Method and device for producing solar modules

The invention relates to a method and a device for producing solar modules.

Such methods and devices are known from practice. In this case, photovoltaic cells are assembled into lines and the solar modules are constructed from electrically interconnected lines.

WO 2010/000812 A2 discloses a method for producing a solar module comprising solar cells interconnected in at least two rows which are aligned in relation to one another, such as parallel to one another, and arranged on a substrate, characterized by the following sequence of method steps: providing and aligning the substrate, aligning the solar cells and positioning them on the substrate, placing cell connectors on mutually facing edge regions of mutually adjacent solar cells, and connecting the cell connectors to the edge regions, connecting the interconnected solar cells to transverse connectors, and covering the connected solar cells with a cover.

DE 202 20 444 U1 discloses photovoltaic modules having the following structure: A) at least one outer cover layer, which is made from glass or an impact-resistant, UV-stable, weather-proof, transparent plastic with low vapour permeability, is at the front, and faces towards the energy source, B) at least one layer of adhesive plastic, which is located between A) and C) and in which at least one or multiple electrically interconnected solar cells are embedded, C) at least one outer layer, which is made from glass or a weather-proof plastic with low vapour permeability, is at the rear, and faces away from the energy source, characterized in that the layer of adhesive plastic in B) consists of an aliphatic thermoplastic polyurethane with a hardness of 75 Shore A to 70 Shore D and with a softening temperature Terw of 90°C to 150°C given a modulus of elasticity

of 2 MPa (measured according to the DMS method), the aliphatic thermoplastic polyurethane being a reaction product of an aliphatic diisocyanate (A), at least one Zerewitinoff-active polyol with an average of at least 1.8 to at most 3.0 Zerewitinoff-active hydrogen atoms and with a number-average molecular weight of 600 to 10 000 g/mol (B), and at least one Zerewitinoff-active polyol with an average of at least 1.8 to at most 3.0 Zerewitinoff-active hydrogen atoms and with a number-average molecular weight of 60 to 500 g/mol as chain extender (C), wherein the molar ratio of the NCO groups of the aliphatic diisocyanate to the Zerewitinoff-active hydrogen atoms of (B) and (C) is 0.85 to 1.2, preferably 0.9 to 1.1.

WO 2016/063244 A1 discloses a connecting apparatus for electrically connecting at least one end portion of at least one longitudinal connector of at least one solar cell string to a transverse connector, wherein the longitudinal connector extends preferably substantially in the longitudinal direction of the string, wherein the connecting apparatus comprises:

- a first transporting device suitable for transporting the at least one string, preferably multiple strings arranged one behind the other, in a first transport direction and at a first transporting speed, wherein the first transporting device is preferably a conveyor belt;
- at least one feeding station for feeding a transverse connector to the end portion of the at least one longitudinal connector;
- at least one connecting station, preferably a welding or soldering station, for electrically connecting the at least one end portion of the longitudinal connector to the transverse connector; at least one pressing device for pressing the transverse connector and the end portion of the longitudinal connector against one another, wherein at least part of the pressing device extends in the working area of the connecting station; wherein the working area of the connecting station and the pressing area of the pressing device extend laterally along

the transport path of the string on the first transporting means and/or in a lateral region of the first transporting means.

DE 10 2008 046 327 A1 discloses an arrangement of multiple production apparatuses to afford an installation for processing solar cells to form a module, wherein the arrangement comprises at least the following: – at least one production apparatus for providing the support; – at least one production apparatus for pre-assembling the solar cells by attaching contact wires; – at least one production apparatus for arranging transverse contact wires on the support before the pre-assembled solar cells are placed thereon; – at least one production apparatus for placing the pre-assembled solar cells on a support; – at least one production apparatus for longitudinally connecting the pre-assembled solar cells to the contact wires after the pre-assembled solar cells have been placed on; – at least one production apparatus for transversely connecting the pre-assembled solar cells to the transverse contact wire after the pre-assembled solar cells have been placed on; – at least one production apparatus for bringing together the solar cells located on the support onto a support glass for manufacturing the module.

