment of the present disclosure, a cell unit includes a cell 31 and conductive wires 32, so the conductive wires 32 can be called the conductive wires 32 of the cell unit.

A cell 31 includes a cell substrate 311, secondary grid lines 312 disposed on a front surface (the surface on which light is incident) of the cell substrate 311, a back electric field 313 disposed on a back surface of the cell substrate 311, and back electrodes 314 disposed on the back electric field 313. Thus, the secondary grid lines 312 can be called the secondary grid lines 312 of the cell 31, the back electric field 313 called the back electric field 313 of the cell 31, and the back electrodes 314 called the back electrodes 314 of the cell 31.

A cell substrate 311 can be an intermediate product obtained by subjecting, for example, a silicon chip to processes of felting, diffusing, edge etching and silicon nitride layer depositing. However, it shall be understood that the cell substrate 311 in the present disclosure is not limited to be formed by the silicon chip.

In other words, the cell 31 comprises a silicon chip, some processing layers on a surface of the silicon chip, secondary grid lines on a shiny surface(namely a front surface), and a back electric field 313 and back electrodes 314 on a shady surface(namely a back surface), or includes other equivalent solar cells of other types without any front electrode.

The cell unit, the cell 31 and the cell substrate 311 are used to illustrate the present disclosure, but shall not be construed to limit the scope of the present disclosure.

A solar cell array 30 is arranged by a plurality of cells, i.e. by a plurality of cells 31 connected by conductive wires 32.

In the solar cell array 30, a metal wire S constitutes the conductive wire 32 of the cell unit, and extends between surfaces of the adjacent cells 31, which shall be understood in a broad sense that the metal wire S may extend between surfaces of the adjacent cells 31, or may be connected with a secondary grid line 312 of the cell 31, or may be connected with a secondary grid line 312 of a first cell 31 and a back electrode 314 of a second cell 31 adjacent to the first cell 31, or a part of the metal wire S is connected with the secondary grid line 312 and the other part of the metal wire S is connected with a back electrode 314 of the cell 31.

That's to say, the metal wire S can extend between front surfaces of adjacent cells 31, or extend between a front surface of a first cell 31 and a back surface of a second cell 31 adjacent to the first cell 31. When the metal wire S extends between the front surface of the first cell 31 and the back surface of the second cell 31 adjacent to the first cell 31, the conductive wire 32 may include a front conductive wire 32A extending on the front surface of the cell 31 and electrically connected with the secondary grid lien 312 of the cell 31, and a back conductive wire 32B extending on the back surface of the cell 31 and electrically connected with the back electrode 314 of the cell 31. Part of the metal wire S between the adjacent cells 31 can be called a connection conductive wire.

All the ranges disclosed in the present disclosure include terminals, and can be individual or combined. It shall be understood that the terminals and any value of the ranges are not limited to an accurate range or value, but also include values proximate the ranges or values.

In the present disclosure, the orientation terms such as “upper” and “lower” usually refer to the orientation “upper” or “lower” as shown in the drawings under discussion, unless specified otherwise; “front surface” refers to a surface of the solar cell module facing the light in practical application(for example, when the module is in operation), i.e. a shiny surface on which light is incident, while “back surface” refers to a surface of the solar cell module back to the light in practical application.

In the following, the solar cell unit will be described according to the embodiments of the present disclosure.

As shown in Fig. 1 to Fig. 13, the solar cell unit according to the embodiments of the present disclosure includes a cell 31 and conductive wires 32. Specifically, the cell 31 consists of a cell substrate 311 and secondary grid lines 312 disposed on a front surface of the cell substrate 311; the plurality of conductive wires 32 are spaced apart from each other, and intersected and connected with the secondary grid lines 312, in which at least one secondary grid line 312 has at least one gap located between adjacent conductive wires 32.

In other words, the solar cell according to the present disclosure is mainly formed with the cell 31 and conductive wires 32; the cell 31 is mainly constituted by the cell substrate 311 and secondary grid lines 312. In the present disclosure, the secondary grid lines 312 disposed on the front surface of the cell substrate 311 will be described in detail.

Specifically, a plurality of secondary grid lines 312 are disposed on the front surface of the cell substrate 311 and extend in a direction. A plurality of conductive wires 32 are disposed on the secondary grid lines 312 and extend in another direction. Each conductive wire 32 is intersected with the plurality of secondary grid lines 312 respectively; each secondary grid line 312 is intersected with the plurality of conductive wires 32 respectively.

That’s to say, a plurality of conductive wires 32 and a plurality of secondary grid lines 312 can be intersected as a network, segments of multiple different secondary grid lines 312 are distributed between any two adjacent conductive wires 32, in which the segment of at least one secondary grid line 312 has one gap 3124, i.e. at least one of the multiple different secondary grid lines 312 between any two adjacent conductive wires 32 is formed with two segments.

As shown in Fig. 13, the secondary grid line 312 with the gap 3124 may have only one gap 3124, i.e. the part of the secondary grid line 312 is formed with two segments, or have multiple gaps 3124, i.e. the part of the secondary grid line 312 is formed with at least three segments.

It shall be noted that in the present disclosure, the secondary grid lines 312 are usually printed on the surface of the solar cell by silver paste, and sintered. The secondary grid lines 312 are provided with gaps 3124, i.e. being divided into multiple segments, such that the broken parts of the secondary grid lines 312 do not need silver paste printing, which can save the amount of silver.

Thus, as for the solar cell unit according to embodiments of the present disclosure, at least one secondary grid line 312 between adjacent conductive wires 32 is provided with a gap 3124, i.e. the at least one secondary grid line 312 between the adjacent conductive wires 32 breaks off in a position where there is no need to print silver paste or other materials for manufacturing the secondary grid lines 312, so as to save the amount of the material for manufacturing the secondary grid lines 312 to lower the cost.

According to an embodiment of the present disclosure, there are n conductive wires 32; and there is/are n-1 gap(s) 3124 in a single secondary grid line 312.

That’s to say, supposing there are 15 conductive wires 32 arranged in parallel and intersected with the secondary grid lines 312 respectively. Any two adjacent conductive wires 32 divide each secondary grid line 312 into multiple segments. The fifteen conductive wires 32 divide each secondary grid line 312 into 16 segments, in which there are 14 segments of each secondary grid line 312 between the fifteen conductive wires 32, and each segment of each secondary grid line 312 is provided with one gap.

Thus, the secondary grid lines 312 of this structure can reduce the amount of raw materials to the greatest extent, so as to lower the cost.

Alternatively, in some embodiments of the present disclosure, a gap 3124 is disposed between two adjacent conductive wires 32.

That’s to say, the secondary grid line 312 between two adjacent conductive wires 32 has a broken part, i.e. the secondary grid line 312 between two adjacent conductive wires 32 is formed with two segments. If only one gap 3124 is disposed between the two adjacent conductive wires 32, the process of manufacturing the secondary grid lines 312 can be reasonably controlled to simplify the production process at the same time of saving raw materials.

According to an embodiment of the present disclosure, the gap 3124 has a length of 0.2 to 5mm in a longitudinal direction of the secondary grid line 312. Preferably, the gap 3124 has a length of 0.5 to 3mm. Further, the gap 3124 is located in a middle position of the adjacent conductive wires 32.

Consequently, the length of the gap 3124 is designed as the above size, and the broken part of the secondary grid line 312 is located in a middle position of the adjacent conductive wires 32, such that the performance of the cell will not be greatly affected if the secondary grid lines break off, so as to save the raw materials, to guarantee the production operability, to simplify the production process, and control the photoelectric conversion efficiency of the cell in practical value.

Alternatively, according to an embodiment of the present disclosure, there are 20 to 200 secondary grid lines 312, preferably 30 to 120. A gap 3124 can be arranged at the part of each secondary grid line 312 between two adjacent conductive wires 32, to further reduce the materials for the secondary grid lines 312, thereby lowering the cost.

In some embodiments of the present disclosure, the conductive wires 32 are constituted by the metal wire body 321. In some embodiments, preferably, the metal wire body 321 is a copper wire, but the present disclosure is not limited thereto. For example, the metal wire body 321 can be an aluminum wire. Preferably, the metal wire body 321 has a circular cross section, such that more sunlight can irradiate the cell substrate to further improve the photoelectric conversion efficiency.

Further, the metal wire body 321 is coated with a welding layer at least at a part welded with the secondary grid lines 312, and the conductive wires 32 are welded with the secondary grid lines 312.

More preferably, as shown in Fig. 4, the metal wire body 321 is coated with a connection material layer 322, such as a conductive adhesive layer or a welding layer. The metal wire is welded with the secondary grid line and/or the back electrode by the welding layer, such that it is convenient to electrically connect the metal wire body 321 with the secondary grid lines 312, and to avoid drifting of the metal wire in the connection process so as to guarantee the photoelectric conversion efficiency. Of course, the electrical connection of the metal wire body 321 with the cell

31 can be conducted when or before the solar cell module is laminated, and preference is given to the latter.

In some other embodiments of the present disclosure, the secondary grid lines 312 are coated with a welding layer by which the conductive wires 32 are welded with the secondary grid lines 312.

That's to say, the conductive wires 32 and the secondary grid lines 312 can be welded by arranging the welding layer on the conductive wires 32 or on the secondary grid lines 312. When the welding layer is disposed on the secondary grid lines 312, only the welding point on the secondary grid lines 312 is usually provided with the welding layer, so as to guarantee the effect of welding the conductive wires 32 with the secondary grid lines 312, and to avoid the influence on the shading area to guarantee the photoelectric conversion efficiency.

Alternatively, according to an embodiment of the present disclosure, the metal wire S extends reciprocally. Preferably, the metal wire S extends reciprocally under strain, before being connected with the secondary grid lines 312.

It shall be understood that the term "extending reciprocally" in the application can be called "winding" which refers to that the metal wire S extends between the surfaces of the cells 31 along a reciprocal route.

Thus, in the cells according to the embodiments of the present disclosure, the conductive wires 32 are constituted by the metal wire S which extends reciprocally, and adjacent cells 31 are connected by the conductive wires 32. In such a case, the conductive wires 32 of the cell do not need expensive silver paste, and it is not necessary to use the welding strip to connect the cells, which is an easy manufacturing process. It is convenient to connect the metal wire S with the secondary grid lines 312 and back electrodes of the cells, so the cost of the cells is considerably reduced.

In some specific embodiments of the present disclosure, the secondary grid lines have a width in a welding position with the conductive wires 32 greater than in a non-welding position.

