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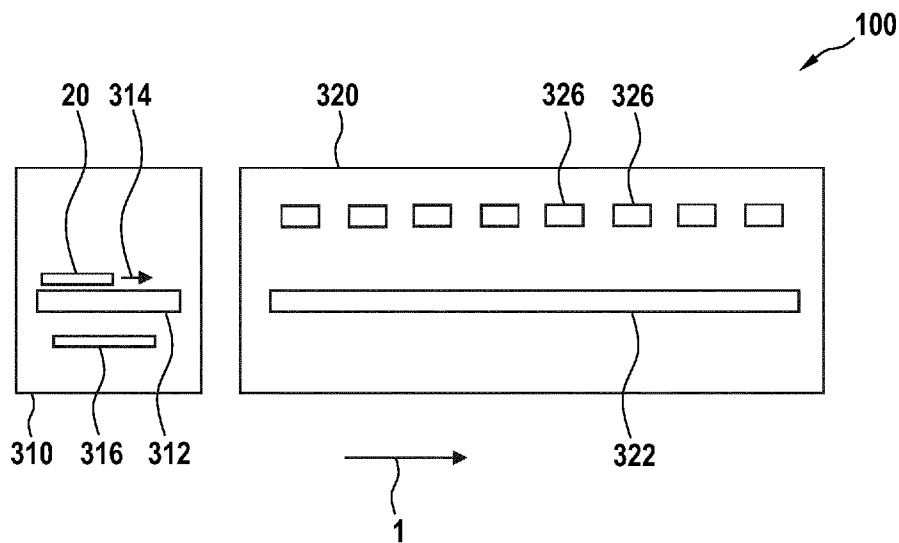
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(54) Title: APPARATUS FOR PROCESSING A SOLAR CELL ARRANGEMENT INCLUDING A PLURALITY OF OVERLAPPING SOLAR CELL PIECES, HEATING DEVICE FOR HEATING THE SAME, METHOD FOR PROCESSING THE SAME

Fig. 3a



(57) Abstract: An apparatus (100) for processing a solar cell arrangement (20) including a plurality of overlapping solar cell pieces is provided. The apparatus (100) includes a first heating device (310) for pre-curing the solar cell arrangement (20). The apparatus (100) includes a second heating device (320) for curing the solar cell arrangement (20). The second heating device (320) is arranged downstream of the first heating device (310) relative to a processing direction (1) of the apparatus (100).

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APPARATUS FOR PROCESSING A SOLAR CELL ARRANGEMENT INCLUDING A
PLURALITY OF OVERLAPPING SOLAR CELL PIECES, HEATING DEVICE FOR
HEATING THE SAME, METHOD FOR PROCESSING THE SAME

5 FIELD

[0001] Embodiments of the present disclosure relate to solar cell arrangements including a plurality of overlapping solar cell pieces, or shingled solar cell arrangements. More specifically, embodiments described herein relate to an apparatus and a method for processing such solar cell arrangements and to a heating device for heating such solar cell
10 arrangements.

BACKGROUND

[0002] Solar cells are photovoltaic devices that convert sunlight directly into electrical power. The efficiency of the solar cells can be affected by an active area on a front surface of the solar cell which is exposed to light for converting sunlight into electrical power. The
15 active area can be reduced due to the presence of electrical contacts, such as fingers and/or bus bars, on the front surface of the solar cells. The presence of the electrical contacts on the front surface of the solar cells can thus reduce a module power of a solar cell module including the solar cells.

[0003] Shingled solar cell arrangements can increase an output power of a solar cell
20 module. The increase in the output power can be affected by a quality of a manufacturing process, such as a quality of the elements used to assemble the shingled solar cell arrangement. Further, a proper assembling of the shingled solar cell arrangement can be cumbersome, and a throughput and/or yield can be low.

[0004] In view of the above, new methods and apparatuses for processing solar cells for
25 the manufacture of shingled solar cell arrangements that overcome at least some of the problems in the art are beneficial. The present disclosure particularly aims at improving the manufacturing process of solar cell arrangements, such as shingled solar cell arrangements.

