

Apparatus and method for bending a peeled-off section of an inter-connection busbar of a solar module over an electrical contact portion of a junction box of the solar module

FIELD OF THE DISCLOSURE

- 5 The present disclosure relates to an apparatus and a method for bending a peeled-off section of an inter-connection busbar of a solar module over an electrical contact portion of a junction box of the solar module using a finger device and an actuator device.

BACKGROUND

- Solar modules for generating electrical energy from sunlight comprise one or more junction boxes (JBs) which are connected to inter-connection busbars (ICBs). Commonly, junction boxes are manually mounted onto the solar modules. The mounting process includes peeling of inter-connection busbars (ICBs); mounting the junction box through peeled-of inter-connection busbars; and bending the inter-connection busbars onto solder pads of the junction boxes for a subsequent (automated) soldering process of soldering the bent inter-connection busbars to the solder pads. The step of bending the inter-connection busbars onto solder pads of the junction boxes is often manually executed.

CN 111 112 392 A, CN 107 626 853 A, CN 203 610 813 U, CN 103 639 562 A, and CN 207 154 951 U describe various aspects of methods and apparatuses for attaching junction boxes to inter-connection busbars.

20 SUMMARY

This objective is solved by the subject matter of the independent claims. The dependent claims describe preferred embodiments of the invention.

- According to a first aspect of the invention, there is provided an apparatus for bending a peeled-off section of an inter-connection busbar of a solar module over an electrical contact portion of a junction box of the solar module. The apparatus comprises a finger device having a first end and a second end, an actuator device, and a control device configured to control the actuator device. The actuator device is attached to the finger device at the second end and is configured to move the finger device in a first direction (which optionally is perpendicular to a plane of the solar module) and in a second direction perpendicular to the first direction (which optionally is parallel to a direction of extension of the inter-connection busbar). The first end includes a first surface area (e.g. region or portion), and/or a second surface area (e.g. region or portion), and/or a third surface area (e.g. region or portion). The first surface area is offset from the third surface area and/or from the first end in the first direction from the first

end towards the second end. The second surface area connects the first surface area to the first end and/or the third surface area. The third surface area may be arranged at the first end. The control device is configured to control the actuator device to move the finger device (e.g. towards the inter-connection busbar) along the first direction and to then move the finger device along the second direction for bending the peeled-off inter-connection busbar over the electrical contact portion.

According to a second aspect of the invention, there is provided a method for bending a peeled-off section of an inter-connection busbar of a solar module over an electrical contact portion of a junction box of the solar module. The method comprises the steps of a) positioning a first end of a finger device in a cavity of the junction box, the first end including a first surface area, a second surface area, and/or a third surface area,, the first surface area being offset from the first end and/or third surface area in a first direction away from the first end, the second surface area connecting the first surface area to the first end and/or the third surface area; and b) bending the peeled-off section of the inter-connection busbar over the electrical contact portion by moving the finger device along a second direction perpendicular to the first direction and parallel to a direction of extension of the inter-connection busbar.

The bending of the peeled-off sections of the inter-connection busbar can be achieved by two (linear) movements which may correspond to steps a) and b). These movements allow a fast bending of the peeled-off sections of the inter-connection busbar. In addition, reliable results can be achieved. The bending of the peeled-off sections of the inter-connection busbar is achieved by the shape/contour of the finger device. The movement of the finger device presses the peeled-off sections of the inter-connection busbar against the finger device resulting in a bending of the finger device in line with the shape/contour of the finger device.

After the bending of the peeled-off sections of the inter-connection busbar, the bent section of the inter-connection busbar is arranged above or in contact with the contact portion which may be a solder pad of the junction box. In a subsequent step, the bent section of the inter-connection busbar can be pressed into the contact portion and/or can be soldered to the contact portion.

The apparatus and method of this disclosure can replace a manual bending of the peeled-off sections of the inter-connection busbar. This may increase the reliability of the bending process due to an elimination of human error. If the inter-connection busbar is not or not properly bent, power loss with the solar module can occur due to a deficient electrical connection between the inter-connection busbar and the junction box. For example, reliable bending of the inter-connection busbar increases the quality of the solder connection of the

inter-connection busbar to the contact portion. Further, the required manpower for attaching the junction box to the solar module can be reduced.

The solar module may include a plurality of solar cells which are electrically connected to each other by the inter-connection busbar. The inter-connection busbar may have a ribbon-shape.

- 5 In other words, the inter-connection busbar may include a flat elongate structure and/or is made from an electrically conductive material such as metal (e.g. copper). The inter-connection busbar can be fixedly attached to the solar module, for example by means of adhesives and/or soldering. The inter-connection busbar may include metal-based flat wire used to connect silicon cells electrically and/or to carry out current in crystalline silicon and/or
- 10 thin-film photovoltaic modules. The inter-connection busbar may be directly soldered onto silicon crystal to interconnect solar cells in a solar panel. The interconnect ribbon may carry the current generated in solar cells to PV bus-bar.

- A section of the inter-connection busbar is peeled off for attaching the junction box. For example, the ends of the inter-connection busbar are bent away from the solar module such
- 15 that they protrude from the solar module. Alternatively, the inter-connection busbar is cut through and two sections are peeled off from the solar module. The junction box is attached to the peeled-off section(s) of the inter-connection busbar(s).

- The junction box may include an enclosure that protects a connection (the junction) of two or more wires carrying electrical current (such as the inter-connect busbars). This protection is
- 20 often needed to prevent fires and to maintain solid, reliable connections that stay tight over many years. The junction box may be attached to rear side of the solar module, i.e. that side of the solar module that is not exposed to the sun light. The junction box may be the electrical output interface for the solar module and/or may act as bypass diode. The junction box may include one or more bypass diodes.

- 25 The junction box includes a cavity that extends from a first side of the junction box to an opposing second side of the junction box. The first side of the junction box is in contact with the solar module and may cover a part of the inter-connection busbar that is not peeled off from the solar module. The junction box is positioned such that the peeled-off section(s) of the inter-connection busbar(s) protrude(s) into the cavity of the junction box. The junction box may
- 30 be manually or robotically positioned.

- The cavity of the junction box allows insertion of the finger device from the second side. The cavity is a continuous space within the junction box or can include various spaces associated with the respective contact portions. The contact portion may be positioned exposed within the cavity. The contact portion may be made from an electrically conductive material and is
- 35 that portion/part of the junction box to which the busbars is connected. In particular, the

junction box includes two contact portions. Each peeled-off section of the inter-connection busbar(s) is electrically connected to a respective contact portion. Thus, each peeled-off section of the inter-connection busbar(s) is bent to be positioned above or in contact with the contact portion after the bending process.