Specifically, as shown in Fig. 1, the secondary grid lines 312 are disposed on the front surface of the cell substrate 311 and extend in a direction. The conductive wires 32 are disposed on the secondary grid lines 312 and extend in another direction. The conductive wires 32 and the secondary grid lines 312 are welded at a portion where they are intersected. Usually, the conductive wires 32 are broader than the secondary grid lines 312, and the secondary grid lines

312 have a width in the welding portion with the conductive wire 32 greater than a width thereof in a non-welding portion.

That's to say, as shown in Fig. 13, the secondary grid lines 312 are broadened in a position where the secondary grid lines 312 are intersected with the conductive wires 32, and the broadened part of the secondary grid lines 312 is taken as a welding portion 3123 to be welded with the conductive wires 32. The welding portion 3123 of the secondary grid lines 312 is broaden to facilitate welding the secondary grid lines 312 with the conductive wires 32. Meanwhile, other parts of the secondary grid lines 312 remain the original width, or even reduce the width, which cannot only guarantee the welding effect of the secondary grid lines 312 and the conductive wires 32, but also reduce the shading area.

Consequently, as for the solar cell according to the embodiments of the present disclosure, the portion where the secondary grid lines 312 are welded with the conductive wires 32 is widen, while other portions are relatively narrow, which makes it easier to weld the conductive wires 32 with the secondary grid lines 312, and to manufacture the welding portion, thereby reducing the cost. In such a case, the connection strength of the conductive wires 32 and the secondary grid lines 312 is enhanced, and the shading area is decreased, which improves the photoelectric conversion efficiency of the solar cell.

According to an embodiment of the present disclosure, the secondary grid lines 312 have a width in the welding position greater than or equal to a diameter or width of the conductive wires 32.

In other words, the welding portion 3123 of the secondary grid lines 312 has a line width larger than or equal to that of the conductive wires 32. Thus, the portion where the secondary grid lines 312 are welded with the conductive wires 32 is configured to have a line width larger than or equal to that of the conductive wires 32, so as to further enhance the connection strength of the conductive wires 32 and the secondary grid lines 312, and to facilitate welding to reduce the cost.

In some other specific embodiments of the present disclosure, the short grid line 33 are disposed on the front surface of the cell substrate 311; the secondary grid lines 312 include middle secondary grid lines 3122 intersected with the conductive wires 32 and an edge secondary grid lines 3121 non-intersected with the conductive wires 33; the short grid lines 33 are connected with the edge secondary grid lines 3121, and connected with the conductive wires 32 or at least one middle secondary grid line 3122. Preferably, the short grid lines 33 are connected with the middle secondary grid lines 3122 closest to the edge secondary grid lines 3121.

As shown in Fig. 12, the secondary grid lines 312 located at a side surface of the cell substrate 311 comprises two parts – one part of the secondary grid lines 312 intersected with the conductive wires 32 and located in a middle position of the cell substrate 311 to form middle secondary grid lines 3122; the other part of the secondary grid lines 312 non-intersected with the conductive wires 32 and located at an edge of one side away from the conductive wires 32 to form edge secondary grid lines 3121.

The edge secondary grid lines 3121 are provided with short grid lines 33 connected with the conductive wires 32 or at least one middle secondary grid line 3122. The short grid lines 33 are located at the edges of the cell 31 where the conductive wires 32 cannot reach when being winded, so as to avoid current loss.

Thus, in the solar cell array 30 according to the embodiments of the present disclosure, the conductive wires 32 are constituted by the metal wire which extends reciprocally. The conductive wires 32 are constituted by the metal wire which extends reciprocally. The conductive wires 32 of this structure extend reciprocally between two adjacent cells in a winding way to form a folded shape, which is easy to manufacture in low cost, and can improve the photoelectric conversion efficiency of the solar cell array 30.

In the following, the solar cell array 30 will be described according to the embodiments of the present disclosure.

According to the embodiments of the present disclosure, the solar cell array 30 includes a plurality of solar cell units which are the solar cell units according to the above embodiment, cells 31 of adjacent cell units being connected by the conductive wires 32.

Since the solar cell unit according to the above embodiment of the present disclosure has the above technical effect, the solar cell array 30 according to the embodiment of the present disclosure has the corresponding technical effect, i.e. saving the materials for manufacturing the secondary grid lines 312 and lowering the cost.

Specifically, in some embodiments of the present disclosure, the conductive wires are constituted by the metal wire S which extends reciprocally between a surface of a first cell 31 and a surface of a second cell 31 adjacent to the first cell 31.

The cell unit is formed by the cell 31 and the conductive wires 32 constituted by the metal wire S which extends on the surface of the cell 31. In other words, the solar cell array 30 according to the embodiments of the present disclosure are formed with a plurality of cell units; the conductive wires 32 of the plurality of cells are formed by the metal wire body 321 which extends reciprocally between the surfaces of the cells 31.

It shall be understood that the term “extending reciprocally” in the application can be called “winding” which refers to that the metal wire S extends between the surfaces of the cells 31 along a reciprocal route.

In the present disclosure, it shall be understood in a broad sense that “the metal wire S extends reciprocally between a surface of a first cell 31 and a surface of a second cell 31 adjacent to the first cell 31. For example, the metal wire S may extend reciprocally between a front surface of a first cell 31 and a back surface of a second cell 31 adjacent to the first cell 31; the metal wire S may extend from a surface of the first cell 31 through surfaces of a predetermined number of middle cells 31 to a surface of the last cell 31, and then extends back from the surface of the last cell 31 through the surfaces of a predetermined number of middle cells 31 to the surface of the first cell 31, extending reciprocally like this.

In addition, when the cells 31 are connected in parallel by the metal wire S, the metal wire S can extend on front surfaces of two cells, such that the metal wire S constitutes a front conductive wire 32A of two cells connected in series. Alternatively, a first metal wire S extends reciprocally on a front surface of a cell 31, and a second metal wire S extends reciprocally on a back surface of the cell 31, such that the first metal wire S constitutes a front conductive wire 32A, and the second metal wire S constitutes a back conductive wire 32B.

When the cells 31 are connected in series by the metal wire S, the metal wire S can extend reciprocally between a front surface of a first cell 31 and a back surface of a second cell 31 adjacent to the first cell 31, such that part of the metal wire S which extends on the front surface of the first cell 31 constitutes a front conductive wire 32A, and part thereof which extends on the back surface of the second cell 31 constitutes a back conductive wire 32B. In the present disclosure, unless specified otherwise, the conductive wire 32 can be understood as the front conductive wire 32A, the back conductive wire 32B, or the combination thereof.

The term “extending reciprocally” can be understood as that the metal wire body 321 extends reciprocally once to form to two conductive wires 32 which form a U-shape or V-shape structure by the metal wire body 321 extending reciprocally, yet the present disclosure is not limited to the above.

In the solar cell array 30 according to the embodiments of the present disclosure, a plurality of conductive wires 32 of the cell units are constituted by the metal wire body 321 which extends reciprocally; and the adjacent cells 31 are connected by the conductive wires 32. Hence, the conductive wires 32 of the cell units in the present disclosure are used to output the current, and are not necessarily printed by expensive silver paste, and can be manufactured in a simple manner without using a solder strip to connect the cells. It is easy and convenient to connect the metal wire body 321 with the secondary grid line and the back electrode, so that the cost of the cells is reduced considerably.

Moreover, since the conductive wires 32 are constituted by the metal wire body 321 which extends reciprocally, the width of the conductive wires 32 (i.e. the width of projection of the metal wire on the cell) is much smaller than that of the current primary grid lines printed by silver paste, thereby decreasing the shading area. Further, the number of the conductive wires 32 can be adjusted easily, and thus the resistance of the conductive wires 32 is reduced, compared with the conductive wires made of the silver paste, and the efficiency of photoelectric conversion is improved. Since the metal wire body 321 extends reciprocally to form the conductive wires, when the cell array 30 is used to manufacture the solar cell module 100, the metal wire body 321 is easier to control accurately and will not tend to shift, i.e. the metal wire is not easy to “drift”, which will not affect but further improve the photoelectric conversion efficiency.

Therefore, the solar cell array 30 according to the embodiments of the present disclosure has low cost and high photoelectric conversion efficiency.

In the following, the solar cell array 30 according to specific embodiments of the present disclosure will be described with reference to the drawings.

The solar cell array 30 according to a specific embodiment of the present disclosure is illustrated with reference to Fig. 1 to Fig. 3.

In the embodiment shown in Fig. 1 to Fig. 3, two cell units in the solar cell array 30 are shown. In other words, it shows two cells bodies 31 connected with each other via the conductive wire 32 constituted by the metal wire S.

It can be understood that the cell 31 comprises a cell substrate 311, a secondary grid line 312 (a front secondary grid line 312A) disposed on a front surface of the cell substrate 311, a back electric field 313 disposed on a back surface of the cell substrate 311, and a back electrode 314 disposed on the back electric field 313. In the present disclosure, it can be understood that the back electrode 314 may be a back electrode of a traditional cell, for example, printed by the silver paste, or may be a back secondary grid line 312B similar to the secondary grid line on the front surface of the cell substrate, or may be multiple discrete welding portions, unless specified otherwise. The secondary grid line refers to the secondary grid line 312 on the front surface of the cell substrate 311, unless specified otherwise.

Specifically, in an embodiment of the present disclosure, the metal wire extends reciprocally between a front surface of a first cell 31 and a back surface of a second cell 31.

As shown in Fig. 1 to Fig. 3, the solar cell array in the embodiment includes two cells 31A, 31B (called a first cell 31A and a second cell 31B respectively for convenience of description). The metal wire S extends reciprocally between the front surface of the first cell 31A (a shiny surface, i.e. an upper surface in Fig. 2) and the back surface of the second cell 31B, such that the metal wire S constitutes a front conductive wire of the first cell 31A and a back conductive wire of the second cell 31B. The metal wire S is electrically connected with the secondary grid line of the first cell 31A (for example, being welded or bounded by a conductive adhesive), and electrically connected with the back electrode of the second cell 31B.

In an embodiment of the present disclosure, back electrodes 314 are disposed on the back surface of the cell substrate 311, and the metal wire is welded with the back electrodes 314.

That’s to say, in the embodiment, front secondary grid lines 312A are disposed on the front surface of the cell substrate 311, and back electrodes 314 are disposed on the back surface thereof. When the conductive wires 32 are located on the front surface of the cell substrate 311, the conductive wires 32 are welded with the front secondary grid lines 312A; when the conductive wires 32 are located on the back surface of the cell substrate 311, the conductive wires 32 are welded with the back electrodes 314 on the back surface of the cell substrate 311.