US 2019/058436 A1 discloses a flexible photovoltaic (PV) module comprising the following:
a first PV tile area; a second PV tile area; a third PV tile area, wherein the first PV tile area, the second PV tile area, and the third PV tile area are arranged linearly to form an elongate module, with the first PV tile area adjacent to the second PV tile area, and with the second PV tile area adjacent to the third PV tile area; a first flexible joint, electrically and structurally connecting the first PV tile area and the second PV tile area; a second flexible joint, electrically and structurally connecting the second PV tile area and the third PV tile area; a multiplicity of first bus bars on either side of

the first and second flexible joints, the bus bars being designed to electrically interconnect each of the PV tile areas in a series circuit; and a pair of second bus bars, each one of which is electrically connected to one end of the series circuit, forming respective V+ and V- power outputs.

The object of the disclosure is to provide a method for producing solar modules and a corresponding device which are conducive to the efficient production of solar modules.

First proposed to achieve the object is a method comprising the means and features of the first independent claim directed to a method for producing solar modules. In particular, for achieving the object, it is thus proposed in the case of the method mentioned above that at least two lines are built up and that the at least two lines are co-fed to a cell-fitting operation for the solar module.

In a first aspect, the present disclosure provides a method for producing solar modules, wherein photovoltaic cells are assembled into lines and wherein the solar modules are constructed from electrically interconnected lines, characterized in that at least two lines are built up and the at least two lines are co-fed to a cell-fitting operation for the solar module, and in that, for connecting adjacent lines of photovoltaic cells, electrically conductive adhesive is applied with a lateral offset in relation to a longitudinal central axis of a line of photovoltaic cells to the line, after which two adjacent lines are adhesively bonded to one another while mutually overlapping.

The co-feeding, in particular simultaneous feeding, of at least two or more lines allows the cell-fitting operation for the solar module to take place in a shorter time, which is conducive to more efficient production of solar modules.

The at least two lines may be co-fed to the cell-fitting operation for the solar module by means of a motorized transfer unit, for example by means of a tray and/or by means of a vacuum table and/or a belt conveyor. The use of a motorized transfer unit can be conducive to the largely or even completely automated production of solar modules.

For fitting the lines into the solar module without changing an arrangement of the photovoltaic cells in the lines produced

during the building up of the lines, it is advantageous if a relative alignment of the photovoltaic cells within one line and/or within two different lines is maintained during the feeding.

In the finished solar module there may be an electrical voltage level within each of the individual lines of photovoltaic cells. There is therefore no electrical voltage build-up in the longitudinal direction of the lines across the photovoltaic cells of a line. In the finished solar module there may be an electrical voltage build-up across the electrically interconnected lines, and thus transversely or at right angles to a longitudinal direction of the lines.

According to the method, the photovoltaic cells can thus be assembled into lines, with an electrical voltage level within each of the individual lines of photovoltaic cells. The solar modules can then be constructed from electrically interconnected lines, with an electrical voltage build-up taking place in the solar module across the electrically interconnected lines, and thus transversely or at right angles to a longitudinal direction of the lines.

For the purposes of the claimed invention, a line can thus be distinguished from a conventional string of photovoltaic cells. In a string, the photovoltaic cells are electrically interconnected in such a way that an electrical voltage build-up takes place in the longitudinal direction of the string across the electrically interconnected photovoltaic cells of the string.

For the electrical connection of photovoltaic cells within a line and/or of photovoltaic cells of different, in particular adjacent, lines, an electrically conductive adhesive may be applied to the photovoltaic cells.

In order to prevent a bead of adhesive from tearing off when applying the electrically conductive adhesive to a line of photovoltaic cells, it may be advantageous to adapt a number of co-fed lines to an application rate of an electrically conductive adhesive. In particular, when photovoltaic cells are arranged in at least two lines by means of a transfer unit, a maximum feed or transfer rate, with which the lines are co-fed to the cell-fitting operation for the solar cell, may be limited by the cycle time of the transfer unit in the arrangement of the photovoltaic cells.