SUMMARY

[0005] According to an embodiment, an apparatus for processing a solar cell arrangement including a plurality of overlapping solar cell pieces is provided. The apparatus includes a first heating device for pre-curing the solar cell arrangement. The apparatus includes a second heating device for curing the solar cell arrangement. The second heating device is arranged downstream of the first heating device relative to a processing direction of the apparatus.

[0006] According to a further embodiment, a heating device for heating a solar cell arrangement comprising a plurality of overlapping solar cell pieces is provided. The heating device includes a first support system for supporting the solar cell arrangement. The heating device includes one or more heating elements for heating the solar cell arrangement. The heating device is configured to pre-cure the solar cell arrangement.

[0007] According to a further embodiment, a heating device for heating a solar cell arrangement comprising a plurality of overlapping solar cell pieces is provided. The heating device includes a conveyor for transporting the solar cell arrangement in a transport direction. The conveyor defines a receiving area for receiving the solar cell arrangement on the conveyor. The heating device includes one or more heating elements for heating the solar cell arrangement, the one or more heating elements being arranged below the receiving area. The heating device includes a vacuum system for holding the solar cell arrangement on the conveyor. The heating device has a first transportation length in the transport direction of 2 m or less.

[0008] According to a further embodiment, a method for processing a solar cell arrangement comprising a plurality of overlapping solar cell pieces is provided. The method includes pre-curing the solar cell arrangement by a first heating device. The method includes curing the pre-cured solar cell arrangement by a second heating device.

[0009] Embodiments are also directed at apparatuses for carrying out the disclosed methods and include apparatus parts for performing each described method aspect. These method aspects may be performed by way of hardware components, a computer programmed by appropriate software, by any combination of the two or in any other

manner. Furthermore, embodiments according to the disclosure are also directed at methods for operating the described apparatus. The methods for operating the described apparatus include method aspects for carrying out every function of the apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

5 [0010] So that the manner in which the above recited features of the present disclosure can be understood in detail, a more particular description of the disclosure, briefly summarized above, may be had by reference to embodiments. The accompanying drawings relate to embodiments of the disclosure and are described in the following:

FIG. 1 shows an example of a solar cell piece as described herein;

10 FIG. 2 shows an example of a solar cell arrangement including a plurality of overlapping solar cell pieces as described herein;

FIGS. 3a-b show an apparatus for processing a solar cell arrangement including a plurality of overlapping solar cell pieces according to embodiments described herein;

15 FIG. 4 shows an apparatus for processing a solar cell arrangement including a plurality of overlapping solar cell pieces according to embodiments described herein;

20 FIGS. 5-6 show a first heating device for heating a solar cell arrangement including a plurality of overlapping solar cell pieces according to embodiments described herein;

FIG. 7 shows a first heating device for heating a solar cell arrangement including a plurality of overlapping solar cell pieces according to embodiments described herein;

25 FIG. 8 shows an example of a second heating device for curing a solar cell arrangement including a plurality of overlapping solar cell pieces as described herein; and

FIG. 9 illustrates a method for processing a solar cell arrangement including a plurality of overlapping solar cell pieces according to embodiments described herein.

5 DETAILED DESCRIPTION

[0011] Reference will now be made in detail to the various embodiments of the disclosure, one or more examples of which are illustrated in the figures. Within the following description of the drawings, the same reference numbers refer to same components. Generally, only the differences with respect to individual embodiments are described. Each example is provided by way of explanation of the disclosure and is not meant as a limitation of the disclosure. Further, features illustrated or described as part of one embodiment can be used on or in conjunction with other embodiments to yield yet a further embodiment. It is intended that the description includes such modifications and variations.

15 [0012] Embodiments described herein relate to shingled solar cell arrangements. A shingled solar cell arrangement can be made of a plurality of overlapping solar cell pieces. Adjacent solar cell pieces are electrically connected to each other in the overlapping region, e.g. via adhesives as described herein. The solar cell pieces are connected in series such that current generated by the individual solar cell pieces flows along the series of solar cell pieces to be collected, for example, at an end portion of the solar cell arrangement. The overlapping configuration can provide high-efficiency solar cell arrangements. In particular, the solar cell arrangements allow for increasing a solar cell module power by increasing a used or active area. Typically, the overlapping configuration can increase the module power by, for example, 20 to 40 Watts. The used or active area can correspond to an area that is irradiated by solar light and that participates in the generation of power. For example, the used or active area can correspond to an area of the solar cells that is not covered by, for example, conductive line patterns, such as fingers and/or bus bars.