- 5 The contact portion may include a flat metallic surface which extends parallel to a plane of the solar module when the junction box is positioned on the solar module. However, the contact portion may have different shapes. For example, the contact portion may include a solder pad which can include a round contour which protrudes away from the solar module.

- 10 A plurality of junction boxes may be provided on a solar module. The junction box is provided for electrical connection of the solar module with an external electrical power line. The purpose, composition, and/or embodiments of junction boxes are known in the prior art and, therefore, are not further discussed herein. Similarly, the solar modules and/or the interconnection busbars may include components and have embodiments which are known in the prior art.

- 15 The first end of the finger device is inserted into the cavity of the junction box. This corresponds to a positioning of the finger device within the cavity of the junction box. After completion of this positioning step and/or step a), the first end of the finger device may be close to the solar module and/or in contact with the solar module. In addition, the finger device may not be in contact with the peeled-off section of the inter-connection busbar. For example, there may be
20 a gap between the finger device and the peeled-off section of the inter-connection busbar in the second direction. The second direction may extend parallel to the direction of extension of the inter-connection busbar, especially of a section of the inter-connection busbar that is not peeled off from the solar module.

- The positioning step and/or step a) may include a pre-positioning step of positioning the finger
25 device above the cavity of the junction box. This pre-positioning step may include positioning the finger device in the second direction such that the finger device is arranged above the cavity. Then, the finger device may be linearly moved in the first direction until the final position of this positioning step and/or step a) is reached. The positioning step and/or step a) may solely include a linear movement along the first direction. However, it is possible that the finger
30 device is moved along the first direction and in a direction perpendicular to the first direction (such as the second direction) for a laterally positioning the finger device within the cavity during the positioning step and/or step a).

- The first end of the finger device may be that end of the finger device that is closest to the solar module and/or the section of the inter-connection busbar that is not peeled off from the
35 solar module after the positioning step and/or step a) is completed. This may include that the

first end of the finger device is firstly inserted into the cavity of the junction box. The second end of the finger device may remain outside of the cavity of the junction box during the complete bending process.

When the final position of the positioning step and/or step a) is reached, the first surface area
5 may be positioned at a height above the contact portion but offset in the second direction. Thus, when the final position of the positioning step and/or step a) is reached, the first surface area may be positioned offset both in the first direction and the second direction relative to the contact portion. In addition, when the final position of the positioning step and/or step a) is reached, the contour of the first surface area may be aligned with the contour of the contact
10 portion.

When the final position of the positioning step and/or step a) is reached, the third surface area and/or the first surface area may be arranged parallel to a surface of the solar module. The third surface area and/or the second surface may be offset from the surface of the solar module in the first direction.

15 The first surface area, the second surface area, and/or the third surface area can be sections of the outer surface of the finger device. The finger device may include a unitary (solid or hollow) component on which the first surface area, the second surface area, and/or the third surface area are located. However, the first surface area, the second surface area, and/or the third surface area may be constituted by components which can be removably or releasably
20 attached to the finger device. The contour of the first surface area and/or and the second surface area are important for bending the peeled-off section of the inter-connection busbar. The third surface area may be omitted, for example in case of a sharp first end. This may be the case if the second surface area is directly connected to and/or ends with a side surface of the finger device.

25 The third surface area may be (approximately) flat and may constitute the first end (e.g. end face) of the finger device. The first surface area can be offset from the third surface area in the first direction. Thus, when viewed along the first direction, the first end/third surface area and the first surface area are separated by a gap. Thus, when the third surface area is in contact with a flat surface (e.g. of the solar module), the first surface area is not in contact with
30 this flat surface.

The first surface area has a contour which allows the bending of the peeled-off section of the inter-connection busbar. In particular, the contour of the first surface area approximately defines the shape of the bent section of the inter-connection busbar. For example, the first surface area may be (approximately) flat and can extend (approximately) parallel to the third
35 surface area. In this case, the bent section of the inter-connection busbar extends parallel to

the surface of the solar module after the completion of the bending process. The first and third surface areas may be parallel to each other. The first surface area may be configured to bend the inter-connection busbar in a first direction of the finger device.

However, the contour of the first surface area is not limited thereto. Other shapes are possible, as long as a movement of the finger device in the second direction results in a bending of the peeled-off section of the inter-connection busbar. To this end, the first surface area partially extends in the second direction or only in the second direction. For example, the first surface area may include a surface section that extends parallel to the third surface area and/or the plane of the solar module when the finger device is positioned. In a further optional embodiment, a section of the first surface area matches (e.g. has a corresponding or cooperating shape as) a section of contour/shape of the contact portion. The first surface area may at least partially extend perpendicular to the first direction.

The second surface area connects the first end or the third surface area to the first surface area. In other words, the second surface area is a part of the surface of the finger device which is arranged between the first end or the third surface area and the first surface area when moving along the outer surface of the finger device. Due to the separation of the third surface area and the first surface area along the first direction, the second surface area extends at least partially along the first direction. The second surface area may be shaped to match a portion of the junction box against which the second surface area can be pressed during bending process, such as an abutment portion of the junction box. The second surface area may be perpendicular to the third surface area and/or first surface area. The first surface area may be configured to bend the inter-connection busbar in a direction perpendicular to the first direction of the finger device.

The abutment portion of the junction box may be directly adjacent to the contact portion and extends at least partially in the first direction. The abutment portion may also include a side surface of the contact portion which faces the finger device. For example, the abutment portion of the junction box may be perpendicular to an upper surface the contact portion (or an average direction of the contact portion). The abutment portion may include a part of a wall of the junction box that limits the cavity. The abutment portion can include a wall of a portion of the junction box that supports the contact portion or on which the contact portion is arranged or attached. This wall may be exposed to the cavity. The abutment portion may extend between the first side of the junction box and the contact portion.

The bending of the peeled-off section of the inter-connection busbar is achieved by (linearly) moving the finger device in the second direction while optionally maintaining the position of the finger device along the first direction. The bending of the peeled-off section of the inter-

connection busbar may be achieved by linearly moving the finger device. During the movement of step b), the finger device gets in contact with the peeled-off section of the inter-connection busbar and presses the peeled-off section of the inter-connection busbar in the direction of movement. The peeled-off section of the inter-connection busbar may be in direct
5 contact or close to the abutment portion of the junction box. The bending of the peeled-off section of the inter-connection busbar is limited by the abutment portion of the junction box. In other words, the peeled-off section of the inter-connection busbar is pressed against the abutment portion. If the abutment portion and the second surface area have a matching shape, the second surface area may imprint the shape of the abutment portion and the second
10 surface area to the section of the peeled-off section of the inter-connection busbar that is in contact with the abutment portion.