The higher the number of lines that are co-fed, the lower a feed or transfer rate at which the at least two lines can be fed to the cell-fitting operation can be. If the electrically conductive adhesive is to be applied during the feeding of at least two lines of photovoltaic cells to the cell-fitting operation for the solar module, for example by a relative movement of the lines during their feeding to the cell-fitting operation for the solar module in relation to a dispensing unit, with which adhesive is dispensed, it may thus be expedient to adapt a number of co-fed lines to the application rate of the electrically conductive adhesive in order to make the application of the electrically conductive adhesive reliable within the process.

If the application rate of the electrically conductive adhesive in turn is variable, the application rate of the electrically conductive adhesive can also be adapted to a number of co-fed lines.

In one embodiment of the method it is provided that a first group of co-fed lines in a first cycle phase are fed at a first vertical distance from a dispensing unit for electrically conductive adhesive and a second group of co-fed lines are then fed at a

second vertical distance from the dispensing unit, which is different from the first vertical distance. In this embodiment of the method there may therefore be two transfer levels in which different groups of co-fed lines are fed to the cell-fitting operation for solar modules. These transfer levels may be arranged here one vertically above the other, so that the transfer levels have different vertical distances from a dispensing point, for example, a dispensing unit, for electrically conductive adhesive onto the co-fed lines.

In order to effect connection of adjacent lines to one another, according to the disclosure electrically conductive adhesive is applied with a lateral offset in relation to a longitudinal central axis of a line of photovoltaic cells to a line. In this way, according to the disclosure two adjacent lines are adhesively bonded to one another while mutually overlapping.

It may also be provided in the method that offsetting elements are used during the building up of the lines to form an offset of adjacent lines in relation to one another.

The offset of adjacent lines in relation to one another may be advantageous to produce a mechanically secure and stable connection between adjacent lines within a solar module.

The use of relatively offset lines of photovoltaic cells in a solar module offers the possibility of electrically connecting a photovoltaic cell of a line to multiple photovoltaic cells of the same and/or adjacent lines surrounding the photovoltaic cell on the solar module. This can lead to a solar module that is

constructed in such a way that, even if one or more photovoltaic cells of the solar module are shaded, it provides a high performance.

If the offset of adjacent lines in relation to one another is already produced before the solar module is fitted with cells, when the lines of photovoltaic cells are being built up, handling of the lines when the solar module is fitted with cells can be made considerably easier. This can significantly increase the efficiency of the method in the production of solar modules.

It should be mentioned at this point that the use of such offsetting elements may also be useful in the case of the previously mentioned method which is characterized by the features of the first independent claim 1.

Photovoltaic cells that have a shorter length and/or a different geometry compared to other photovoltaic cells of a line may be used for example as offsetting elements.

In one embodiment of the method, it may be provided that at least two lines offset in relation to one another are co-fed to the cell-fitting operation.

The photovoltaic cells that are assembled into lines may be so-called photovoltaic cell shingles.

In one embodiment of the method, groups of at least two lines are built up in parallel in time and are fed to a common cell-fitting operation. In this way, the number of co-fed lines can be increased by scaling the process.

Also proposed to achieve the object is a device for producing solar modules which has the means features of the independent claim directed to such a device. To achieve the object, in the

case of the device defined at the beginning it is thus proposed in particular that this device has means by which the device is set up for carrying out a method according to one of the claims directed to a method for producing solar modules.

In a second aspect, the present disclosure provides a device for producing solar modules, wherein the device comprises means by which the device is set up for carrying out a method according to the first aspect, specifically a motorized transfer unit, with which at least two lines of photovoltaic cells can be co-fed to a cell-fitting operation for a solar module to be produced, and a dispensing unit for dispensing electrically conductive adhesive onto lines of photovoltaic cells and a control unit, by which the device is set up for carrying out the method according to the first aspect.