[0013] A solar cell arrangement, as described herein, can be a shingled solar cell arrangement.

[0014] The term “solar cell piece”, as used herein, refers to a piece, portion or segment of a solar cell. A solar cell piece may be understood as a solar cell segment, or solar cell shingle. A solar cell piece may be a portion of a solar cell resulting from the cleaving of the solar cell, i.e. separating the solar cell into solar cell pieces. The area of a solar cell piece is smaller than the area of a solar cell. For example, the area of a solar cell piece may be 90% or less of the area of a solar cell. In some cases, a solar cell piece may have an area of 50% or less of the area of a solar cell.

[0015] A solar cell piece, as described herein, may include a conductive pattern, particularly a conductive line pattern. A conductive pattern can include one or more bus bars and/or a plurality of fingers. The solar cell piece can include a conductive pattern on a front side of the solar cell or solar cell piece. Additionally or alternatively, a solar cell piece can include a conductive pattern on a back side of the solar cell piece. For example, a solar cell piece can include a first conductive pattern including one or more bus bars and a plurality of fingers on the front side of the solar cell or solar cell piece. The solar cell piece can include a second conductive pattern including one or more bus bars on the back side of the solar cell piece.

[0016] Fig. 1 shows an example of a solar cell piece 10 as described herein.

[0017] A solar cell piece 10 may have a back side 12 and a front side 14 opposite the back side 12, as shown for example in Fig. 1. The front side 14 may be configured for receiving light, e.g. sunlight, which may be converted into electrical power by the solar cell piece 10.

[0018] A solar cell piece 10 may include a bus bar 24, as shown for example in Fig. 1. The bus bar 24 may be provided on the front side of the solar cell piece 10. The solar cell piece 10 may include a bus bar 22. The bus bar 22 may be provided on the back side 12 of the solar cell piece 10.

[0019] A solar cell piece 10 may include an adhesive 5, as shown for example in Fig. 1. The adhesive 5 may be provided on the front side 14 of the solar cell piece 10. In some

implementations, the adhesive 5 may be provided on the bus bar 24. Alternatively, the adhesive 5 may be provided on the back side 12 of the solar cell piece 10, such as e.g. on the bus bar 22.

5 [0020] An adhesive, as described herein, may be configured for connecting, particularly attaching, solar cell pieces to each other. The adhesive can be configured for connecting a first solar cell piece of a solar cell arrangement to a second solar cell piece of the solar cell arrangement. The adhesive can provide for an electrical and mechanical connection between two solar cell pieces of a solar cell arrangement. The adhesive may be in a substantially liquid form, e.g. a conductive paste, when applied to a solar cell piece.

10 [0021] An adhesive, as described herein, can be an electrically conductive adhesive (ECA). The adhesive can be selected from the group consisting of solder, silver paste, silicone-based electrically conductive adhesive, and epoxy-based electrically conductive adhesive.

15 [0022] Fig. 2 shows an example of a solar cell arrangement 20 including a plurality of overlapping solar cell pieces, as described herein.

[0023] As shown for example in Fig. 2, a solar cell arrangement 20 may include a first solar cell piece 10a. The solar cell arrangement 20 may include a second solar cell piece 10b. The second solar cell piece 10b may overlap with the first solar cell piece 10a. The first solar cell piece 10a and the second solar cell piece 10b may be adjacent solar cell
20 pieces of the solar cell arrangement 20. The first solar cell piece 10a may be connected to the second solar cell piece 10b. The first solar cell piece 10a may be connected to the second solar cell piece 10b by an adhesive 5a. In some implementations, the adhesive 5a may connect a bus bar 24a of the first solar cell piece 10a to a bus bar 22b of the second solar cell piece 10b.