In some embodiments, there is a metal wire S. The metal wire S extends reciprocally between the first cell 31A and the second cell 31B for 1o to 60 times. Preferably, as shown in Fig. 1, the metal wire extends reciprocally for 12 times to form 24 conductive wires, and there is only one metal wire. In other words, a single metal wire extends reciprocally for 12 times to form 24 conductive wires, and the distance of the adjacent conductive wires can range from 2.5mm to 15mm. In this embodiment, the number of the conductive wires is increased, compared with the traditional cell, such that the distance between the secondary grid line and the conductive wire which the current runs through is decreased, so as to reduce the resistance and improve the photoelectric conversion efficiency. In the embodiment shown in Fig. 1, the adjacent conductive wires forms a U-shape structure, for convenience of winding the metal wire. Alternatively, the present disclosure is not limited to the above. For example, the adjacent conductive wires forms a V-shape structure.

In some embodiments, preferably, the metal wire is a copper wire, yet the present disclosure is not limited thereto. For example, the metal wire body 321 may be an aluminum wire. Preferably, the metal wire body 321 has a circular cross section, such that more sunlight can reach the cell substrate to further improve the photoelectric conversion efficiency.

More preferably, as shown in Fig. 4, the metal wire body 321 is coated with a connection material layer 322, such as a conductive adhesive layer or a welding layer. The metal wire is welded with the secondary grid line and/or the back electrode by the welding layer, such that it is convenient to electrically connect the metal wire with the secondary grid line and/or the back electrode, and to avoid drifting of the metal wire in the connection process so as to guarantee the photoelectric conversion efficiency. Of course, the electrical connection of the metal wire with the cell can be conducted when or before the solar cell module is laminated, and preference is given to the latter.

In some embodiments, preferably, before the metal wire contact the cell, the metal wire extends under strain, i.e. straightening the metal wire. After the metal wire is connected with the secondary grid line and the back electrode of the cell, the strain of the metal wire can be released, so as to further avoid the drifting of the conductive wire when the solar cell module is manufacture, and to guarantee the photoelectric conversion efficiency.

Fig. 5 is a schematic diagram of a solar cell array according to another embodiment of the present disclosure. As shown in Fig. 5, the metal wire extends reciprocally between the front surface of the first cell 31A and the front surface of the second cell 31B, such that the metal wire constitutes front conductive wires of the first cell 31A and the second cell 31B. In such a way, the first cell 31A and the second cell are connected in parallel. Of course, it can be understood that preferably the back electrode of the first cell 31A and the back electrode of the second cell 31B can be connected via a back conductive wire constituted by another metal wire which extends reciprocally. Alternatively, the back electrode of the first cell 31A and the back electrode of the second cell 31B can be connected in a traditional manner.

The solar cell array 30 according to another embodiment of the present disclosure is illustrated with reference to Fig.6.

The solar cell array 30 according to the embodiment of the present disclosure comprises n×m cells 31. In other words, a plurality of cells 31 are arranged in an n×m matrix form, n representing a column, and m representing a row. More specifically, in the embodiment, 36 cells 31 are arranges into six columns and six rows, i.e. n=m=6. It can be understood that the present disclosure is not limited thereto. For example, the column number and the row number can be different. For convenience of description, in Fig. 6, in a direction from left to right, the cells 31 in one row are called a first cell 31, a second cell 31, a third cell 31, a fourth cell 31, a fifth cell 31, and a sixth cell 31 sequentially; in a direction from up to down, the columns of the cells 31 are called a first column of cells 31, a second column of cells 31, a third column of cells 31, a fourth column of cells 31, a fifth column of cells 31, and a sixth column of cells 31 sequentially.

In a row of the cells, the metal wire extends reciprocally between a surface of a first cell 31 and a surface of a second cell 31 adjacent to the first cell 31; in two adjacent rows of cells 31, the metal wire extends reciprocally between a surface of a cell 31 in a a^{th} row and a surface of a cell in a $(a+1)^{th}$ row, and $m-1 \geq a \geq 1$.

As shown in Fig. 6, in a specific example, in a row of the cells 31, the metal wire extends reciprocally between a front surface of a first cell 31 and a back surface of a second cell 31 adjacent to the first cell 31, so as to connect the cells in one row in series. In two adjacent rows of cells 31, the metal wire extends reciprocally between a front surface of a cell 31 at an end of the a^{th} row and a back surface of a cell 31 at an end of the $(a+1)^{th}$ row, to connect the two adjacent rows of cells 31 in series.

More preferably, in the two adjacent rows of cells 31, the metal wire extends reciprocally between the surface of the cell 31 at an end of the a^{th} row and the surface of the cell 31 at an end of the $(a+1)^{th}$ row, the end of the a^{th} row and the end of the $(a+1)^{th}$ row located at the same side of the matrix form, as shown in Fig. 6, located at the right side thereof.

More specifically, in the embodiment as shown in Fig. 6, in the first row, a first metal wire extends reciprocally between a front surface of a first cell 31 and a back surface of the second cell 31; a second metal wire extends reciprocally between a front surface of the second cell 31 and a back surface of a third cell 31; a third metal wire extends reciprocally between a front surface of the third cell 31 and a back surface of a fourth cell 31; a fourth metal wire extends reciprocally between a front surface of the fourth cell 31 and a back surface of a fifth cell 31; a fifth metal wire extends reciprocally between a front surface of the fifth cell 31 and a back surface of a sixth cell 31. In such a way, the adjacent cells 31 in the first row are connected in series by corresponding metal wires.

A sixth metal wire extends reciprocally between a front surface of the sixth cell 31 in the first row and a back surface of a sixth cell 31 in the second row, such that the first row and the second row are connected in series. A seventh metal wire extends reciprocally between a front surface of the sixth cell 31 in the second row and a back surface of a fifth cell 31 in the second row; a eighth metal wire extends reciprocally between a front surface of the fifth cell 31 in the second row and a back surface of a fourth cell 31 in the second row, until a eleventh metal wire extends reciprocally between a front surface of a second cell 31 in the second row and a back surface of a first cell 31 in the second row, and then a twelfth metal wire extends reciprocally between a front surface of the first cell 31 in the second row and a back surface of a first cell 31 in the third row, such that the second row and the third row are connected in series. Sequentially, the third row and the fourth row are connected in series, the fourth row and the fifth row connected in series, the fifth row and the sixth row connected in series, such that the cell array 30 is manufacture. In this embodiment, a bus bar is disposed at the left side of the first cell 31 in the first row and the left side of the first cell 31 in the sixth row respectively; a first bus bar is connected with a conductive wire extending from the left side of the first cell 31 in the first row, and a second bus bar is connected with a conductive wire extending from the left side of the first cell 31 in the sixth row.

As said above, the cells in the embodiments of the present disclosure are connected in series by the conductive wires – the first row, the second row, the third row, the fourth row, the fifth row and the sixth row are connected in series by the conductive wires. As shown in Figs. Alternatively, the second and third row, and the fourth and fifth rows can be connected in parallel with a diode respectively to avoid light spot effect. The diode can be connected in a manner commonly known to those skilled in the art, for example, by a bus bar.

However, the present disclosure is not limited to the above. For example, the first and second rows can be connected in series, the third and fourth rows connected in series, the fifth and sixth rows connected in series, and meanwhile the second and third rows are connected in parallel, the fourth and fifth connected in parallel. In such a case, a bus bar can be disposed at the left or right side of corresponding rows respectively.

Alternatively, the cells 31 in the same row can be connected in parallel. For example, a metal wire extends reciprocally from a front surface of a first cell 31 in a first row through the front surfaces of the cells 31 in the second row to the sixth row.

Preferably, there is a metal wire extending reciprocally between adjacent cells 31 in a row; and there is a metal wire extending reciprocally between cells 31 in adjacent rows. Thus, adjacent cells 31 can be connected by a single metal wire that extends reciprocally for several times, which is easier to manufacture in lower cost.

In an embodiment of the present disclosure, the metal wire is coated with a welding layer. The ratio of the thickness of the welding layer and the diameter of the metal wire is (0.02-0.5): 1.

That's to say, in the cell array 30, the ratio of the thickness of the welding layer and the diameter of the conductive wire 32 (including the front conductive wire 32A and back conductive wire 32B) is (0.02-0.5): 1.

In the present disclosure, the conductive wires 32 (including the front conductive wires 32A and back conductive wires 32B) consist of a metal wire and a welding layer coating the metal wire. The welding layer may coat the metal wire completely or partially. When the welding layer coats the metal wire partially, the alloy layer is, preferably, formed at a position where the welding layer is welded with the secondary grid lines 312 of the cell 31. When the welding layer coats the metal wire completely, the welding layer can coat the periphery of the metal wire in a circular manner. The thickness of the welding layer can fall into a relatively wide range. Preferably, the welding layer has a thickness of 1 to 100μm, more preferably, 1 to 30μm.

The alloy with a low melting point for forming the welding layer may be a conventional alloy with a low melting point which can be 100 to 220°C. Preferably, the alloy with the low melting point contains Sn, and at least one of Bi, In, Ag, Sb, Pb and Zn, more preferably, containing Sn, Bi, and at least one of In, Ag, Sb, Pb and Zn.

Specifically, the alloy may be at least one of Sn-Bi alloy, In-Sn alloy, Sn-Pb alloy, Sn-Bi-Pb alloy, Sn-Bi-Ag alloy, In-Sn-Cu alloy, Sn-Bi-Cu alloy and Sn-Bi-Zn alloy. Most preferably, the alloy is Bi-Sn-Pb alloy, for example, containing 40 weight percent of Sn, 55 weight percent of Bi, and 5 weight percent of Pb (i.e. Sn40%-Bi55%-Pb5%). The thickness of the welding layer can be 0.001 to 0.06mm. The conductive wire 32 may have a cross section of 0.01 to 0.5mm^2. The metal wire can be conventional in the art, for example, a copper wire.

The solar cell module 100 according to embodiments of the present disclosure is illustrated with reference to Fig.10 and Fig. 11.

As shown in Fig. 10 and Fig. 11, the solar cell module 100 according to embodiments of the present disclosure includes an upper cover plate 10, a front adhesive layer 20, the cell array 30, a back adhesive layer 40 and a lower cover plate 50 superposed sequentially along a direction from up to down.