According to the disclosure it is provided that the device, as means for carrying out the method, has a motorized transfer unit, with which at least two lines of photovoltaic cells can be co-fed to a cell-fitting operation for a solar module to be produced.

A tray, a conveyor table, in particular with a vacuum table, a belt conveyor, in particular with a vacuum table and/or a vacuum table may serve for example as a motorized transfer unit. With the aid of a vacuum table, it is possible to use a vacuum to fix photovoltaic cells arranged in lines on the vacuum table during the feeding to the cell-fitting operation. Fixing photovoltaic cells by means of a vacuum is particularly gentle and can help to reduce or even completely avoid waste in the production of solar modules.

The motorized transfer unit may be set up to move the photovoltaic cells of the lines from a loading point to an

unloading point, at which the lines of photovoltaic cells are removed from the transfer unit for fitting into a solar module.

At the transfer unit, at least two support positions for each line of photovoltaic cells may be formed and/or defined. In this way, it is possible with the transfer unit to co-feed at least two lines of photovoltaic cells to a cell-fitting operation for solar modules.

In the case of a preferred embodiment of the device, the transfer unit may have at least one series of suction openings for each support position. In this way, rows of photovoltaic cells

arranged on the at least two support positions of the transfer unit can be fixed on the transfer unit by means of a vacuum.

The device may comprise a vacuum generating unit, with which lines of photovoltaic cells can be fixed on the transfer unit by a vacuum, in particular during the co-feeding of at least two lines to the cell-fitting operation for a solar module. As already previously mentioned, the use of vacuum to fix the lines allows particularly gentle, and therefore efficient, fixing of photovoltaic cells during their feeding on the transfer unit.

The vacuum generating unit may be connected here to suction openings of the transfer unit. The vacuum generated by the vacuum generating unit can be transferred to the lines of photovoltaic cells via the suction openings of the transfer unit.

The device also has according to the disclosure, as means for carrying out the method, a dispensing unit for dispensing electrically conductive adhesive onto lines of photovoltaic cells. The dispensing unit may be arranged in such a way that dispensing of electrically conductive adhesive onto lines of photovoltaic cells that are arranged on the transfer unit is possible. The dispensing unit may for example be arranged between a loading point, at which the photovoltaic cells are arranged for the building up of lines on the previously mentioned transfer unit, and an unloading point, at which the lines are unloaded from the transfer unit. In this way, it is possible to apply the electrically conductive adhesive to the lines of photovoltaic cells with the aid of the dispensing unit by a relative movement between the dispensing unit and the transfer unit. The lines can thus be provided with electrically conductive adhesive during their transfer between the loading point and the unloading point. If necessary, here the relative movement may be the transfer movement of the lines.

The dispensing unit may have a number of dispensing nozzles corresponding to a number of support positions for lines of photovoltaic cells of the transfer unit. In this way it is possible to provide all of the lines of photovoltaic cells that are arranged on the transfer unit during the transfer with electrically conductive adhesive.

In one embodiment of the device it is provided that the dispensing unit, in particular at least one dispensing nozzle of the dispensing unit, from which electrically conductive adhesive can be applied to lines of photovoltaic cells is movable in the longitudinal direction of support positions of the transfer unit for lines, and thus in the longitudinal direction of lines arranged on the transfer unit. This allows electrically conductive adhesive to be applied to lines of photovoltaic cells that are fed to the cell-fitting operation with the aid of a transfer unit, wherein the transfer unit carries out a transfer movement that is aligned transversely or at right angles to the longitudinal direction of the lines of photovoltaic cells arranged on the transfer unit. Here, the movement of the dispensing unit, in particular its dispensing nozzles, may then be aligned transversely or correspondingly at right angles to the transfer movement of the transfer unit.

The device may have a magazine for providing photovoltaic cells. The magazine may for example comprise a conveying means, for example a conveyor belt, on which a supply of photovoltaic cells and/or offsetting elements can be moved into a removal position. This is conducive to particularly efficient and largely uninterrupted provision of photovoltaic cells for the production of solar modules.