25 [0024] As shown for example in Fig. 2, a solar cell arrangement 20 may include a plurality of further solar cell pieces, such as solar cell pieces 10c and 10d. The solar cell arrangement 20 may include a plurality of adhesives 5a, 5b, 5c connecting adjacent solar cell pieces of the solar cell arrangement 20.

[0025] According to an embodiment, an apparatus for processing a solar cell arrangement including a plurality of overlapping solar cell pieces is provided. The apparatus includes a first heating device for pre-curing the solar cell arrangement. The apparatus includes a second heating device for curing the solar cell arrangement. The second heating device is arranged downstream of the first heating device relative to a processing direction of the apparatus.

[0026] Figs. 3a-b show an apparatus 100 for processing a solar cell arrangement 20 including a plurality of overlapping solar cell pieces according to embodiments described herein.

[0027] An apparatus 100 according to embodiments described herein may have a process direction for processing the solar cell arrangement 20. In Figs. 3a-b, the process direction is indicated by arrow 1, indicating that, in the exemplary embodiment shown in Figs 3a-b, the solar cell arrangement 20 is processed from left to right.

[0028] An apparatus 100 according to embodiments described herein may include a first heating device 310 for heating the solar cell arrangement 20, as shown for example in Figs. 3a-b.

[0029] A first heating device 310 as described herein may be a drying device, particularly a pre-drying, pre-curing or pre-tacking device. The first heating device 310 may be configured to pre-cure at least a portion of the solar cell arrangement 20. The first heating device 310 may be configured to pre-cure an adhesive of the solar arrangement 20. The adhesive may connect a first solar cell piece of the solar cell arrangement 20 to a second solar cell piece of the solar cell arrangement 20.

[0030] A first heating device 310, as described herein, may include a first support system 312 for supporting the solar cell arrangement 20. The solar cell arrangement 20 may be supported by the first support system 312. The solar cell arrangement 20 supported by the first support system 213 may be heated by the first heating device 310.

[0031] A first support system 312, as described herein, may be configured for transporting the solar cell arrangement 20 in a transport direction of the first heating device 310. The first support system 312 may include, for example, a belt conveyor for

transporting the solar cell arrangement 20 in the transport direction of the first heating device 310. In Fig. 3a, the transport direction of the first heating device 310 is indicated by the arrow 314. As the solar cell arrangement 20 is transported in the transport direction of the first heating device 310, the solar cell arrangement 20 is heated by the first heating device 310. When the solar cell arrangement 20 has travelled from one end of the first heating device to the opposite end of the first heating device 310, the heating process by the first heating device may be completed.

[0032] The first support system 312 may be adapted for transporting the solar cell arrangement 20 through a receiving area, as described herein, of the first support system 312. The first support system 312 may be adapted for transporting the solar cell arrangement 20 in a step-by-step movement, i.e. a movement comprising a sequence of discrete steps in the transport direction.

[0033] A first heating device 310, as described herein, may include one or more heating elements 316 for heating the solar cell arrangement 20, as shown for example in Figs 3a-b.

[0034] A solar cell arrangement 20, as described herein, may include a first solar cell piece. The solar cell arrangement 20 may include a second solar cell piece. The solar cell arrangement 20 may include an adhesive, e.g. an electrically conductive adhesive, for connecting the first solar cell piece to the second solar cell piece. The first solar cell piece and the second solar cell piece may be adjacent solar cell pieces of the solar cell arrangement 20. The solar cell arrangement 20 may include a plurality of overlapping solar cell pieces. Each solar cell piece of the solar cell arrangement may be connected, e.g. electrically and mechanically connected, to an adjacent solar cell piece of the solar cell arrangement by a respective adhesive.

[0035] Prior to heating the solar cell arrangement 20 by the first heating device 310, the adhesives of the solar cell arrangement 20 may be in a substantially liquid state. For example, the adhesives may be provided in the form of a conductive paste. In particular, prior to heating the solar cell arrangement 20 by the first heating device 310, the adhesives of the solar cell arrangement may be uncured adhesives.

[0036] A first heating device 310, as described herein, may be configured for pre-curing, or partially curing, the solar cell arrangement 20. The solar cell arrangement 20 may include a first solar cell piece. The solar cell arrangement 20 may include a second solar cell piece. The solar cell arrangement 20 may include an adhesive connecting the first solar cell piece to the second solar cell piece. The first heating device may be configured to pre-cure the adhesive.