The front adhesive layer 20 and the back adhesive layer 40 are adhesive layers commonly used in the art. Preferably, the front adhesive layer 20 and the back adhesive layer 40 are polyethylene-octene elastomer (POE) and/or ethylene-vinyl acetate copolymer (EVA). In the present disclosure, polyethylene-octene elastomer (POE) and/or ethylene-vinyl acetate copolymer (EVA) are conventional products in the art, or can be obtained in a method known to those skilled in the art.

In the embodiments of the present disclosure, the upper cover plate 10 and the lower cover plate 50 can be selected and determined by conventional technical means in the art. Preferably, the upper cover plate 10 and the lower cover plate 50 can be transparent plates respectively, for example, glass plates.

In the process of manufacturing the solar cell module 100, the conductive wire can be first bounded or welded with the secondary grid lines and the back electrode of the cell 31, and then superposed and laminated.

Other components of the solar cell module 100 according to the present disclosure are known in the art, which will be not described in detail herein.

Specifically, the solar module 100 includes an upper cover plate 10, a front adhesive layer 20, the cell array 30, a back adhesive layer 40 and a lower cover plate 50. The cell array 30 includes a plurality of cells 31, and adjacent cells 31 are connected by the plurality of conductive wires 32. The conductive wires 32 are constituted by the metal wire S which extends reciprocally between surfaces of adjacent cells. The conductive wires 32 are welded with the secondary grid lines. The front adhesive layer 20 contacts with the conductive wires 32 directly and fills between the adjacent conductive wires 32.

That’s to say, the solar cell module 100 according to the present disclosure includes an upper cover plate 10, a front adhesive layer 20, the cell array 30, a back adhesive layer 40 and a lower cover plate 50 superposed sequentially along a direction from up to down. The cell array 30 includes a plurality of cells 31 and conductive wires 32 for connecting the plurality of cells 31. The conductive wires are constituted by the metal wire S which extends reciprocally between surfaces of two adjacent cells 31.

The conductive wires 32 are electrically connected with the cells 31, in which the front adhesive layer 20 on the cells 31 contacts with the conductive wires 32 directly and fills between the adjacent conductive wires 32, such that the front adhesive layer 20 can fix the conductive wires 32, and separate the conductive wires 32 from air and moisture from the outside world, so as to prevent the conductive wires 32 from oxidation and to guarantee the photoelectric conversion efficiency.

Thus, in the solar cell module 100 according to embodiments of the present disclosure, the conductive wires 32 constituted by the metal wire S which extends reciprocally replace traditional primary grid lines and solder strips, so as to reduce the cost. The metal wire S extends reciprocally to decrease the number of free ends of the metal wire S and to save the space for arranging the metal wire S, i.e. without being limited by the space. The number of the conductive wires 32 constituted by the metal wire which extends reciprocally may be increased considerably, which is easy to manufacture, and thus is suitable for mass production. The front adhesive layer 20 contacts with the conductive wires 32 directly and fills between the adjacent conductive wires 32, which can effectively isolate the conductive wires from air and moisture to prevent the conductive wires 32 from oxidation to guarantee the photoelectric conversion efficiency.

In some specific embodiments of the present disclosure, the metal wire S extends reciprocally between a front surface of a first cell and a back surface of a second cell adjacent to the first cell; the front adhesive layer 20 contacts with the conductive wires on the front surface of the first cell 31 directly and fills between the adjacent conductive wires 32 on the front surface of the first cell 31; the back adhesive layer 40 contacts with the conductive wires 32 on the back surface of the second cell 31 directly and fills between the adjacent conductive wires 32 on the back surface of the second cell 31.

In other words, in the present disclosure, the two adjacent cells 31 are connected by the metal wire S. In the two adjacent cells 31, the front surface of the first cell 31 is connected with the metal wire S, and the back surface of the second cell 31 is connected with the metal wire S.

The front adhesive layer 20 on the first cell 31 whose front surface is connected with the metal wire S is in direct contact with the metal wire S on the front surface of the first cell 31 and fills between the adjacent conductive wires 32. The back adhesive layer 40 on the second cell 31 whose back surface is connected with the metal wire S is in direct contact with the metal wire S on the back surface of the second cell 31 and fills between the adjacent conductive wires 32 (as shown in Fig. 2).

Consequently, in the solar cell module 100 according to the present disclosure, not only the front adhesive layer 20 can separate the conductive wires 32 on the front surfaces of part of the cells 31 from the outside world, but also the back adhesive layer 40 can separate the conductive wires 32 on the back surfaces of part of the cells 31 from the outside world, so as to further guarantee the photoelectric conversion efficiency of the solar cell module 100.

In some specific embodiments of the present disclosure, for a typical cell with a dimension of 156mm×156mm, the solar cell module has a series resistance of 380 to 440mΩ per 60 cells. The present disclosure is not limited to 60 cells, and there may be 30 cells, 72 cells, etc. When there are 72 cells, the series resistance of the solar cell module is 456 to 528mΩ, and the electrical performance of the cells is better.

In some specific embodiments of the present disclosure, for a typical cell with a dimension of 156mm×156mm, the solar cell module has an open-circuit voltage of 37.5-38.5V per 60 cells. The present disclosure is not limited to 60 cells, and there may be 30 cells, 72 cells, etc. The short-circuit current is 8.9 to 9.4A, and has nothing to do with the number of the cells.

In some specific embodiments of the present disclosure, the solar cell module has a fill factor of 0.79 to 0.82, which is independent from the dimension and number of the cells, and can affect the electrical performance of the cells.

In some specific embodiments of the present disclosure, for a typical cell with a dimension of 156mm×156mm, the solar cell module has a working voltage of 31.5-32V per 60 cells. The present disclosure is not limited to 60 cells, and there may be 30 cells, 72 cells, etc. The working current is 8.4 to 8.6A, and has nothing to do with the number of the cells.

In some specific embodiments of the present disclosure, for a typical cell with a dimension of 156mm×156mm, the solar cell module has a conversion efficiency of 16.5-17.4%, and a power of 265-280W per 60 cells.

A method for manufacturing the solar cell module 100 according to the embodiments of the present disclosure will be illustrated with respect to Fig. 7 to Fig. 9.

Specifically, the method according to the embodiments of the present disclosure includes the following steps:

providing a cell 31 which includes a cell substrate 311 and a secondary grid line 312 disposed on a front surface of the cell substrate 311;

welding a conductive wire 32 constituted by a metal wire with the secondary grid line 312 to obtain a solar cell unit, in which the secondary grid line 312 has a width in a welding position with the conductive wire 32 greater than a width thereof in a non-welding position;

superposing the upper cover plate 10, the front adhesive layer 20, the cell array 30, the back adhesive layer 40 and the back plate 50 in sequence, in which the front surface of the cell 31 faces the front adhesive layer 20, and the back surface thereof faces the back adhesive layer 40, and laminating them to obtain the solar cell module 100.

The method includes the steps of preparing a solar array 30, superposing the upper cover plate 10, the front adhesive layer 20, the cell array 30, the back adhesive layer 40 and the back plate 50 in sequence, and laminating them to obtain the solar cell module 100. It can be understood that the method further includes other steps, for example, sealing the gap between the upper cover plate 10 and the back plate 50 by a sealant, and fixing the above components together by a U-shape frame, which are known to those skilled in the art, and thus will be not described in detail herein.

The method includes a step of forming a plurality of conductive wires by a metal wire which extends reciprocally surfaces of cells 31 and is electrically connected with the surfaces of cells 31, such that the adjacent cells 31 are connected by the plurality of conductive wires to constitute a cell array 30.

Specifically, as shown in Fig. 7, the metal wire extends reciprocally for 12 times under strain. As shown in Fig. 8, a first cell 31A and a second cell 31B are prepared. As shown in Fig. 9, a front surface of the first cell 31A is connected with a metal wire, and a back surface of the second cell 31B is connected with the metal wire, such that the cell array 30 is formed. Fig. 9 shows two cells 31. When the cell array 30 has a plurality of cells 31, the metal wire which extends reciprocally connects the front surface of the first cell 31 and the back surface of the second cell 31 adjacent to the first cell 31, i.e. connecting a secondary grid line of the first cell 31 with a back electrode of the second cell 31 by the metal wire. The metal wire extends reciprocally under strain from two clips at two ends thereof. The metal wire can be winded only with the help of two clips, which saves the clips considerably and then reduces the assembling space.

In the embodiment shown in Fig. 9, the adjacent cells are connected in series. As said above, the adjacent cells can be connected in parallel by the metal wire based on practical requirements.

The cell array 30 obtained is superposed with the upper cover plate 10, the front adhesive layer 20, the back adhesive layer 40 and the back plate 50 in sequence, in which a front surface of the cell 31 faces the front adhesive layer 20, a back surface thereof facing the back adhesive layer 40, and laminating them to obtain the solar cell module 100. It can be understood that the metal wire can be bounded or welded with the cell 31 when or before they are laminated.

The front adhesive layer 20 is disposed in direct contact with the conductive wires 32. In the process of laminating, the front adhesive layer 20 melts and fills the gaps between adjacent conductive wires 32. The back adhesive layer 40 is disposed in direct contact with the conductive wires 32. In the process of laminating, the back adhesive layer 40 melts and fills the gaps between adjacent conductive wires 32.

Example 1

Example 1 is used to illustrate the solar cell module 100 according to the present disclosure and the manufacturing method thereof.

(1) Manufacturing a metal wire S

An alloy layer of Sn40%-Bi55%-Pb5% (melting point: 125°C) is attached to a surface of a copper wire, in which the copper wire has a cross section of 0.04mm^2, and the alloy layer has a thickness of 16μm. Hence, the metal wire S is obtained.

(2) Manufacturing a solar cell module 100

A POE adhesive layer in 1630×980×0.5mm are provided (melting point: 65°C), and a glass plate in 1633×985×3mm and a polycrystalline silicon cell 31 in 156×156×0.21mm are provided correspondingly. The cell 31 has 91 secondary grid lines (silver, 60μm in width, 9μm in thickness), each of which substantially runs through the cell 31 in a longitudinal direction, and the distance between the adjacent secondary grid lines is 1.7mm. Each secondary grid line is provided with 14 gaps. The cell 31 has five back electrodes (tin, 1.5mm in width, 10μm in thickness) on its back surface. Each back electrode substantially runs through the cell 31 in a longitudinal direction, and the distance between the adjacent back electrodes is 31mm.