The device may also have a transfer unit, in particular with a handling robot, for example a swivel-arm robot, with which photovoltaic cells can be arranged in lines on the transfer unit.

With the aid of the transfer unit, the photovoltaic cells and/or offsetting elements can for example be removed from the already previously mentioned magazine.

The transfer unit, in particular the previously mentioned handling robot, may have at least one suction gripper. With the aid of a suction gripper, photovoltaic cells can be gripped particularly gently and also released again.

For monitoring photovoltaic cells, the device may have a monitoring unit. The monitoring unit may comprise at least one optical monitoring means, for example a camera. In one embodiment of the device, the monitoring unit is provided between a magazine for providing photovoltaic cells and the transfer unit, in particular between the magazine for providing photovoltaic cells and the already previously mentioned transfer unit of the device, with which photovoltaic cells can be removed from the magazine and arranged in lines on the transfer unit. This allows the photovoltaic cells taken out of the magazine to be checked before they are arranged in lines on the transfer unit.

The magazine may comprise at least one belt conveyor, with which the photovoltaic cells can be brought into a removal position.

The device may also have a cell-fitting unit, in particular with at least one gripper, preferably with at least one suction gripper. The cell-fitting unit may be adapted to receive at least one or more or all of the lines of photovoltaic cells which are provided by the transfer unit at a unloading point and/or to transfer them to a downstream processing step and/or handling step, in particular to a downstream transporting unit of the device. With the aid of the cell-fitting unit, it is possible to fit the lines of photovoltaic cells provided by the transfer unit into the solar module.

The device may have a transporting unit downstream of the transfer unit. With the aid of the transporting unit, at least one solar module fitted with lines of photovoltaic cells can be fed to a downstream processing station. A downstream processing station may for example be an oven in which electrically conductive adhesive which can be used to connect the lines of photovoltaic cells of a module to one another is cured. A downstream processing station may also be for example a packaging and/or loading station. For example, a layup, which may be set up for matrix transfer, may be used as a packaging and/or loading station.

In one embodiment of the device it is provided that a transfer movement of the transfer unit is aligned transversely, in particular at right angles, to a longitudinal direction of support positions for lines of photovoltaic cells on the transfer unit or in the longitudinal direction of support positions for lines on the transfer unit.

In one embodiment of the device it is provided that a transfer movement of the transfer unit is aligned transversely, in particular at right angles, to a transporting movement of the transporting unit. In the case of another embodiment of the device it is provided that a transfer movement of the transfer unit is aligned in the direction of a transporting movement of the transporting unit. In this embodiment of the device, it may be advantageous if the previously mentioned dispensing unit, at least at least one dispensing nozzle of the dispensing unit, with which electrically conductive adhesive can be applied to the lines of photovoltaic cells can be moved relative to the transfer unit and in the longitudinal direction of the support positions for lines, and thus in the longitudinal direction of the lines of photovoltaic cells that are arranged on the transfer unit, and/or relative to the transfer unit and/or transversely

or at right angles to the support positions and/or lines of photovoltaic cells.

The device also has, as means for carrying out the method, a control unit, by which the device is set up for carrying out the method in accordance with one of the claims directed to such a method.

The invention is described in more detail below with reference to exemplary embodiments, but is not limited to the exemplary embodiments shown. Further exemplary embodiments result from the combination of the features of one or more claims among themselves and/or in combination of one or more features of the exemplary embodiments.

In the figures:

Figures 1 and 2 show a first exemplary embodiment of a device for producing solar modules, wherein the device has a transfer unit in the form of a movable vacuum table, which may also be referred to as a tray, with which a total of three lines of photovoltaic cells can be co-transferred into an unloading position for the operation of fitting the lines into a solar module,

Figures 3 and 4 show a second exemplary embodiment of a device for producing solar modules, wherein here a transfer unit of the device, with which three lines

Figures 5 and 6 show a third exemplary embodiment of a device for producing solar modules, wherein this device likewise