[0037] The notion “pre-curing”, or “partially curing”, of a solar cell arrangement 20 may be understood in the sense that the solar cell arrangement 20, and more particularly the adhesives of the solar cell arrangement 20 connecting respective solar cell pieces of the solar cell arrangement to each other, are heated during a period of time which is not long enough to fully cure, i.e. fully dry or harden, the adhesives of the solar cell arrangement. When the pre-curing process undertaken in the first heating device 310 is completed, the adhesives of the solar cell arrangement 20 may be in a state which is more solid, i.e. dryer, less fluid, more hardened, as compared to e.g. the substantially liquid state of a fully uncured adhesive in the form of a conductive paste. When the pre-curing process undertaken in the first heating device 310 is completed, the adhesives of the solar cell arrangement 20 may not be fully cured.

[0038] The pre-curing process undertaken by the first heating device 310 may allow for fixing the relative position or alignment of the respective solar cell pieces within the solar cell arrangement 20. When the pre-curing process undertaken in the first heating device 310 is completed, the adhesives of the solar cell arrangement 20 may be sufficiently dry for attaching adjacent solar cell pieces of the solar cell arrangement 20 to each other in a manner such that the alignment of respective solar cell pieces relative to each other can remain fixed. Accordingly, after the pre-curing, the solar cell pieces of the solar cell arrangement 20 are connected to each other in a sufficiently rigid manner such that the solar cell arrangement 20 as a whole may be transferred from the first heating device 310 to a further process station, particularly to the second heating device 320, without affecting the relative position or alignment of the solar cell pieces within the solar cell arrangement 20.

[0039] Fig. 3a shows the solar cell arrangement 20 being pre-cured in the first heating device 310 while the solar cell arrangement 20 moves through the first heating device 310

in the transport direction as indicated by the arrow 314. When the pre-curing process in the first heating device 310 is completed, the solar cell arrangement 20 may be transferred from the first heating device 310 to the second heating device 320 of the apparatus 100. Fig. 3b shows the solar cell arrangement 20 in the second heating device 320, i.e. after the solar cell arrangement 20 has been transferred from the first heating device 310 to the second heating device 320.

[0040] An apparatus 100 according to embodiments described herein may include a second heating device 320, as shown for example in Figs. 3a-b. The second heating device 320 may be arranged downstream of the first heating device 310 relative to the processing direction 1 of the apparatus.

[0041] An apparatus 100 according to embodiments described may be configured for transferring the solar cell arrangement 20 from the first heating device 310 to the second heating device 320. The apparatus 100 may be configured to cure the solar cell arrangement 20 by the second heating device 320 after pre-curing the solar cell arrangement 20 by the first heating device 310.

[0042] A second heating device 320, as described herein, may include a second support system 322 for supporting the solar cell arrangement 20. The second support system 322 may be configured for transporting the solar cell arrangement in a transport direction of the second heating device 320. The second support system 322 may include, for example, a belt conveyor for transporting the solar cell arrangement 20 in the transport direction of the second heating device 320. In Fig. 3b, the transport direction of the second heating device 320 is indicated by the arrow 324. As the solar cell arrangement 20 is transported in the transport direction of the second heating device 320, the solar cell arrangement 20 may be heated by the second heating device 320. When the solar cell arrangement 20 has travelled from one end of the second heating device 320 to the opposite end of the second heating device 320, the heating process may be completed and the solar cell arrangement may be cured, particularly fully cured. When the heating process by the second heating device 320 is completed, the adhesives connecting adjacent solar cell pieces of the solar cell arrangement 20 to each other may be cured, particularly fully cured.

[0043] The transport direction of the first heating device 310 may be the same direction or substantially the same direction as the transport direction of the second heating device, as illustrated in Figs. 3a-b. Alternatively, both transport directions may be different directions.

5 [0044] A second heating device 320, as described herein, may be configured for heating the solar cell arrangement 20. For example, as shown Fig. 3b, the solar cell arrangement 20 may be supported by the second support system 322 of the second heating device 320. The solar cell arrangement 20 supported by the second support system 322 may be heated by the second heating device 320.