60 cells 31 are arranged in a matrix form. In two adjacent cells 31 in a row, a metal wire extends reciprocally between a front surface of a first cell 31 and a back surface of a second cell 31 under strain. The metal wire extends reciprocally under strain from two clips at two ends thereof, so as to form 15 parallel conductive wires. The secondary grid line of the first cell 31 is welded

with the conductive wire, the secondary grid lines between two adjacent conductive wires being evenly distributed with one gap, and the back electrode of the second cell 31 is welded with the conductive wire at a welding temperature of 160°C. The distance between parallel adjacent conductive wires is 9.9mm.

Then, an upper glass plate, an upper POE adhesive layer, multiple cells arranged in a matrix form and welded with the metal wire, a lower POE adhesive layer and a lower glass plate are superposed sequentially from up to down, in which the shiny surface of the cell 31 faces the front adhesive layer 20, such that the front adhesive layer 20 contacts with the conductive wires 32 directly; and the shady surface of the cell 31 faces the back adhesive layer 40, and finally they are laminated in a laminator, in which the front adhesive layer 20 fills between adjacent conductive wires 32. In such way, a solar cell module A1 is obtained.

Comparison example 1

The difference of Comparison example 1 and Example 1 lies in that each secondary grid line 312 is a metal wire disposed continuously, so as to obtain a solar cell module D1.

Example 2

The difference of Example 2 and Example 1 lies in that the gap has a length of 3mm in the length direction of the secondary grid line, so as to obtain a solar cell module A2.

Example 3

The difference of Example 3 and Example 1 lies in that the gap has a length of 5mm in the length direction of the secondary grid line, so as to obtain a solar cell module A3.

Example 4

Example 1 is used to illustrate the solar cell module 100 according to the present disclosure and the manufacturing method thereof.

(1) Manufacturing a metal wire S

An alloy layer of Sn40%-Bi55%-Pb5% (melting point: 125°C) is attached to a surface of a copper wire, in which the copper wire has a cross section of 0.03mm^2, and the alloy layer has a thickness of 10μm. Hence, the metal wire S is obtained.

(2) Manufacturing a solar cell module 100

A EVA adhesive layer in 1630×980×0.5mm are provided (melting point: 65°C), and a glass plate in 1633×985×3mm and a polycrystalline silicon cell 31 in 156×156×0.21mm are provided correspondingly. The cell 31 has 91 secondary grid lines (silver, 60μm in width, 9μm in thickness), each of which substantially runs through the cell 31 in a longitudinal direction, and the distance between the adjacent secondary grid lines is 1.7mm. Each secondary grid line is provided with 19 gaps. The cell 31 has five back electrodes (tin, 1.5mm in width, 10μm in thickness) on its back surface. Each back electrode substantially runs through the cell 31 in a longitudinal direction, and the distance between the adjacent back electrodes is 31mm.

60 cells 31 are arranged in a matrix form. In two adjacent cells 31 in a row, a metal wire extends reciprocally between a front surface of a first cell 31 and a back surface of a second cell 31 under strain. The metal wire extends reciprocally under strain from two clips at two ends thereof, so as to form 20 parallel conductive wires. The secondary grid line of the first cell 31 is welded with the conductive wire, the secondary grid lines between two adjacent conductive wires being evenly distributed with one gap, and the back electrode of the second cell 31 is welded with the conductive wire at a welding temperature of 160°C. The distance between parallel adjacent conductive wires is 7mm.

Then, an upper glass plate, an upper POE adhesive layer, multiple cells arranged in a matrix form and welded with the metal wire, a lower POE adhesive layer and a lower glass plate are superposed sequentially from up to down, in which the shiny surface of the cell 31 faces the front adhesive layer 20, such that the front adhesive layer 20 contacts with the conductive wires 32 directly; and the shady surface of the cell 31 faces the back adhesive layer 40, and finally they are laminated in a laminator, in which the front adhesive layer 20 fills between adjacent conductive wires 32. In such way, a solar cell module A4 is obtained.

Example 5

The solar cell module is manufactured according to the method in Example 4, but the difference compared with Example 4 lies in that each secondary grid line is provided with 14 gaps. The secondary grid lines between part of adjacent conductive wires are evenly distributed with the gaps, while the secondary grid lines between other part of adjacent conductive wires are continuously arranged, so as to obtain a solar cell module A5.

Testing example 1

(1) According to the method disclosed in IEC904-1, the solar cell modules manufactured in the above examples and the comparison example are tested with a single flash simulator under standard test conditions: 1000W/m^2 of light intensity, AM1.5 spectrum, and 25°C. The photoelectric conversion efficiency of each cell is recorded. The testing result is shown in Table 1.

Table 1

Solar cell module	A1	D1	A2	A3	A4	A5
Photoelectric conversion efficiency (%)	17.1	16.8	16.9	16.7	17.2	17.1

As for the solar cell module according to the embodiments of the present disclosure, the gaps are disposed on the secondary grid lines, i.e. the silver paste is not printed at the gaps, which can reduce the amount of the silver paste and reduce the cost. It can be indicated from Fig. 1 that the gaps disposed on the secondary grid lines will not affect the photoelectric conversion efficiency of the solar cell, and the solar cell module according to the embodiments of the present disclosure can obtain relatively high photoelectric conversion efficiency can be obtained.

In the specification, it is to be understood that terms such as “central,” “longitudinal,” “lateral,” “length,” “width,” “thickness,” “upper,” “lower,” “front,” “rear,” “left,” “right,” “vertical,” “horizontal,” “top,” “bottom,” “inner,” “outer,” “clockwise,” and “counterclockwise” should be construed to refer to the orientation as then described or as shown in the drawings under discussion. These relative terms are for convenience of description and do not require that the present disclosure be constructed or operated in a particular orientation.

In addition, terms such as “first” and “second” are used herein for purposes of description and are not intended to indicate or imply relative importance or significance or to imply the number of indicated technical features. Thus, the feature defined with “first” and “second” may comprise one or more of this feature. In the description of the present disclosure, “a plurality of” means two or more than two, unless specified otherwise.

In the present disclosure, unless specified or limited otherwise, a structure in which a first feature is “on” or “below” a second feature may include an embodiment in which the first feature is in direct contact with the second feature, and may also include an embodiment in which the first feature and the second feature are not in direct contact with each other, but are contacted via an additional feature formed therebetween. Furthermore, a first feature “on,” “above,” or “on top of” a second feature may include an embodiment in which the first feature is right or obliquely “on,” “above,” or “on top of” the second feature, or just means that the first feature is at a height higher than that of the second feature; while a first feature “below,” “under,” or “on bottom of” a second feature may include an embodiment in which the first feature is right or obliquely “below,” “under,” or “on bottom of” the second feature, or just means that the first feature is at a height lower than that of the second feature.

Reference throughout this specification to “an embodiment,” “some embodiments,” or “some examples” means that a particular feature, structure, material, or characteristic described in connection with the embodiment or example is included in at least one embodiment or example of the present disclosure. Thus, these terms throughout this specification do not necessarily refer to the same embodiment or example of the present disclosure. Furthermore, the particular features, structures, materials, or characteristics may be combined in any suitable manner in one or more embodiments or examples.

Although embodiments of the present disclosure have been shown and described, it would be appreciated by those skilled in the art that changes, modifications, alternatives and variations can be made in the embodiments without departing from the scope of the present disclosure.

WHAT IS CLAIMED IS:

1. A solar cell unit, comprising:

a cell including a cell substrate and a plurality of secondary grid lines disposed on a front surface of the cell substrate; and

a plurality of conductive wires spaced apart from each other, the plurality of conductive wires being intersected and connected with the secondary grid lines, in which at least one secondary grid line has at least one gap located between adjacent conductive wires.

2. The solar cell unit according to claim 1, wherein there are n conductive wires; and there is/are n-1 gap(s) in a single secondary grid line.

3. The solar cell unit according to claim 2, wherein there is one gap between adjacent conductive wires.

4. The solar cell unit according to any one of claims 1 to 3, wherein the gap has a length of 0.2 to 5mm in a longitudinal direction of the secondary grid line.

5. The solar cell unit according to claim 4, wherein the gap has a length of 0.5 to 3mm in a length direction of the secondary grid line.

6. The solar cell unit according to any one of claims 1 to 5, wherein the gap is located in a middle position of the adjacent conductive wires.

7. The solar cell unit according to any one of claims 1 to 6, wherein there are 20 to 200 secondary grid lines.

8. The solar cell unit according to any one of claims 1 to 7, wherein the conductive wires are constituted by a metal wire.

9. The solar cell unit according to claim 8, wherein the metal wire is a copper wire.

10. The solar cell unit according to claim 8 or 9, wherein the metal wire is coated with a welding layer by which the conductive wires are welded with the secondary grid lines.

11. The solar cell unit according to claim 10, wherein the secondary grid line has a width in a welding position with the conductive wire greater than that in a non-welding position.

12. The solar cell unit according to claim 11, wherein the secondary grid line has a width in the welding position greater than or equal to a diameter or width of the conductive wire.

13. The solar cell unit according to any one of claims 1 to 12, wherein a short grid line is disposed on the front surface of the cell substrate; the secondary grid lines include a middle secondary grid line intersected with the conductive wires and an edge secondary grid line

non-intersected with the conductive wires; the short grid line is connected with the edge secondary grid line, and connected with the conductive wires or at least one middle secondary grid line.

14. The solar cell unit according to claim 13, wherein the short grid lines are connected with the middle secondary grid lines closest to the edge secondary grid lines.

15. A solar cell array, comprising a plurality of solar cell units which are the solar cell units according to any one of claims 1 to 14, cells of adjacent cell units being connected by the conductive wires.

16. The solar cell array according to claim 15, wherein the conductive wire is constituted by a metal wire; and the metal wire extends reciprocally between a surface of a first cell and a surface of a second cell adjacent to the first cell.

17. The solar cell array according to claim 16, wherein the metal wire extends reciprocally between a front surface of the first cell and a back surface of the second cell.

18. The solar cell array according to claim 17, wherein a back electrode is disposed on the back surface of the cell substrate, and the metal wire is welded with the back electrode of the second cell.

19. The solar cell array according to claim 16, wherein the metal wire extends reciprocally between the front surface of the first cell and the back surface of the second cell for 10 to 60 times.

20. The solar cell array according to any one of claims 16 to 19, wherein a distance between two adjacent conductive wires ranges from 2.5mm to 15mm.

21. The solar cell array according to any one of claims 16 to 20, wherein the two adjacent conductive wires form a U-shape structure or a V-shape structure.