The section of the peeled-off section of the inter-connection busbar that is actually bent is that part that arranged above the abutment portion. Thus, the movement of the finger device bends the section of the peeled-off section of the inter-connection busbar around or close to an upper
15 end or edge of the abutment portion and over the contact portion. The contour of the first surface area defines the final shape of the bent section of the peeled-off section of the inter-connection busbar. In particular, the degree of bending is defined by the degree of inclination of the first surface area in relation to the second surface area.

After completion of the bending process, the bent section of the peeled-off section of the inter-connection busbar follows the contour of the first surface area and/or the second surface area.
20 At the same time, the non-bent section of the peeled-off section of the inter-connection busbar is sandwich between the second surface area and the abutment portion, optionally in direct contact with either or both. Further optionally, the peeled-off section of the inter-connection busbar is in complete contact with the first surface area and/or second surface area after the
25 completion of the bending process.

Since the first surface area was positioned above the contact portion before step b) (the bending step), the bent section of the peeled-off section of the inter-connection busbar may be arranged above the contact portion, i.e. there is a gap between the contact portion and the bent section of the peeled-off section of the inter-connection busbar in the first direction.
30 Alternatively, the bent section of the peeled-off section of the inter-connection busbar may be in contact with the contact portion.

The respective movements of the finger device are provided by the actuator device with which includes one or more electric and/or hydraulic means for moving the finger device. The actuator device may include a robotic arm, a linear motor, and/or further components that
35 provide the movements of step a) and step b). The actuator device may include a first actuator

configured to move the finger device in the first direction and a second actuator configured to move to finger device in the second direction.

The control device may be electrically or electronically connected to the actuator device. The control device can control the actuator device for moving and positioning the finger device.

- 5 The control device may be arranged remote from the actuator device and/or the finger device. The control device may include one or more processors and/or one more memories storing algorithms and/or other programmes for controlling the actuator device. The control device may include a computer and/or server. The control device can be configured to execute the method described herein.

- 10 The first direction and/or the second direction may be a linear or non-rotational direction. The first direction and the second direction may define two directions of a cartesian coordinate system that can by aligned with the upper surface and/or a plane of the solar module.

Optional features will now be set out. These are applicable singly or in any combination with any aspect.

- 15 In an optional embodiment, step b) includes moving the finger device along the second direction until the peeled-off section of the inter-connection busbar has a contour that matches a contour of the first surface area and/or of the second surface area.

- The peeled-off section of the inter-connection busbar may be in contact with the complete first surface area and/or the second surface area after completion of step b). The peeled-off section
20 of the inter-connection busbar may follow the shape of the first surface area and/or the second surface area. In other words, the contour/shape of the first surface area and/or the second surface area define the bending of the peeled-off section of the inter-connection busbar. The contour/shape of the first surface area and/or the second surface area can be imprinted on the peeled-off section of the inter-connection busbar. Thus, the contour/shape of the first
25 surface area and/or the second surface area may define the bending curvature/shape of the peeled-off section of the inter-connection busbar.

- The bending process may be completed once the second surface area is in contact with the peeled-off section of the inter-connection busbar, in particular when the peeled-off section of the inter-connection busbar is pressed between the second surface area and the abutment
30 portion. In other words, the second surface area is in direct contact with the peeled-off section of the inter-connection busbar which is tightly pressed against the abutment portion. At this position, a further movement of the finger device in the second direction is no longer possible since the abutment portion prohibits a further movement. Thus, the abutment of the second

surface area against the abutment portion (with the peeled-off section of the inter-connection busbar in between) defines an end point of the movement in the second direction.

Step b) may include moving the finger device in the second direction for a predetermined distance. The finger device may be positioned after the completion of step b) such that the
5 second surface area is arranged at a distance from the abutment portion. For example, step a) includes positioning the finger device at a predetermined position away from the contact portion. This may include positioning the finger device such that an outer surface of the finger device (which is on the opposite side relative to the second surface area) is in contact with an outer wall of the junction box. This corresponds to a position that this furthest away from the
10 abutment portion in the second direction.

In an optional embodiment, the control device is further configured to control the actuator device to move the finger device along the first direction such that the first surface area bends the bent inter-connection busbar towards the electrical contact portion which optionally includes pressing the bent inter-connection busbar into the electrical contact portion.

15 In a further optional embodiment, the method further comprises step c) of further bending the bent inter-connection busbar towards the electrical contact portion by moving the finger device along the first direction, wherein optionally step c) further includes pressing the bent inter-connection busbar into the electrical contact portion.

After completion of the bending process or step b), at least a part of the first surface area can
20 be positioned above the contact portion. Thus, moving the finger device in the first direction towards the contact portion bends the bent section of the inter-connection busbar towards the contact portion. This additional bending or step c) may ensure that the bent section of the inter-connection busbar does not bounce back and/or does not move away from the contact portion when the finger device is removed. In particular, step c) may help that the bent section
25 of the inter-connection busbar remains positioned above the contact portion or in contact with the contact portion.

This positioning of the bent section of the inter-connection busbar may be more reliable if the further bending step or step c) includes bending the bent section of the inter-connection busbar to such an extent that the bent section of the inter-connection busbar is pressed against or
30 into the contact portion. In this case, the bent section of the inter-connection busbar may stick and/or adhere to the contact portion which can remove the risk that the bent section inter-connection busbar moves away from the contact portion when the finger device is removed. Thus, the positioning/bending of the bent section of the inter-connection busbar is improved which contributes to a more reliable soldering of the bent section of the inter-connection
35 busbar to the contact portion.

The further bending is provided by the first surface area which is moved towards the contact portion. Thus, the first surface area presses the bent section of the inter-connection busbar into the contact portion. This may include a deformation of the contact portion, for example if the contact portion includes a round solder pad.