10 [0045] A second heating device 320, as described herein, may include one or more heating elements 326 for heating the solar cell arrangement 20, as shown for example in Figs 3a-b.

[0046] A second heating device 320, as described herein, may be configured for curing, particularly fully curing, the solar cell arrangement 20. The solar cell arrangement 20 may include a first solar cell piece. The solar cell arrangement 20 may include a second solar cell piece. The solar cell arrangement 20 may include an adhesive connecting the first solar cell piece to the second solar cell piece. The second heating device may be configured to cure, particularly fully cure, the adhesive.

[0047] For example, a solar cell arrangement 20 in a partially cured state may be transferred from the first heating device 310 to the second heating device 320. Since the solar cell arrangement 20 is in a partially cured state, the transfer does not cause changes in the relative alignment of the respective solar cell pieces of the solar cell arrangement 20. After the transfer, the pre-cured solar cell arrangement 20 may be cured by the second heating device 320. When the curing process by the second heating device 320 is completed, the solar cell arrangement 20 may be cured, particularly fully cured. When the curing process by the second heating device 320 is completed, the adhesives connecting adjacent solar cell pieces of the solar cell arrangement 20 to each other may be cured, particularly fully cured.

[0048] The pre-curing process performed by the first heating device 310 may involve heating the solar cell arrangement 20 over a shorter period of time as compared to the curing process performed by the second heating device 320. In light thereof, the first heating device 310 may have a shorter length than the second heating device.

5 [0049] Fig. 4 shows an apparatus 100 according to embodiments described herein. In the exemplary embodiment, the transport direction of the first heating device 310 and the transport direction of the second heating device 320 are both substantially the same as direction 402. Alternatively, the transport direction of the second heating device 320 may be at an angle with respect to the transport direction of the first heating device 310.

10 [0050] A first heating device 310, as described herein, may have a first transportation length 410 in the transport direction of the first heating device 310, as shown for example in Fig. 4. The first transportation length 410 may be the total distance over which the solar cell arrangement 20 is transported by the first support system 312, e.g. a belt conveyor, during heating of the solar cell arrangement 20 by the first heating device 310. The first
15 transportation length 410 may correspond to a distance, in the transport direction of the first heating device 310, from one end of the first support system 312 to an opposite end of the first support system 312. The first transportation length 410 may correspond to a length of the first support system 312 in the transport direction of the first heating device 310. The first transportation length 410 may be the distance between the rotation axes of a first roller
20 and a second roller arranged at opposing ends of a conveyor of the first support system 312.

[0051] A second heating device 320, as described herein, may have a second transportation length 420 in the transport direction of the second heating device 320, as shown for example in Fig. 4. The second transportation length 420 may be the total
25 distance over which the solar cell arrangement 20 is transported by the second support system 322, e.g. a belt conveyor, during heating of the solar cell arrangement 20 by the second heating device 320. The second transportation length 420 may correspond to a distance, in the transport direction of the second heating device 320, from one end to the second support system 322 to an opposite end of the second support system 322. The
30 second transportation length 420 may correspond to a length of the second support system 322 in the transport direction of the second heating device 320. The second transportation

length 420 may be the distance between the rotation axes of a first roller and a second roller at opposing ends of a conveyor of the second support system 322.

[0052] Since the first heating device may provide a pre-curing of the solar cell arrangement 20, as compared to the second heating device, which may provide a complete curing of the solar cell arrangement 20, the first transportation length 410 can be shorter than the second transportation length 420. For example, the first transportation length 410 can be 50% or less of the second transportation length 420.

[0053] A short transportation length of the first heating device 310 provides the advantage that the first heating device provides a pre-cured solar cell arrangement 20 wherein the respective solar cell pieces of the pre-cured solar cell arrangement 20 are accurately aligned relative to each other. For example, in case of a belt conveyor for transporting the solar cell arrangement 20, possible imperfections, e.g. deformations, of the belt conveyor may shift the position of at least some of the solar cell pieces of the solar cell arrangement during transportation of the solar cell arrangement 20 on the belt conveyor.

