Title of invention: Process and apparatus for manufacturing solar panels

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

Methods and devices of this type are already known from practice. In this context, solar elements are combined to form lines and the solar modules are constructed from electrically interconnected lines. The solar elements used for this may be photovoltaic solar cells or partially sectioned parts of them, what are referred to as shingles.

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 toward 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 2016/090304 A1 discloses a device for applying a conductive paste to photovoltaic structures while a solar panel is being produced, wherein the device comprises: a cartridge for receiving the conductive paste; a nozzle dispensing module coupled to the cartridge, wherein the nozzle dispensing module is configured such that it dispenses a predetermined amount of the conductive paste through a nozzle onto busbars of a respective photovoltaic structure; and a robot arm which is coupled to the nozzle dispensing module, wherein the robot arm is configured such that it sets a position of the nozzle dispensing module and as a result facilitates the alignment between the nozzle dispensing module and the busbars of the photovoltaic structure.

It is an object of the disclosure to provide a method for producing solar modules and a corresponding direction which promote the efficient production of solar modules.

To achieve the object, what is proposed first of all is a method which comprises the means and features of the first independent claim, which concerns a method for producing solar modules. In particular, to achieve the object, what is thus proposed in the case of the method mentioned in the introduction is that the lines are adhesively bonded with an electrically conductive adhesive and that the electrically conductive adhesive is applied to the solar elements while the lines are being moved for transfer, in particular while a solar module is being charged with the lines.

In a first aspect, the present disclosure provides a method for producing solar modules, wherein solar elements are combined to form lines, wherein each line comprises at least two solar elements, and wherein the solar modules are constructed from electrically interconnected lines, **characterized in that** the lines are adhesively bonded to one another by means of an electrically conductive adhesive in order to electrically and mechanically interconnect the lines of solar elements and in that the electrically conductive adhesive is applied to the solar elements during a transfer movement of the lines, in particular in order to charge a solar module.

The use of an electrically conductive adhesive produces firstly the mechanical interconnection and secondly the electrical interconnection of the lines of solar elements.

In this way, in one process step firstly the adhesive bonding of the lines to one another and secondly also

the electrical contact-connection of the solar elements of a line and ultimately also of two adjacent lines to one another are at least prepared.

In the finished solar module, a respective electrical voltage level can be applied within the individual lines of solar elements. Accordingly, there is no electrical voltage build-up beyond the solar elements of a line in the longitudinal direction of the lines. In the finished solar module, an electrical voltage build-up can take place beyond the electrically interconnected lines and thus transversely or at right angles to a longitudinal direction of the lines.

According to the method, the solar elements can thus be combined to form lines, with a respective electrical voltage level being applied within the individual lines of solar elements. The solar modules can then be constructed from electrically interconnected lines, with an electrical voltage build-up in the solar module taking place beyond the electrically interconnected lines and thus transversely or at right angles to a longitudinal direction of the lines.

Within the meaning of the claimed invention, a line can therefore be distinguished from a conventional string of solar elements. In a string, the solar elements are electrically interconnected in such a way that an electrical voltage build-up takes place in the longitudinal direction of the string beyond the electrically interconnected solar elements of the string.

In one embodiment of the method, it is envisaged that a discharge unit, in particular at least one discharge nozzle and/or at least one screen printing unit and/or at least one web-fed printing unit of the discharge unit, for discharging the conductive adhesive remains spatially fixed at least in

terms of horizontal position during the discharge. In this embodiment of the method, the electrically conductive adhesive is applied to the lines of solar elements which are moved relative to the discharge unit, which is spatially fixed in that case, during the transfer movement.

To modify a spacing between the lines, the discharge unit, in particular at least one discharge nozzle and/or at least one screen printing unit and/or at least one web-fed printing unit of the discharge unit is adjusted in terms of its vertical position in one embodiment of the method.

In another embodiment of the method, it is envisaged that a discharge unit, in particular at least one discharge nozzle and/or at least one screen printing unit and/or at least one web-fed printing unit of the discharge unit, for discharging the electrically conductive adhesive is moved during the discharge. The discharge unit can be moved in particular in a longitudinal direction and/or obliquely in relation to the longitudinal direction of at least one row of solar elements to which the electrically conductive adhesive is to be applied, and/or in a vertical direction.