- 5 The soldering step may be an additional step to the bending process of this disclosure. The soldering may be executed by a separate soldering device. However, the finger device may include means for soldering the bent section of the inter-connection busbar to the contact portion, for example immediately after the bent section of the inter-connection busbar is pressed onto the contact portion. In this case, the finger device is not removed from the bent
- 10 section of the inter-connection busbar prior to the soldering step which ensures that the bent section of the inter-connection busbar is in contact with the contact portion during the soldering step. This can provide a reliable solder connection since the risk that the bent section of the inter-connection busbar moves away from the contact portion is eliminated. The finger device may include a heater for heating the first surface area.
- 15 The positioning step or step a) may include moving the finger device along the first direction in such a way that the third surface area points in the moving direction. The bending step or step b) may include moving the finger device along the second direction in such a way that the second surface area points in the moving direction. The additional bending/pressing step or step c) includes moving the finger device along the first direction in such a way that the first
- 20 surface area points in the moving direction.

In an optional embodiment, step a) comprises positioning the first surface area at a first height position in the first direction which is greater than a second height position in the first direction at which an upper surface of the contact portion is located, wherein optionally the difference between the first height position and the second height position is a predetermined value.

- 25 The first height position and the second height position relate to a position in the first direction. For example, the first height position and the second height position define a distance in relation to a plane of the solar module or a bottom plane of the junction box. It is also possible that the first high position and the second height position are determined in relation to the upper surface of the junction box or the opening of the junction box (corresponding to the
- 30 upper limit of the cavity) into which the finger device is inserted. The difference between the first height position and the second height position can be an absolute value.

- The first height position may refer to that point of the first surface area that protrudes the most towards the first end in the first direction. Similarly, the second height position may refer to that point of the contact portion that protrudes the furthest away from the solar module in the
- 35 first direction.

The predetermined value can be a measure of the distance between the bent section of the inter-connection busbar and the contact portion because the second height position defines the height position of the first surface area and, therefore, at which point the peeled-off section of the inter-connection busbar is bent. Thus, reducing the predetermined value results in a reduced distance between the bent section of the inter-connection busbar and the contact portion.

During the additional bending step or step c), the finger device needs to be at least moved in the first direction by the predetermined value in order to press the bent section of the inter-connection busbar into the contact portion.

- 10 In an optional embodiment, step a) comprises positioning the first surface area parallel to a surface of the solar module.

The surface of the solar module may be that surface of the solar module to which the junction box is attached. This may be the upper or outer surface of the solar module. Optionally, the first surface area is flat, i.e. extends in a plane. In this case, the first surface area is position parallel to the plane or surface of the solar module in step a) and/or maintained in this orientation during the step b).

- More generally, a main orientation of the first surface area is positioned parallel to the plane or surface of the solar module. For example, if the first surface area has a contour/shape that matches the contour/shape of the contact portion, the first surface area is positioned such that the contour/shape of the first surface area and of the contact portion have to same orientation. The main orientation may refer to an average orientation or to an orientation of a section of the first surface area that constitute the largest section of the first surface area. Other means for determining the main orientation are possible. In other words, the first surface area is position based on its contour/shape and in relation to the contour/shape of the contact portion.
- 20 This may ensure that the peeled-off section of the inter-connection busbar is bent to a contour/shape that matches the contour/shape of the contact portion.

In an optional embodiment, the apparatus further comprises a camera, optionally a 3D-camera, wherein optionally the control device is configured to position the finger device using the camera.

- 30 In a further optional embodiment, step a) includes imaging the junction box using a camera, optionally a 3D-camera, and/or positioning the finger device based on the images taken by the camera.

The camera can be arranged at a fixed position. Alternatively, the camera may be movably arranged such that it can be positioned above the junction box. The camera may be separate

to the control device, the finger device, and/or the actuator device. The camera may be positioned such that it can image into the cavity and/or the contact portion(s). Thus, the camera provides information where to position the finger device in the positioning step or step a). In other words, the camera may facilitate the positioning of the finger device in relation to

5 the contact portion.

The camera may be a video camera, i.e. a camera providing a stream of images. The camera may include an optical system and an optical sensor for generating electrical signals depending on the light impinging on the optical sensor. The optical system is provided for focusing/directing/guiding the light from the surrounding of the camera onto the optical sensor.

10 Thus, the camera is an imaging system that convert visual information into electrical or electronical information. The camera is electrically or electronically connected to the control device which includes a programme or algorithm for analysing the electrical data generated by the camera in order to control the actuator device, in particular to position the finger device in the positioning step or step a). The information generated by the camera may not be used
15 during the bending steps (step b) and/or c)) which may be executed independent from the camera or with the camera turned off.

Optionally, one or more cameras are provided to obtain a three-dimensional (3D) representation of the cavity and/or the contact portion. Alternatively or additionally, a 3D-camera is provided which is configured to obtain a 3D image. The 3D-camera may include
20 two optical systems and two optical sensors which are offset to each other to obtain a 3D representation.

The camera may also be used for positioning the junction box on the solar module. For example, a robotic device (such a robotic arm) positions the junction box over the peeled-off sections of the inter-connection busbar wherein the image taken by the camera is used to
25 determine the positions of the peeled-off sections of the inter-connection busbar.

Alternatively or additionally, the finger device may be positioned in step a) based on information on the current position of the finger device and the current position of the contact portion. These positions may be determined using one or more sensors or can be input into the control device. Based on the current position of the finger device and of the contact portion,
30 the control devices may be configured to calculate the trajectory for moving the finger device in the positioning step (step a)).

In an optional embodiment, the finger device includes a first finger and a second finger, wherein optionally the first finger and the second finger each include respective third surface areas, respective first surface areas, and respective second surface areas, and wherein

further optionally the second surface area of the first finger faces the second surface area of the second finger.

In a further optional embodiment, the finger device includes a first finger and a second finger, wherein optionally the first finger and the second finger each include respective third surface areas, respective first surface areas, and respective second surface areas, the second surface area of the first finger facing the second surface area of the second finger, and wherein further optionally step b) includes (concurrently) moving the first finger and the second finger towards each other to bend two peeled-off sections of inter-connection busbars onto respective contact portions.

10 The first finger may include the third surface area, the first surface area, and the second surface area and/or the second finger may include the third surface area, the first surface area, and the second surface area.

The first finger and the second finger may provide a double acting gripper. The first finger and a second finger may be (linearly) moved towards to each other during the bending step or step 15 b). Thereby, the two peeled-off sections of the inter-connection busbar are concurrently bent. This reduces the time required for the complete bending process. What is more, the first finger and the second finger are concurrently positioned in step a) which further reduces the time required for completing the bending process. For example, a cycle time of less than two seconds can be achieved. This allows an overall cycle time for attaching a junction box to 20 the solar module of less than 45 seconds.