22. The solar cell array according to claim 16, wherein the cells are arranged in an $n \times m$ matrix form, n representing a column, and m representing a row;

in a row of cells, the metal wire extends reciprocally between a surface of a first cell and a surface of a second cell adjacent to the first cell; in two adjacent rows of cells, the metal wire extends reciprocally between a surface of a cell in a a^{th} row and a surface of a cell in a $(a+1)^{th}$ row; and $m-1 \geq a \geq 1$.

23. The solar cell array according to claim 22, wherein in two adjacent rows of cells, the metal wire extends reciprocally between a surface of a cell at an end of the a^{th} row and a surface of a cell at an end of the $(a+1)^{th}$ row, the end of the a^{th} row and the end of the $(a+1)^{th}$ row located at the same side of the matrix form.

24. The solar cell array according to claim 23, wherein in a row of cells, the metal wire extends reciprocally between a front surface of a first cell and a back surface of a second cell adjacent to the first cell;

in two adjacent rows of cells, the metal wire extends reciprocally between a front surface of the cell at the end of the a^{th} row and a back surface of the cell at the end of the $(a+1)^{th}$ row, to connect the two adjacent rows of cells in series.

25. The solar cell array according to any one of claims 22 to 24, wherein there is a metal wire extending reciprocally between adjacent cells in a row; and there is a metal wire extending reciprocally between cells in adjacent rows.

26. The solar cell array according to claim 16, wherein there is a metal wire.

27. The solar cell array according to any one of claims 16 to 26, wherein the metal wire is coated with a welding layer, and a ratio of a thickness of the welding layer and a diameter of the metal wire is (0.02-0.5): 1.

28. The solar cell array according to claim 27, wherein the welding layer contains Sn, and at least one of Bi, In, Ag, Sb, Pb and Zn.

29. The solar cell array according to claim 27, wherein the welding layer contains Sn, Bi, and at least one of In, Ag, Sb, Pb and Zn.

30. The solar cell array according to claim 27, wherein the welding layer has a thickness of 1 to 100μm.

31. The solar cell array according to claim 16, wherein the metal wire is a copper wire.

32. A solar cell module, comprising an upper cover plate, a front adhesive layer, a cell array, a back adhesive layer and a back plate superposed in sequence, the cell array being a solar cell array according to any one of claims 15 to 31.

33. A method for manufacturing a solar cell module, comprising:

providing a cell which includes a cell substrate and a plurality of secondary grid lines disposed on a front surface of the cell substrate;

intersecting and connecting conductive wires constituted by a metal wire with the secondary grid lines to obtain a solar cell unit, in which at least one secondary grid line has at least one gap located between adjacent conductive wires;

superposing an upper cover plate, a front adhesive layer, the solar cell unit, a back adhesive layer and a back plate in sequence, in which a front surface of the cell faces the front adhesive layer, a back surface thereof facing the back adhesive layer, and laminating them to obtain the solar cell module.

34. The method according to claim 33, wherein there are multiple cells; and adjacent cells are connected by the conductive wires to form the cell array according to any one of claims 14 to 30.