An initially well-aligned solar cell arrangement could, when reaching the end of the conveyor, have a decreased alignment accuracy. Accordingly, transportation of the solar cell arrangement 20 on a shorter belt conveyor can reduce the risk that deformations of the belt conveyor may affect the alignment of the solar cell arrangement. In light of the short length of the first heating device 310, the pre-cured solar cell arrangement 20 provided upon completion of the heating process by the first heating device 310 is more accurately aligned as compared to a solar cell arrangement heated by a longer heating device. Further, as discussed above, when the pre-curing process undertaken by the first heating device 310 is completed, the pre-cured adhesives of the solar cell arrangement 20 are sufficiently hardened such that the relative alignment of the solar cell pieces of the solar cell arrangement remains fixed. Accordingly, the high-accuracy alignment of the solar cell arrangement 20 obtained after the pre-curing process can be maintained, e.g. when transferring the pre-cured solar cell arrangement 20 from the first heating device 310 to the second heating device 320 for completing the curing process. Accordingly, a cured solar cell arrangement 20 wherein the solar cell pieces of the solar cell arrangement are aligned with high accuracy with respect to each other can be provided by embodiments described herein.

[0054] A first heating device 310, as described herein, may have a first transportation length 410 in a transport direction of the first heating device 310. The first support system 312 may be configured to transport the solar cell arrangement 20 over the first transportation length 410.

5 [0055] A second heating device 320, as described herein, may have a second transportation length 420 in a transport direction of the second heating device 320. The second support system 322 may be configured to transport the solar cell arrangement 20 over the second transportation length 420.

[0056] The first transportation length 410 may be shorter than the second transportation length 420. The first transportation length may be 50% or less, particularly 40% or less, of the second transportation length 420. For example, the first transportation length 410 may be 1 m or less, such as e.g. about 800 mm. The second transportation length 420 may be about 4 m.

15 [0057] Fig. 5 shows an example of a first heating device 310 of an apparatus according to embodiments described herein.

[0058] The first support system 312 may have a receiving area 510 for receiving a solar cell arrangement 20, as shown for example in Fig. 5. The receiving area 510 of the first support system 312 may correspond to an area, particularly a total area, of the first support system 312 configured for supporting a solar cell arrangement 20. While the solar cell arrangement 20 is heated by the first heating device 310, the solar cell arrangement may be transported from a first end of the receiving area 510 to a second end of the receiving area 510, the second end being opposite the first end. When the solar cell arrangement 20 reaches the second end of the receiving area 510, the heating process by the first heating device 310 may be completed. The length of the receiving area 510 in the transport direction of the first heating device 310 may correspond, or be equal to, the first transportation length, as described herein, of the first heating device 310.

25 [0059] Fig. 6 shows an example of a first heating device 310 of an apparatus according to embodiments described herein.

[0060] The first support system 312 of the first heating device 310 may include a conveyor 520, particularly a belt conveyor, for transporting the solar cell arrangement 20, as shown for example in Fig. 6. The conveyor 520 may extend in the transport direction of the first heating device 310. The first support system 312 may include a first roller 522.

5 The first roller 522 may be at a first side of the first support system 312. The first support system 312 may include a second roller 524. The second roller 524 may be at a second side of the first support system 312. The second side may be opposite the first side. The first roller 522 and/or the second roller 524 may be configured for guiding the conveyor 520, particularly for guiding a belt of the conveyor. The first roller 522 may be a guide roller.

10 The second roller 524 may be adapted for driving the conveyor 520. The first support system 312 may include an actuator, e.g. a motor, connected to the second roller 524 for driving a rotation of the second roller 524.

[0061] A first heating device 310, as described herein, may include one or more heating elements 316 for heating the solar cell arrangement. The one or more heating elements 316

15 of the first heating device 310 may be arranged below the receiving area 510, as shown for example in Fig. 6. The one or more heating elements 316 may be arranged such that a solar cell arrangement 20 supported by the first support system 312 is heated from below by the one or more heating elements 316. The one or more heating elements 316 may be arranged between a first roller 522 and a second roller 524 of the first support system 312. The one

20 or more heating elements 316 may be arranged between two opposing surfaces of a conveyor 520 of the first support system 312.