The first finger and the second finger may include an elongate body allowing insertion into the cavity of the junction box which may be of limited size. Further, the first finger and the second finger are associated with a first contact position and a second contact portion, respectively. In other words, the first finger and the second finger may be provided for bending a first peeled-off section of the inter-connection busbar and a second peeled-off section of the inter-connection busbar, respectively. 25

The first finger and the second finger may be arranged parallel to each other whereby a movement in the second direction and towards each other (maintaining this orientation) is executed in the bending step (step b)). In particular, the third surface area of the first finger and the second finger can be arranged parallel to each other. Further, the first surface area of the first finger and the second finger can be arranged parallel to each other. The second surface area of the first finger and the second finger can be arranged parallel to each other while their respective second surface areas face each other. For example, the first finger (or the elongate body of the first finger) may be mirror symmetric to the second finger (or the elongate body of the second finger). The perspective orientations of the third surface area, the 30 35

first surface area, and/or the second surface area may be maintained during the whole bending process; solely the position of the first finger and the second finger (especially in relation to each other) is varied during the bending process. Thus, during step b), the first finger and the second finger are linearly moved towards each other.

- 5 The third surface area, the first surface area, and/or the second surface area of the first finger may include the same size, shape, orientation, and position compared to the third surface area, the first surface area, and/or the second surface area, respectively, of the second finger. In this case, the first finger and the second finger provide a similar or identical bending of the respective peeled-off sections of the inter-connection busbar.

- 10 In an optional embodiment, the finger device includes a single finger, wherein optionally the single finger includes the third surface area, two first surface areas, and two second surface areas, and wherein further optionally the second surface areas are arranged on opposing sides of the third surface area.

- In a further optional embodiment, the finger device includes a single finger, wherein optionally
15 the single finger includes the third surface area, two first surface areas, and two second surface areas, and wherein further optionally the second surface areas are arranged on opposing sides of the third surface area. Optionally, steps a) and b) are executed for a first peeled-off section of the inter-connection busbar using one of the two first surface areas and one of the two second surface areas and steps a) and b) are repeated for a second peeled-off
20 section of the inter-connection busbar using the other one of the two first surface areas and the other one of the two second surface areas.

- The two first surface areas and the two second surface areas may be arranged on opposing sides of the third surface area. For example, the single finger or the elongated body of the single finger are mirror symmetric along the first direction. In this case, the two first surface
25 areas and the two second surface areas have the same size, shape, and orientation. However, the single finger is not limited thereto. For example, if the first contact portion differs from a second contact solution, the respective two third surface areas and/or the two first surface areas may differ from each other.

- One of the two second surface areas may face the abutment portion after the completion of
30 step a) while the other one of the two second surface area may face away from the abutment portion.

Steps a) and b) are executed for the first peeled-off section of the inter-connection busbar using a first one of the second and second surface areas. Then, steps a) and b) are repeated for the second peeled-off section of the inter-connection busbar using the other one of the

second and second surface areas. Due to the opposed arrangement of the second and second surface areas, the single finger device does not need to be rotated for bending the first and second peeled-off sections of the inter-connection busbar towards each other. Further, the single finger device can be configured to be moved linearly in the second direction.

- 5 The bending process of the first and second peeled-off sections of the inter-connection busbar includes positioning the single finger relative to the first contact portion (step a)) and bending the first peeled-off section of the inter-connection busbar over at the first contact portion using a first one of the second and second surface areas (step b)). Optionally, the first bent section of the inter-connection busbar is further bent towards or pressed into the first contact portion
- 10 using the first one of the first surface area. Then, the single finger is re-positioned relative to the second contact portion (step a)) without changing the orientation or rotating the single finger. For example, the single finger is moved in the first direction away from the first contact portion, linearly moved in the second direction to a position adjacent to the second contact portion, and then lowered to be positioned next to the second contact portion (step a)). Then,
- 15 the second peeled-off section of the inter-connection busbar is bent over the second contact portion using the other one of the second and second surface areas (step b)). Optionally, the second bent section of the inter-connection busbar is further bent towards or pressed into the second contact portion using the other one of the first surface area.

- Alternatively, the finger device includes a single finger which includes a single third surface area, a single first surface area, and a single second surface area. In this case, the bending process as described above equally applies with the addition that this single finger is rotated by 180° around the first direction after bending the first peeled-off section of the inter-connection busbar and before bending the second peeled-off section of the inter-connection busbar.
- 20

- 25 In an optional embodiment, the actuator device includes a base part, wherein the base part includes a first actuator configured to move the finger device in the second direction.

In a further optional embodiment, step b) includes (linearly) moving the finger device relative to a base part.

- The single finger, the first finger, and/or the second finger may be moveably attached to the base part. Thus, by moving the base part, the finger device, in particular single finger, the first finger, and/or the second finger, can be moved. In particular, moving the base part results in a concurrent movement of the first finger and the second finger allowing a concurrent positioning of the first finger and the second finger. This helps to reduce the cycle time.
- 30

The first actuator may include a rail, bar, and/or rod on which the finger device can be linearly moved. Thus, the rail, bar, and/or rod support the finger device (optionally both the first finger and the second finger) and allows a linear movement of the finger device relative to the base part. The first actuator may further include one or more electric motors and/or one or more pneumatic actuators for moving the finger device on the rail, bar, and/or rod. The first actuator may also include transfer mechanism for transferring the movement of the electric motor (e.g. rotary movement) into a linear movement. The transfer mechanism may include gears, belts, and/or other means for driving the finger device. Optionally, the first actuator is configured to concurrently move the first finger and the second finger, in particular towards each other. For example, the first finger and the second finger move towards each other with the same velocity providing a symmetric movement of the first finger and the second finger.

In an optional embodiment, the actuator device includes a second actuator configured to move the base part in the first direction.

In a further optional embodiment, step a) includes moving the base part to which the finger device is attached.

The second actuator may be a means for moving the base part in the first direction for positioning the finger device in the first direction. The second actuator may also include means for positioning the base part above the junction box, i.e. for moving the base part in the second direction and/or a third direction which perpendicular to both the first direction and the second direction. In other words, the second actuator may allow positioning the base part over the junction box.

The second actuator may include a robotic arm for moving the base part. However, other means for moving the base part known to the skilled person are possible. The second actuator may include one or more electric motors and/or one or more pneumatic actuators for moving the base part.

The second actuator is in operation during steps a) and/or c), i.e. when moving the finger device or the base part in the first direction. The first actuator is in operation during step b) i.e. when moving the finger device in the second direction.