35. The method according to claim 33, wherein the metal wire extends reciprocally on a surface of the cell.

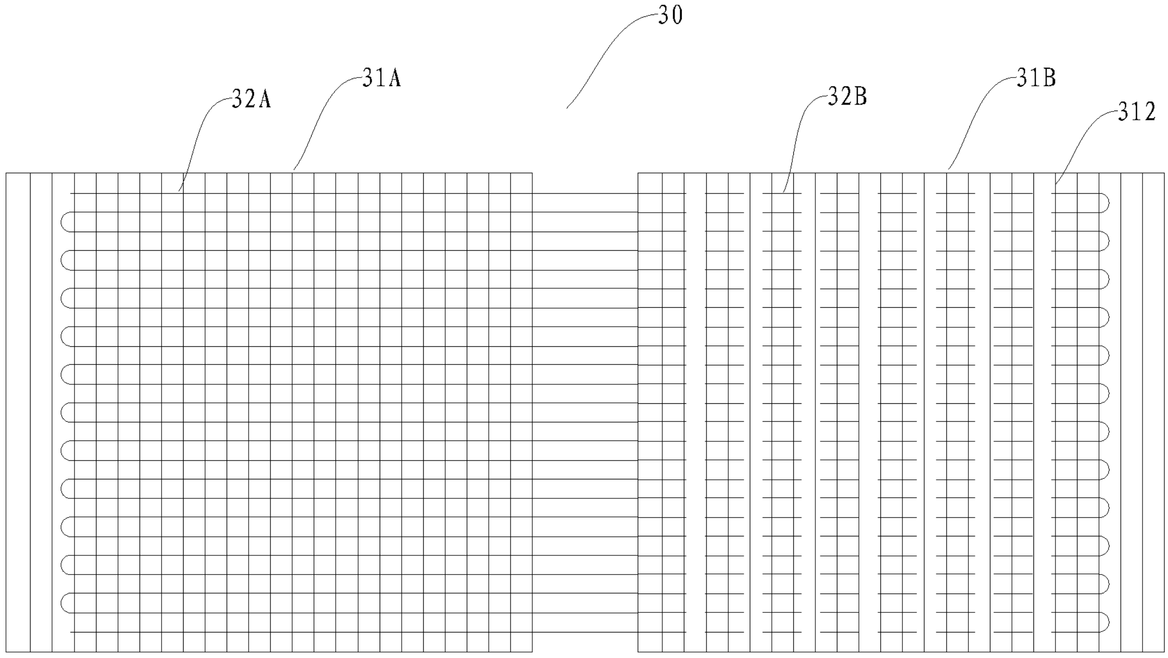

Fig. 1

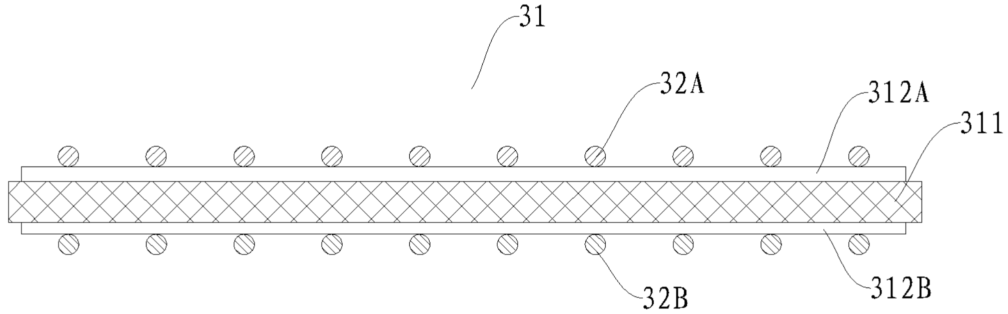

Fig. 2

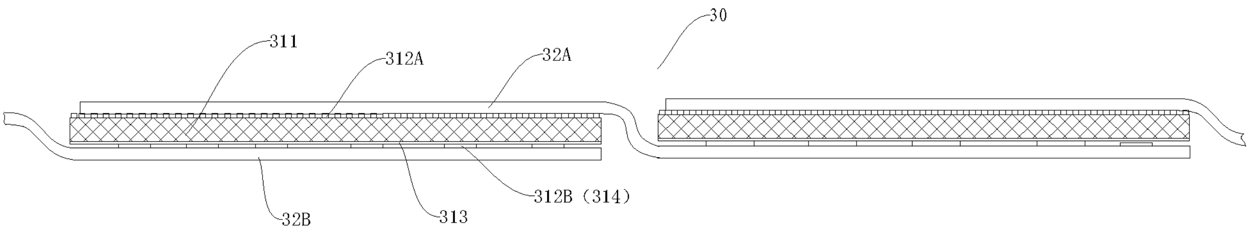

Fig. 3

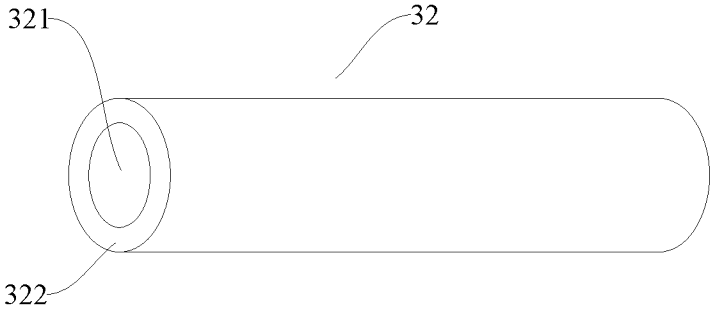

Fig. 4

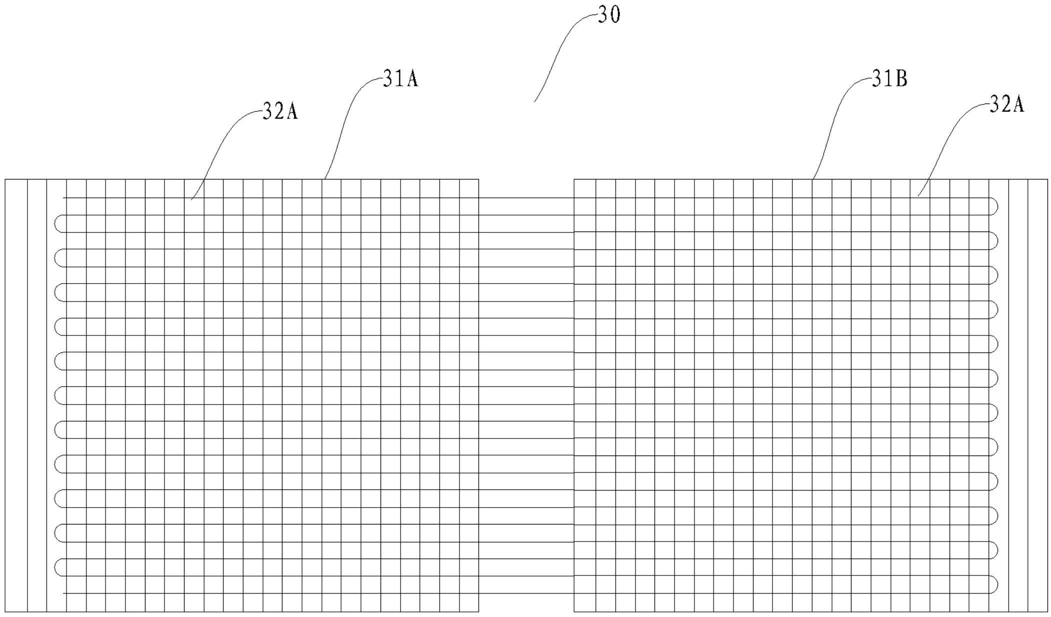

Fig. 5

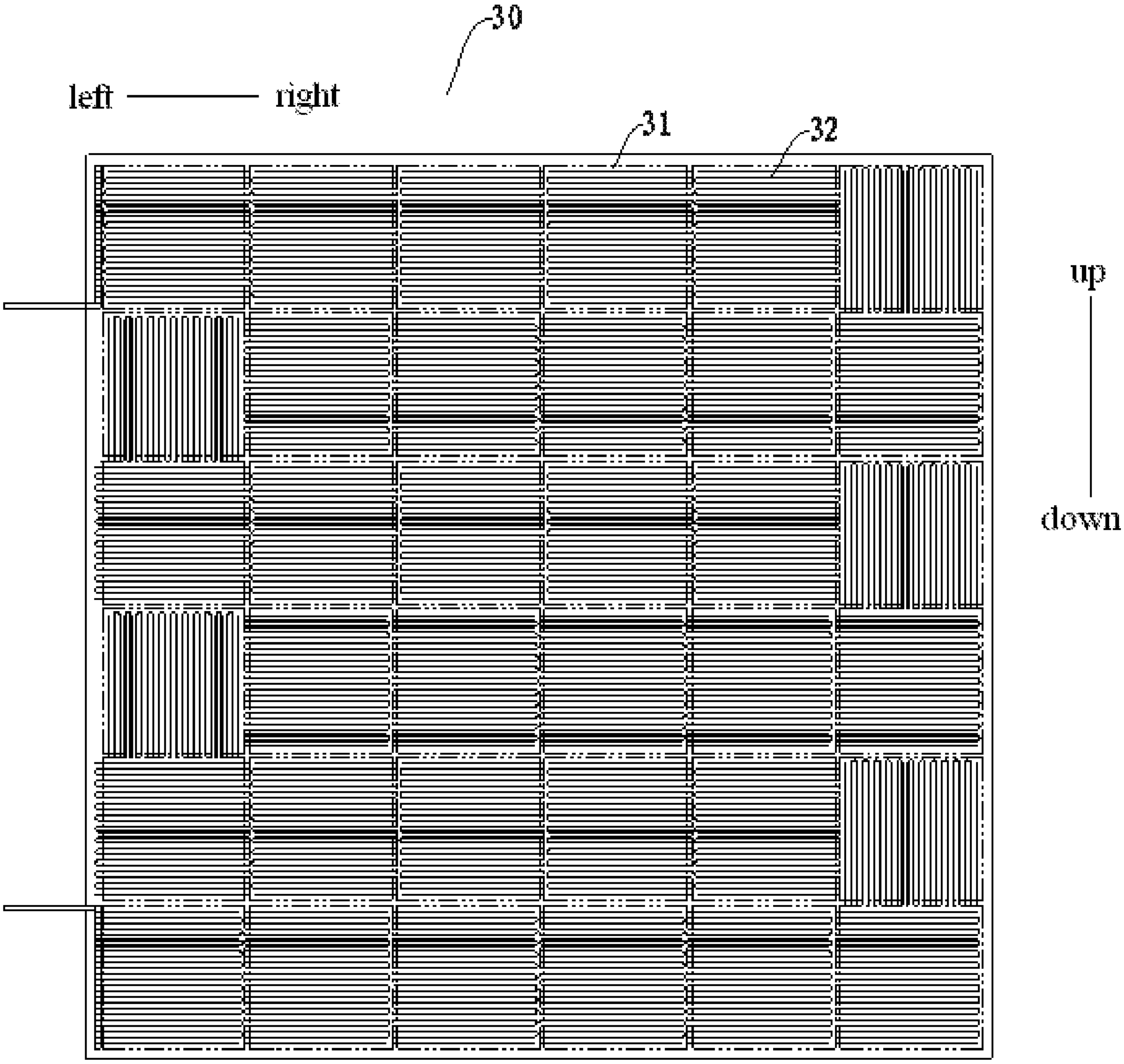

Fig. 6

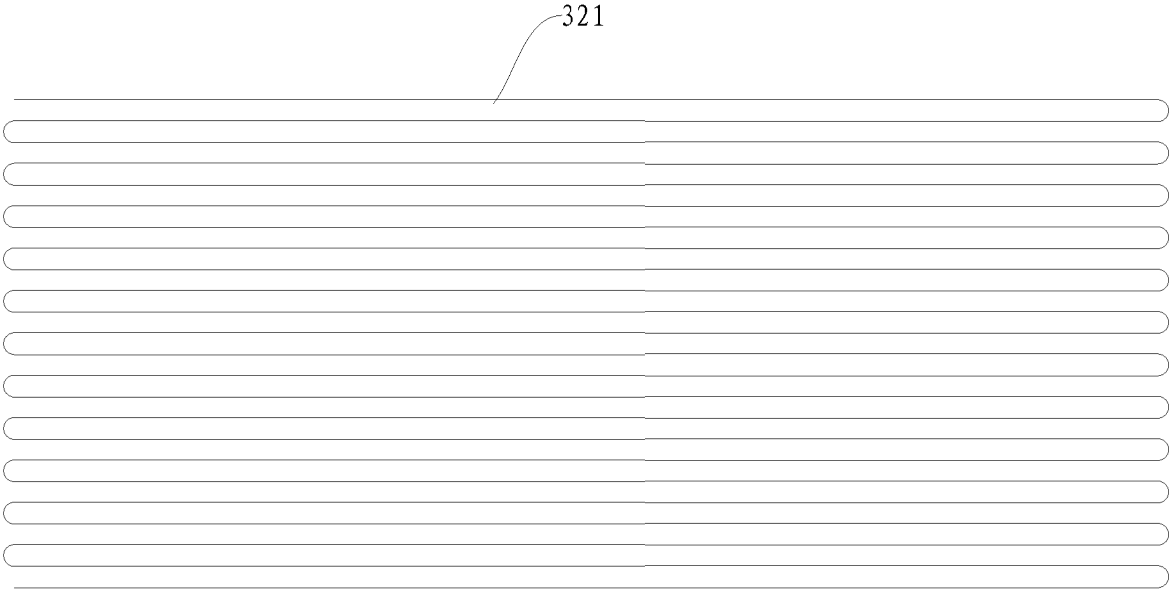

Fig. 7

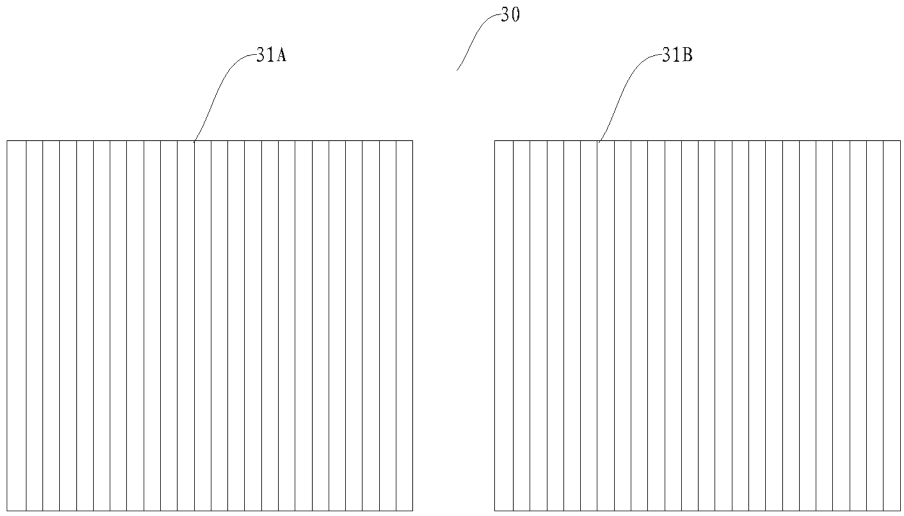

Fig. 8

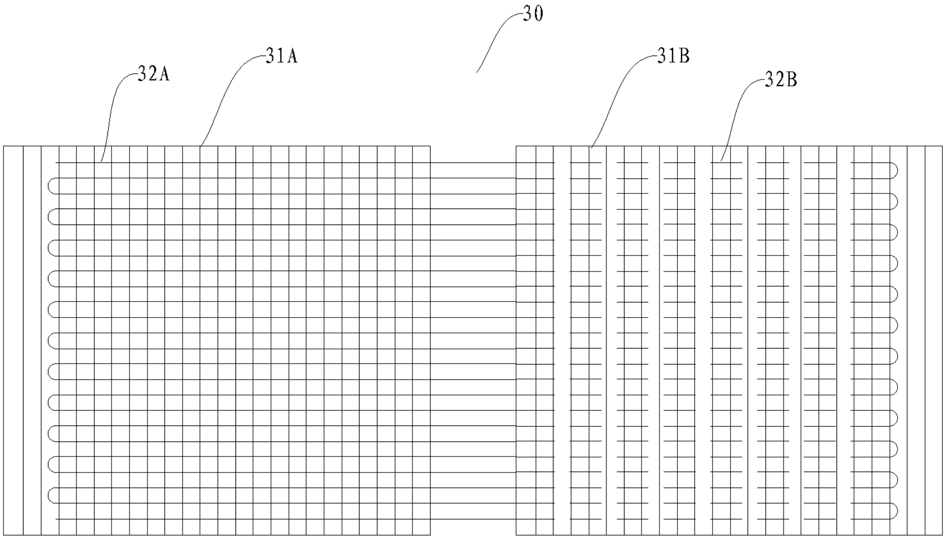

Fig. 9

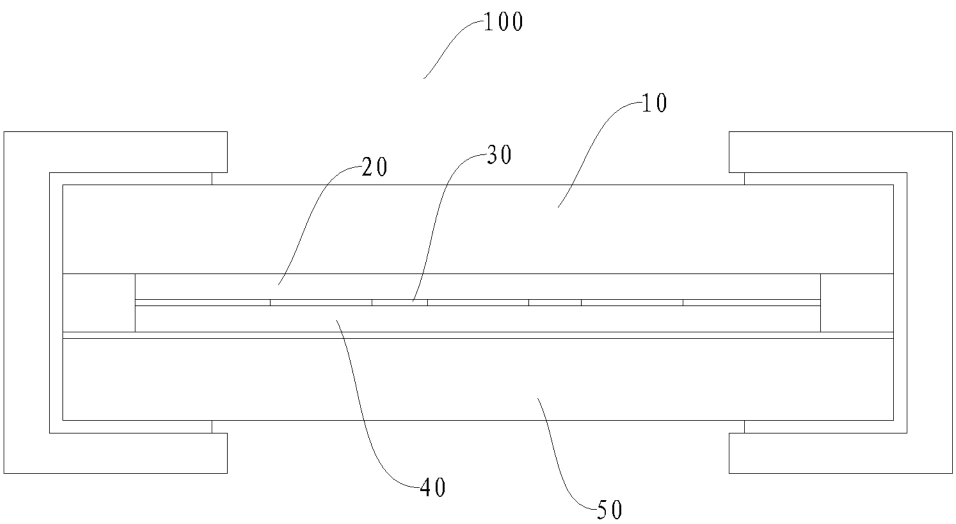

Fig. 10

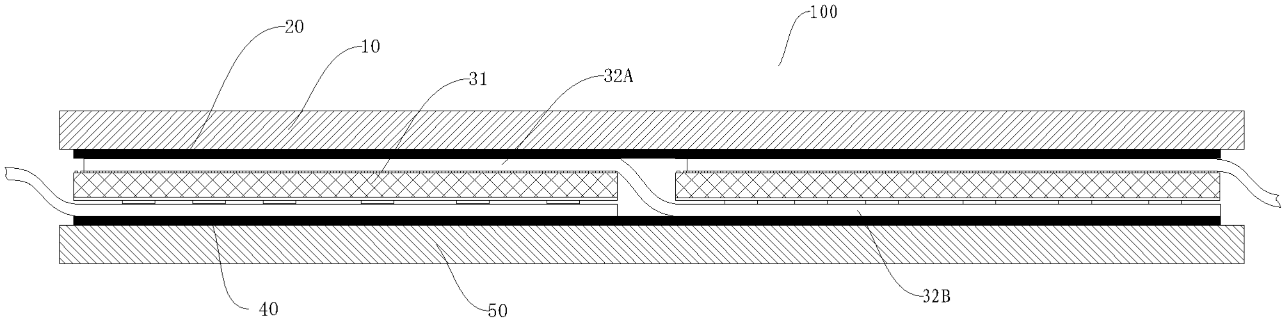

Fig. 11

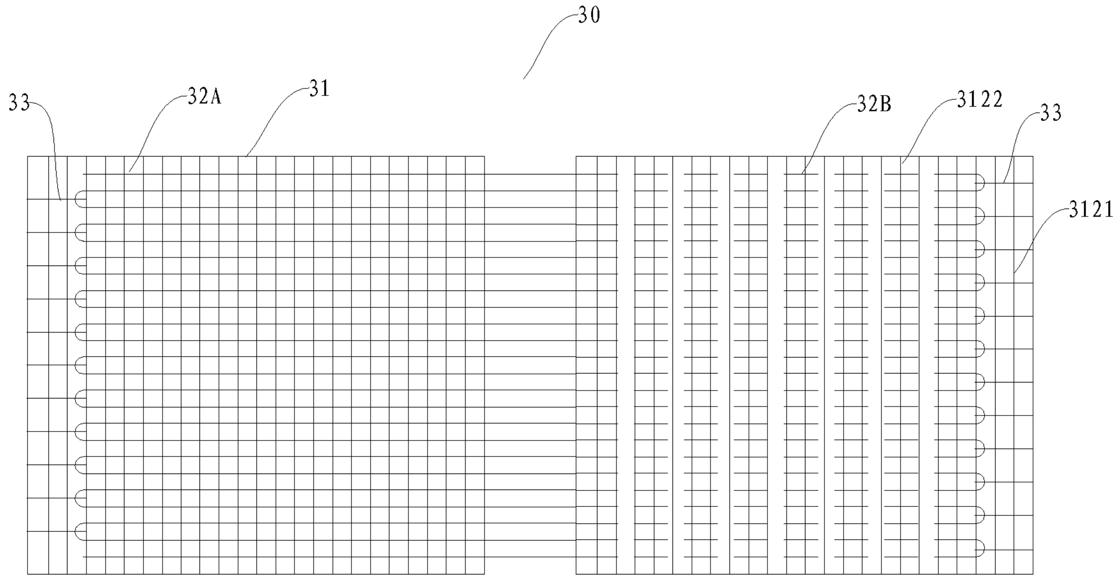

Fig. 12

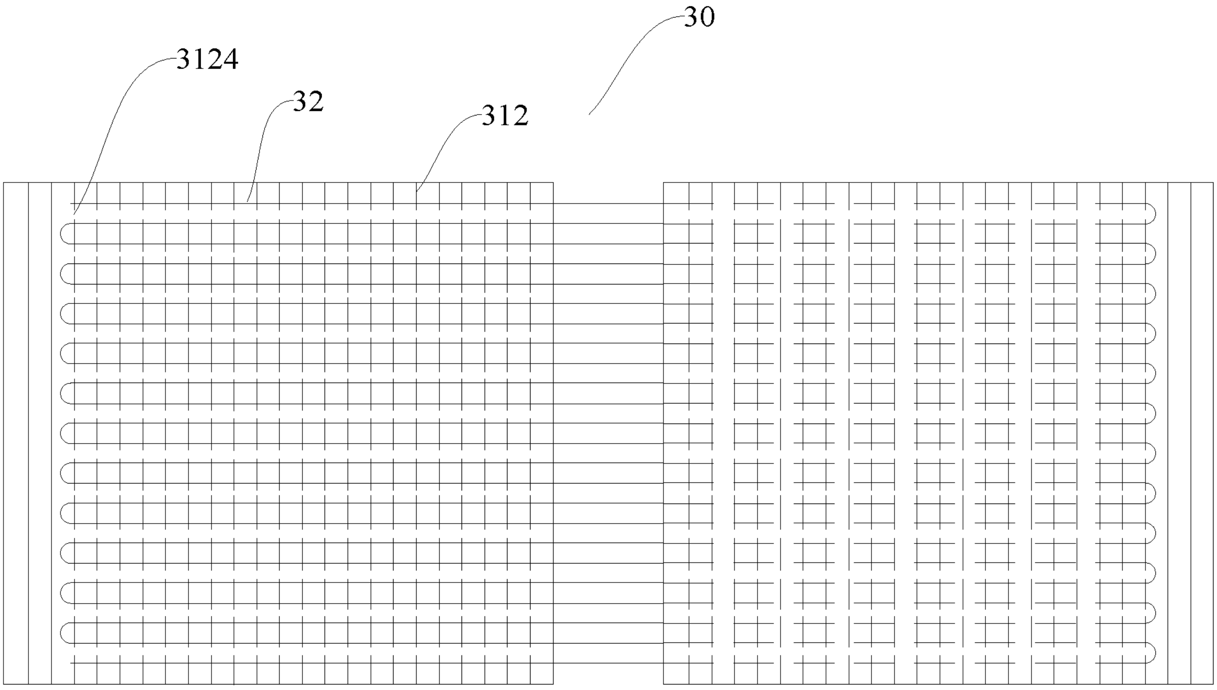

Fig. 13

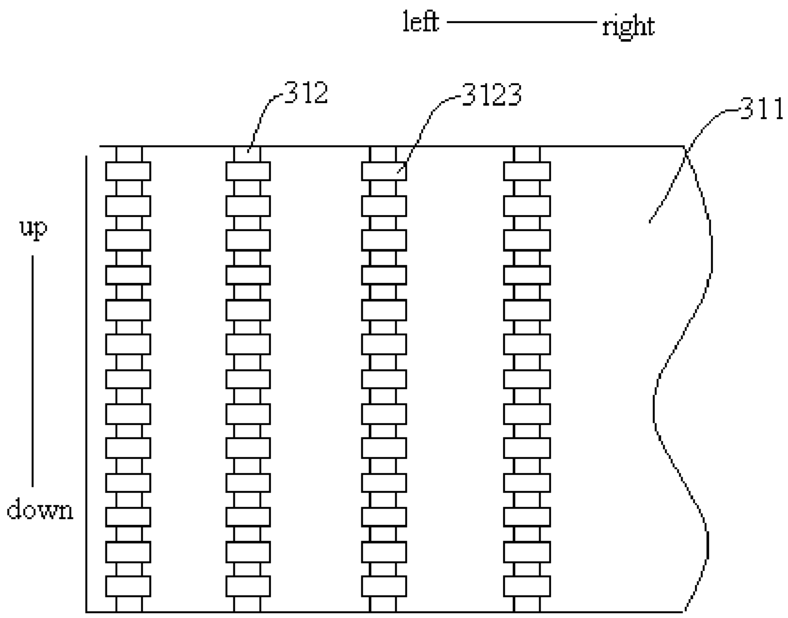

Fig. 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/084118

A. CLASSIFICATION OF SUBJECT MATTER

H01L 31/042(2014.01)i; H01L 31/0224(2006.01)i; H01L 31/18(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01L

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

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

CNPAT,EPODOC,WPI,CNKI,IEEE: solar, cell, photovoltage, grid, line, main, secondary, wire, thread, line, welding, interval, gap, section, shielding, area, width, reciprocally, to and fro, serpentine

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 103137719 A (HANGZHOU DAIWA THERMOMAGNETIC ELECTRONIC CO. LTD.) 05 June 2013 (2013-06-05) description, paragraphs [0009]-[0027], figures 2-4	1-12, 15-35