In this embodiment of the method, it can be at least one discharge nozzle and/or at least one screen printing unit and/or at least one web-fed printing unit of the discharge unit that is moved during the discharge of the electrically conductive adhesive.

The solar elements of a line that are provided with the electrically conductive adhesive may be installed on the solar module at the same time or sequentially. Individual handling of solar elements which are provided with the electrically conductive adhesive and are intended to charge the solar module can be avoided if they are installed at the same time.

In this respect, the electrically conductive adhesive may be applied with an adhesive layer having a height of 0.5 mm or less and a width of 0.6 mm or less.

Also proposed to achieve the object is a method for producing solar modules which comprises the means and features of the second independent claim, which concerns such a method. To achieve the object, what is thus proposed in the case of the method mentioned in the introduction in particular is that the lines are adhesively bonded with an electrically conductive adhesive and that the electrically conductive adhesive is applied to at least two solar elements in a process step.

The features of the two independent claims can be combined with one another in one embodiment of the method.

In one embodiment of the method, it may be envisaged that the at least two solar elements to which the electrically conductive adhesive is applied belong to different lines.

In one embodiment of the method, it may be envisaged to adhesively bond the solar elements of adjacent lines to one another at the same time. In this respect, it is possible to firstly provide a line, which is provided with an adhesive bead, of solar elements on a solar module that is to be produced. Then, a second line of solar elements can be positioned on the already arranged line of solar elements with a certain overlap such that it comes to lie on the adhesive bead of the already provided line of solar elements and in the process is adhesively bonded to the already positioned line of solar elements. In this way, it is avoided that the solar elements of the lines to be interconnected are individually provided with adhesive and individually connected to already positioned solar elements.

In one embodiment of the method, it may be envisaged to adhesively bond the solar elements of adjacent lines to one another sequentially.

In one embodiment of the method, it is envisaged to apply the electrically conductive adhesive to all the solar elements of a line in one process step. This variant of the method promotes a particularly efficient production of solar modules.

It is also possible to apply the electrically conductive adhesive to solar elements of a line with a lateral offset in relation to a longitudinal center axis of the line. This promotes an overlapping connection of two adjacent lines of solar elements on a solar module that is to be produced.

To achieve the object, what is also proposed is a device for producing solar modules which comprises the means and features of the independent claim which concerns such a device.

To achieve the object, what is thus proposed in the case of the device mentioned in the introduction in particular is that the device comprises means by way of which it is designed to carry out a method for producing solar modules according to one of the claims that concerns such a method.

In a second aspect, the present disclosure provides a device for producing solar modules, wherein the device comprises means by way of which it is configured to carry out a method according to the first aspect, specifically a transfer unit for the joint transfer of at least two lines of solar elements to a means for charging a solar module, at least one discharge unit for discharging electrically conductive adhesive and a control unit, by way of which the device is configured to carry out a method according to the first aspect.

According to the disclosure, the device comprises as means a transfer unit, which is configured for the joint transfer of at least two lines of solar elements to a means for charging a solar module.

According to the disclosure, the device further comprises as means at least one discharge unit for discharging electrically conductive adhesive. The discharge unit is preferably configured to discharge electrically conductive adhesive onto at least two lines of solar elements at the same time. The discharge can in

this respect be effected preferably onto at least two lines of solar elements that are fed at the same time for charging a solar module.

The discharge unit may also be configured to discharge electrically conductive adhesive onto at least two lines of solar elements sequentially.

The discharge unit may comprise or be at least one discharge nozzle, in particular two or three or more discharge nozzles, and/or at least one screen printing unit and/or at least one web-fed printing unit. The discharge unit preferably comprises a number of discharge nozzles and/or screen printing units and/or web-fed printing units which corresponds to a number of placement locations for lines on the transfer unit already mentioned above.

In this way, it is possible to apply electrically conductive adhesive to all the lines of solar elements arranged on the transfer unit at the same time by means of the discharge unit. Screen printing units can be used to apply electrically conductive adhesive to the lines in a screen printing process. Web-fed printing units can be used to apply electrically conductive adhesive to the lines in a web-fed printing process.