The skilled person will appreciate that except where mutually exclusive, a feature or parameter described in relation to any one of the above aspects may be applied to any other aspect. Furthermore, except where mutually exclusive, any feature or parameter described herein may be applied to any aspect and/or combined with any other feature or parameter described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments will now be described by way of example only, with reference to the Figures, in which:

- 5 Figs. 1a to 6b each show an isometric view (left) and a section view (right) of an embodiment of the apparatus at various stages of the bending process;
- Figs. 7 shows a side view of a first finger of the apparatus of Figs. 1a to 6b;
- Fig. 8 shows a perspective view of the first finger of Fig. 7 (upper part) and enlarged view of the encircled area in the upper part (lower part);
- Fig. 9 shows a partial side view of a first finger according to an embodiment;
- 10 Fig. 10 shows a partial side view of a first finger according to an embodiment; and
- Fig. 11 shows a block diagram of the bending process of a Figs. 1a to 6b.

DETAILED DESCRIPTION

- 15 Aspects and embodiments of the present disclosure will now be discussed with reference to the accompanying figures. Further aspects and embodiments will be apparent to those skilled in the art.

- In the drawings, the thickness of substrates, components, elements etc., can be exaggerated for clarity. Furthermore, it will be understood that when an element such as a layer, film, region, or substrate is referred to as being "on" another element, it can be directly on the other element or intervening elements may also be present. In contrast, when an element is referred to as being "directly on" another element, there are no intervening elements present.
- 20

- Figs. 1a to 6b show an apparatus 10 for bending a peeled-off section 12 of an inter-connection busbar 14 of a solar module over an electrical contact portion 16 of a junction box 18 of the solar module. The solar module is not shown in the figures, but it is arranged below the junction box 18 and the inter-connection busbar 14. In other words, junction box 18 and the inter-connection busbar 14 define a plane which corresponds to an upper surface after solar module. The apparatus 10 includes a finger device 20, an actuator device 22, a control device 24, and /or a camera 26.
- 25

- The junction box 18 includes one or more electrical components, such as the contact portion 16, for providing an electric connection between the junction box 18 and the inter-connection busbar 14. In particular, the junction box 18 includes a cavity 28 around the contact portion
- 30

16. The junction box 18, optionally the cavity 28, may be closed after the attachment of the inter-connection busbar 14 to the portion 16.

The junction box 18 may include two contact portions 16 which each may include a solder pad. The solder pad is pre-soldered. Each contact portion 16 may be connected to a
5 respective peeled-off section 12 of the inter-connection busbar 14. The peeled-off section 12 of the inter-connection busbar 14 protrudes from the solar module from the extension of the non-peeled-off section 12 of the inter-connection busbar 14. The peeled-off section 12 of the inter-connection busbar 14 protrudes into the cavity 28 before the peeled-off section 12 of the inter-connection busbar 14 is bent over the contact portion 16 (see Figs. 1a and 1b). The
10 peeled-off section 12 of the inter-connection busbar 14 is bent over the contact portion 16 for connecting the inter-connection busbar 14 to the contact portion 16. The inter-connection busbar 14 may be soldered to the contact portion 16 after the bending process (the soldering is not shown in the Figures).

The inter-connection busbar 14 can be manually or automatically peeled off such that a
15 situation as depicted in Figs. 1a and 1b is present. Similarly, the junction box 18 can be manually or automatically positioned on and/or attached to the solar module situation as depicted in Figs. 1a and 1b. If this initial stage is completed, the bending process of this invention is executed. However, at first, the various (optional) components of the apparatus
10 are described.

20 In the embodiment shown in Figs. 1a to 8, the finger device 20 includes a first finger 30 and a second finger 32. As better visible in Figs. 7 and 8, the first finger 30 and a second finger 32 include an elongate body 34, a first end 36, and a second end 38. The first end 36 and a part of the elongate body 34 are inserted into the cavity 28. The second end 38 remains outside of the cavity 28. Thus, the second end 38 may have a bulkier structure compared to the
25 elongated body 34 since the second end 38 does not need to be inserted into the limited space of the cavity 28. The finger device 20 can be attached to the actuator device 22 at the second end 38. In the embodiment shown in the figures, the first finger 30 and the second finger 32 include a plurality of holes through which a bolt or screw can be inserted for attaching the respective fingers 30, 32 to the actuator device 22. The first finger 30 and a second finger 32
30 may be made from a rigid and/or solid material, such as metal.

The finger device 20, optionally the first finger 30 and a second finger 32, includes a third surface area 40, a first surface area 42, and a second surface area 44 which are arranged at the first end 36. In the embodiments shown in the figures, the third surface area 40, the first surface area 42, and/or the second surface area 44 are flat defining planes.

The third surface area 40 may define the furthest area of the first end 36. The first surface area 42 is offset to the third surface area 40 away from the first end 36 towards the second end 38. Optionally, the third surface area 40 and a first surface area 42 are arranged parallel to each other. The second surface area 44 connects this third surface area 40 to the first surface area 42. The second surface area 44 may be arranged perpendicular to the third surface area 40 and/or the first surface area 42. The transition between the respective surface areas may be rounded. The second surface area 44 of the first finger 30 faces the second surface area 44 of the second finger 32.

The actuator device 22 may include a base part 46, a first actuator 48, and/or a second actuator 50. The finger device 20 is moveably attached to the base part 46. Optionally, the finger device 20 can linearly move on the base part 46 in a second direction (see arrows in Fig. 1a). In the embodiments shown in the figures, the first actuator 48 may include a rail on which the first finger 30 and the second finger 32 are movably arranged. The first actuator 48 may also include electrical or programmatic means for moving the first finger 30 and the second finger 32 on the rail in the second direction.

The second actuator 50 can be configured to move the base part 46. The second actuator 50 may include a robotic arm. The second actuator 50 is at least configured to move the finger device 20 in a first direction which is perpendicular to the second direction and perpendicular to the plane of the solar module (see arrows in Figs. 2a and 2b).

The control device 24 may include a computer or server and can be positioned remote from the actuator device 22 and/or finger device 20. The control device 24 is electronically and/or electrically connected to the actuator device 22 for controlling the movement of the finger device 20.

The camera 26 can be a 3D-camera, i.e. a camera that is capable of obtaining three-dimensional (3D) representation of the area that is imaged by the camera 26. The camera 26 can be movably supported such that it can be positioned above the junction box 18 for imaging the cavity 28 and/or the contact portion 16. The camera 26 is electrically or electronically connected to the control device 24 which can analyse the digital information provided by the camera 26 for determining the position of the junction box 18, the contact portion 16, and/or the finger device 20. In particular, the control device 24 is configured to position the finger device 20 in the cavity 28 using the camera 26.