Y	CN 103367549 A (SHANDONG LINUO SOLAR POWER HOL.) 23 October 2013 (2013-10-23) description, paragraphs [0006]-[0024], figures 1-2	1-12, 15-35
Y	CN 103794663 A (CHANGZHOU TRINA SOLAR ENERGY CO., LTD.) 14 May 2014 (2014-05-14) description, paragraphs [0012]-[0014], figures 3-6	11-12, 15-32
Y	US 2010043863 A1 (MIASOLE) 25 February 2010 (2010-02-25) description, paragraphs [0088]-[0105], figures 5-6	15-32, 34-35
A	CN 103348492 A (SANYO ELECTRIC CORPORATION) 09 October 2013 (2013-10-09) the whole document	1-35

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

* Special categories of cited documents:

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

Date of the actual completion of the international search	Date of mailing of the international search report
11 September 2015	**24 September 2015**

Name and mailing address of the ISA/CN	Authorized officer
STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China**	**MA,Zeyu**
Facsimile No. **(86-10)62019451**	Telephone No. **(86-10)82245893**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2015/084118

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	103137719	A	05 June 2013	None			
CN	103367549	A	23 October 2013	None			
CN	103794663	A	14 May 2014	None			
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CN	103348492	A	09 October 2013	WO	2012105331	A1	09 August 2012
				US	2013306149	A1	21 November 2013
				EP	2672526	A1	11 December 2013