In one embodiment of the device, it is envisaged that the discharge unit, in particular at least one discharge nozzle and/or at least one screen printing unit and/or at least one web-fed printing unit of the discharge unit, is positionally fixed at least in terms of horizontal position while electrically conductive adhesive is being discharged. In this embodiment of the device, a relative movement, which might be necessary for the application of the electrically conductive adhesive, between the discharge unit, in particular at least

one discharge nozzle and/or at least one screen printing unit and/or at least one web-fed printing unit of the discharge unit, and the line of solar elements that is to be provided with the electrically conductive adhesive is a transfer movement of the line that is performed relative to the positionally fixed discharge unit.

In order to be able to modify a spacing between the discharge unit, in particular between a discharge nozzle and/or at least one screen printing unit and/or at least one web-fed printing unit of the discharge unit, and the line of solar elements that is to be provided with the electrically conductive adhesive, it can be expedient if a vertical position of the discharge unit, in particular at least one discharge nozzle and/or at least one screen printing unit and/or at least one web-fed printing unit of the discharge unit, can be modified, for example by way of a correspondingly vertically adjustable mount of the device for the discharge unit, in particular for at least one discharge nozzle and/or for at least one screen printing unit and/or for at least one web-fed printing unit of the discharge unit.

In another embodiment of the device, it is envisaged that the discharge unit, in particular at least one discharge nozzle and/or at least one screen printing unit and/or at least one web-fed printing unit of the discharge unit, is movable, in particular while electrically conductive adhesive is being discharged. The discharge unit, in particular at least one discharge nozzle and/or at least one screen printing unit and/or at least one web-fed printing unit of the discharge unit, to this end can be mounted movably and/or driven by a motor. The movement of the discharge unit, in particular of its at least one discharge nozzle and/or at least one screen printing unit and/or at least one web-fed printing unit, can in this respect be aligned at least in a longitudinal

direction of a line of solar elements that is to be provided with electrically conductive adhesive and/or in a longitudinal direction of a placement location for a line of solar elements on a transfer unit, for example the one already mentioned above, of the device.

In one embodiment of the device, it is envisaged that the discharge unit, in particular at least one discharge nozzle and/or at least one screen printing unit and/or at least one web-fed printing unit of the discharge unit, is movable in a longitudinal direction of a line and/or of a placement location for a line on the transfer unit while electrically conductive adhesive is being discharged. To this end, the device may have a corresponding linear guide.

In one embodiment of the device, it is envisaged that two adjacent discharge nozzles and/or screen printing units and/or web-fed printing units of the discharge unit have the same spacing from another as two adjacent lines and/or placement locations for lines on the transfer unit already mentioned above.

This makes it possible to apply electrically conductive adhesive at the same time to adjacent lines of solar elements that are or have been constructed on the transfer unit and are jointly fed for example for charging of a solar module.

A perpendicular projection of at least one discharge unit, in particular at least one discharge nozzle and/or at least one screen printing unit and/or at least one web-fed printing unit of the discharge unit, onto a placement location for a line of solar elements on the transfer unit can in this respect be laterally offset in relation to a longitudinal center axis of the placement location and/or laterally offset in relation to

a longitudinal center axis of a line of solar elements that is arranged at the placement location.

According to the disclosure, the device further comprises as means a control unit, by way of which the device is configured for carrying out a method according to one of the claims that concerns a method for producing solar elements.

The disclosure will be described in more detail below on the basis of exemplary embodiments but is not restricted to the exemplary embodiments shown. Further exemplary embodiments will emerge by combining the features of individual or multiple claims with one another and/or by combining individual or multiple 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 comprises a transfer unit in the form of a negative pressure table, by means of which a total of three lines of solar elements can be transferred jointly to an unloading position in order to charge a solar module with the lines,

Figures 3 and 4 show a second exemplary embodiment of a device for producing solar modules, wherein in this case a transfer unit of the device, by means of which three lines of solar elements can be fed jointly for charging of a solar module, is in the form of a belt conveyor,

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