As depicted in Fig. 10, a method for bending the peeled-off section 12 of the inter-connection busbar 14 of the solar module over the electrical contact portion 16 of the junction box 18 comprises step a), step b), and/or step c). Steps a) to c) will be described in conjunction with Figs. 1a to 6b.

Step a) is depicted in Figs. 1a to 2b. At first, the finger device 20 is positioned above the junction box 18. This can include positioning the base part 46 above the junction box 18 using the second actuator 50. The camera 26 may be used to determine the correct position. The camera 26 may also be used for detecting the cavity 28 which may result in moving the finger device 20, optionally the first finger 30 at the second finger 32, in the second direction by means of the first actuator 48 such that the finger device 20 is positioned above the cavity 28 (see Fig. 1a). In other words, the first finger 30 and the second finger 32 are positioned along the second direction such that they are arranged on a side of the respective contact portions 16. For example, the first finger 30 and the second finger 32 are positioned in the second direction that they are flush with an inner wall of the junction box 18 (see Fig. 2b). This allows moving the finger device 20, optionally the first finger 30 at the second finger 32, along the first direction towards the solar module such that the second surface area 44 is arranged on the side of the contact portion 16.

The junction box 18 may have a total width A along the second direction (see Fig. 1b) which extends from one sidewall of the junction box 18 to the opposing sidewall of the junction box 18. The distance D defines a width of a gap between the contact portion 16 and the sidewall of the junction box 18 (with which the first finger 30 and the second finger 32 are in contact during step a)). Optionally, the distance D extends between an abutment portion 54 and the sidewall of the junction box 18.

The abutment portion 54 may include another wall of the junction box 18 which extends along the first direction on the side of the contact portion 16. For example, the abutment portion 54 may be a side surface of a support structure supporting the contact portion 16. The distance D refers to a dimension which limits the size of the finger device 20; the finger device 20 needs to have a width at the first end 36 that is smaller than the distance D. Thus, this dimension of the junction box 18 and/or of the cavity 28 limits the dimensions of the finger device 20.

The junction box 18 has a height B which extends from a bottom surface to a top surface. The height B indicates the maximum extension of the cavity 28 along the first direction. The distance C indicates the length from the contact portion 16 to the upper surface of the junction box 18 along the first direction.

After the pre-positioning step shown in Fig. 1a, the finger device 20 is inserted into the cavity 28 along the first direction as depicted in Figs. 2a and 2b. This may be done by moving the base part 46 along the first direction using the second actuator 50 (see arrows in Figs. 2a and 2b). After completion of the insertion step or positioning step, the first surface area 42 is separated – in the first direction – from the contact portion 16 by the distance X. The distance X may be a predetermined value which is set in advance. The distance X can be set by

monitoring the movement using the camera 26. Alternatively or additionally, the finger device 20 is moved by the distance E along the first direction after the first end 36 of the finger device 20 enters the cavity 28. In other words, the finger device 20 is further moved along the first direction by the distance E when the first end 36 of the finger device 20 or the third surface area 40 is located at a height position corresponding to the top surface of the junction box 18. The distance E may be the difference between the height B and the predetermined distance X.

The bending step b) follows after step a) (see Figs. 3a and 3b). The completion of step b) is shown in Figs. 4a and 4b. Step b) includes moving the finger device 20 along the second direction. Optionally, step b) includes moving the first finger 30 towards the second finger 32 and the second finger 32 towards the first finger 30 – both movement along the second direction as indicated by the arrows in Figs. 3a and 3b. During this movement, the height position in the first direction of the first surface area 42 or of the finger device 20 is not changed. In other words, the height position of the first surface area 42 is the same before and after step b). This may be achieved by maintaining the position of the base part 46 and only operating the first actuator 48.

The movement of the finger device 20 can end when the second surface area 44 is pressed against the peeled-off section 12 of the inter-connection busbar 14 which in turn is pressed against the abutment portion 54. Alternatively, the finger device 20 is moved by a predetermined distance along the second direction.

During the movement of step b), a side surface of the finger device 20 presses against the peeled-off section 12 of the inter-connection busbar 14. This bends the peeled-off section 12 of the inter-connection busbar 14. This bending is stopped when the lower section of peeled-off section 12 of the inter-connection busbar 14 is pressed against the abutment portion 54. The peeled-off section 12 of the inter-connection busbar 14 is bent around or close to an edge between the contact portion 16 and the abutment portion 54. This bending of the peeled-off section 12 of the inter-connection busbar 14 continues until the peeled-off section 12 of the inter-connection busbar 14 is aligned with the first surface area 42. Since the first surface area 42 extends above the contact portion 16, the bent section of the peeled-off section 12 of the inter-connection busbar 14 extends above the contact portion 16 (see Figs. 4a and 4b).

Optionally, the first finger 30 and the second finger 32 are concurrently moved such that the two peeled-off sections 12 of the inter-connection busbar 14 are concurrently bent over the respective contact portions 16. The distance X may be chosen such that the bent sections of peeled-off sections 12 of the inter-connection busbar 14 are in contact with the contact portion 16 or separated along in the first direction (see Fig. 4b).

Optional step c) follows after step b) and is depicted in Figs. 5a and 5b. The finger device 20 is moved along the first direction, for example by the distance X. This ensures that the bent section of peeled-off sections 12 of the inter-connection busbar 14 is pressed into the contact portion 16. However, it is also possible that the finger device 20 is moved in the first direction and towards the contact portion 16 by a distance that is smaller than the distance X. This increases the likelihood that the bent sections of the peeled-off sections 12 of the inter-connection busbar 14 do not move away (bounce back) from the contact portion 16 once the finger device 20 is removed.

Step c) may include moving the first finger 30 and the second finger 32 by moving the base part 46 in the first direction. Thus, the first finger 30 and the second finger 32 are concurrently moved.

Fig. 6a shows the removal of the finger device 20 from the cavity 28 by moving the finger device 20 in the first direction as indicated by the arrows. This may be done by moving the base part 46 in the first direction. As an end result, the peeled-off sections 12 of the inter-connection busbar 14 are bent onto the contact portion 16 and are in contact with the contact portion 16. This is depicted in Fig. 6b. In an optional step, the bent peeled-off sections 12 of the inter-connection busbar 14 are soldered to respective the contact portions 16.

In another embodiment as depicted in Fig. 9, the finger device 20 includes a single finger 52 which comprises one third surface area 40, two first surface areas 42, and two second surface areas 44. The method for bending the peeled-off section 12 of the inter-connection busbar 14 of the solar module over the electrical contact portion 16 of the junction box 18 is similar to the method described above except steps a) to c) are repeated for the first one of the peeled-off sections 12 of the inter-connection busbar 14. Then, the single finger 52 is repositioned with regard to the other contact portion 16 by moving the single finger 52 along the second direction. Then, step b) is repeated however, the other one of the first surface area 42 and second surface area 44 bends the first second of the peeled-off sections 12 of the inter-connection busbar 14.

In another embodiment as depicted in Fig. 10, the first finger 30 and the second finger 32 includes only the first surface area 42 and the second surface area 44. No third surface area 40 is present. This is due to the fact that the first end 36 is a sharp edge between the second surface area 44 and a side surface of the first finger 30 and the second finger 32. Further, the first surface area 42 and the second surface area 44 form a continuous curved line, e.g. a quarter pipe. The first surface area 42 may be considered that section of the quarter pipe that extends approximately perpendicular to the first direction. The second surface area 44 may

be considered that section of the quarter pipe that extends approximately parallel to the first direction.

- It will be understood that the invention is not limited to the embodiments above described and various modifications and improvements can be made without departing from the concepts described herein. Except where mutually exclusive, any of the features may be employed separately or in combination with any other features and the disclosure extends to and includes all combinations and sub-combinations of one or more features described herein.

Feature List

10	apparatus
12	peeled-off section
14	inter-connection busbar
16	contact portion
18	junction box
20	finger device
22	actuator device
24	control device
26	camera
28	cavity
30	first finger
32	second finger
34	elongate body
36	first end
38	second end
40	third surface area
42	first surface area
44	second surface area
46	base part
48	first actuator
50	second actuator
52	single finger
54	abutment portion

CLAIMS

1. An apparatus for bending a peeled-off section of an inter-connection busbar of a solar module over an electrical contact portion of a junction box of the solar module, comprising
- 5 a finger device having a first end and a second end,
an actuator device, the actuator device being attached to the finger device at the second end, the actuator device being configured to move the finger device in a first direction and in a second direction perpendicular to the first direction, and
a control device configured to control the actuator device,
- 10 wherein the first end includes a first surface area and a second surface area, the first surface area being offset from the first end in the first direction from the first end towards the second end, and the second surface area connecting the first surface area to the first end,
wherein the control device is configured to control the actuator device to move the finger device along the first direction and to then move the finger device along the second
- 15 direction for bending the peeled-off inter-connection busbar over the electrical contact portion.
2. The apparatus of claim 1, wherein the control device is further configured to control the actuator device to move the finger device along the first direction such that the first surface area bends the bent inter-connection busbar towards the electrical contact portion which
- 20 optionally includes pressing the bent inter-connection busbar into the electrical contact portion.
3. The apparatus of claims 1 or 2, wherein the first end includes a third surface area which is arranged at the first end.
- 25 4. The apparatus of any preceding claim, wherein the finger device includes a first finger and a second finger, wherein the first finger and the second finger each include respective first surface areas and respective second surface areas, and wherein the second surface area of the first finger faces the second surface area of the second finger.
- 30 5. The apparatus of any one of claims 1 to 3, wherein the finger device includes a single finger, wherein the single finger includes two first surface areas and two second surface areas, and wherein the second surface areas are arranged on opposing sides finger device.
6. The apparatus of any one of the preceding claims, wherein the actuator device
- 35 includes a base part, wherein the base part includes a first actuator configured to move the finger device in the second direction.

7. The apparatus of claim 6, wherein the actuator device includes a second actuator configured to move the base part in the first direction.
- 5 8. The apparatus of any one of the preceding claims, further comprising a camera, optionally a 3D-camera, wherein the control device is configured to position the finger device using the camera.
9. A method for bending a peeled-off section of an inter-connection busbar of a solar
10 module over an electrical contact portion of a junction box of the solar module, comprising the steps of
- a) positioning a first end of a finger device in a cavity of the junction box, the first end including a first surface area and a second surface area, the first surface area being offset from the first end in a first direction away from the first end, the second surface area connecting
15 the first surface area to the first end, and
- b) bending the peeled-off section of the inter-connection busbar over the electrical contact portion by moving the finger device along a second direction perpendicular to the first direction and parallel to a direction of extension of the inter-connection busbar.
- 20 10. The method of claim 9, wherein step b) includes moving the finger device along the second direction until the peeled-off section of the inter-connection busbar has a contour that substantially matches a contour of the first surface area and/or of the second surface area.
11. The method of claims 9 or 10, wherein the first end includes a third surface area which
25 is arranged at the first end.
12. The method of any one of claims 9 to 11, further comprising step c) of further bending the bent inter-connection busbar towards the electrical contact portion by moving the finger device along the first direction, wherein optionally step c) further includes pressing the bent
30 inter-connection busbar into the electrical contact portion.
13. The method of any one of the claims 9 to 11, wherein step a) comprises positioning the first surface area at a first height position in the first direction which is greater than a second height position in the first direction at which an upper surface of the contact portion is located,
35 wherein the difference between the first height position and the second height position is a predetermined value.

14. The method of any one of the claims 9 to 13, wherein step a) comprises positioning the first surface area parallel to a plane of the solar module.
15. The method of any one of the claims 9 to 14, wherein step a) includes imaging the junction box using a camera, optionally a 3D-camera, and positioning the finger device based on the images taken by the camera.
16. The method of any one of the claims 9 to 15, wherein step a) includes moving a base part to which the finger device is attached.
17. The method of claim 16, wherein step b) includes moving the finger device relative to the base part.
18. The method of any one of the claims 9 to 16, wherein the finger device includes a first finger and a second finger, the first finger and the second finger each include respective first surface areas, and respective second surface areas, the second surface area of the first finger facing the second surface area of the second finger, and step b) includes moving the first finger and the second finger towards each other to bend two peeled-off sections of the inter-connection busbar onto respective contact portions.
19. The method of any one of the claims 9 to 18, wherein the finger device includes a single finger, the single finger includes the two first surface areas and two second surface areas, and wherein the second surface areas are arranged on opposing sides of the finger device, and steps a) and b) are executed for a first peeled-off section of the inter-connection busbar using one of the two first surface areas and one of the two second surface areas and steps a) and b) are repeated for a second peeled-off section of the inter-connection busbar using the other one of the two first surface areas and the other one of the two second surface areas.