[0062] A heating element of the first heating device 310, as described herein, may include a plate. The heating element may include one or more resistors for heating the plate. The one or more resistors may be arranged below the plate. The plate may be

25 configured for heating a solar cell arrangement 20 as described herein. A heating element of the first heating device 310 may be a hot nest.

[0063] The one or more heating elements 316 of the first heating device 310 may be a plurality of heating elements. The plurality of heating elements may include two, three or more heating elements. The plurality of heating elements may be arranged along the

30 transport direction of the first heating device 310.

[0064] The one or more heating elements 316 of the first heating device 310 may include a first heating element, e.g. the leftmost heating element of the three heating elements shown in Fig. 6. The first heating element may be configured to provide a first heating temperature for heating the solar cell arrangement 20.

5 [0065] The one or more heating elements 316 of the first heating device 310 may include a second heating element, e.g. the middle heating element of the three heating elements shown in Fig. 6. The second heating element may be configured to provide a second heating temperature for heating the solar cell arrangement 20. The first heating temperature may be different from the second heating temperature.

10 [0066] The first heating element may be configured to provide a first heating zone of the first heating device 310. The second heating element may be configured to provide a second heating zone of the first heating device 310. The first support system 312 of the first heating device 310 may be configured to move the solar cell arrangement 20 through the first heating zone and subsequently through the second heating zone.

15 [0067] By providing the first heating device 310 with heating elements which can provide different heating temperatures or heating zones for heating the solar cell arrangement 20, it is possible to gradually ramp up the heating temperature as the solar cell arrangement 20 moves through the first heating device 310 in the transport direction of the first heating device. An advantage of gradually ramping up the heating temperature is that
20 a thermal shock of the solar cell arrangement 20 can be avoided.

[0068] The one or more heating elements 316 of the first heating device 310 may be configured to provide a maximum temperature of 450 °C or less, more particularly 350 °C or less, such as e.g. a maximum temperature of 300 °C, for heating the solar cell arrangement 20.

25 [0069] Fig. 7 shows an example of a first heating device 310 of an apparatus according to embodiments described herein.

[0070] A first heating device 310 as described herein may include a vacuum system 710 for holding the solar cell arrangement 20 on the first support system 312, as shown for example in Fig. 7.

[0071] The terminology “vacuum system”, as used herein, does not necessarily imply that a vacuum in the strict sense is provided by the vacuum system. A vacuum system can be understood in the sense that the vacuum system provides an under-pressure, or suctioning force, suitable for urging a solar cell arrangement 20 onto the first support system 312. The under-pressure provided by the vacuum system 710 is such that the solar cell arrangement 20 can be held in a fixed position onto the first support system 312.

[0072] A vacuum system 710, as described herein, may be a vacuum chucking system for holding the solar cell arrangement 20 on the first support system 312.

[0073] By using a vacuum system 710, the solar cell arrangement 20 can be held in a fixed position on a supporting surface of the first support system 312 while the solar cell arrangement is transported through the first heating device 310 by the first support system 312. Particularly, the individual solar cell pieces of the solar cell arrangement 20 can be held in a fixed position relative to each other by the vacuum system 710 during transportation of the solar cell arrangement 20 through the first heating device 310. The vacuum system 710 may provide a stronger chucking force for holding the solar cell arrangement 20 as compared to other systems for holding the solar cell arrangement 20, e.g., electrostatic chucking systems. The possibility of movements of the solar cell arrangement 20 with respect to the support surface of the first support system 312, or movements of the individual solar cell pieces of the solar cell arrangement 20 relative to each other, is reduced by using a vacuum system 710 as compared to other systems. In light thereof, by using a vacuum system 710 as described herein, the accuracy of the alignment of the solar cell pieces relative to each other can further be improved.

[0074] For heating devices having a long length in the transport direction, a vacuum system for holding the solar cell arrangement in place can be less beneficial, since the use of vacuum chucking systems over longer distances can give rise to effects such as e.g. an increased friction. The first heating device 310 as described herein, being configured for pre-curing the solar cell arrangement 20, can have a shorter length as compared to e.g. a systems for fully curing the solar cell arrangement 20. In light thereof, the first heating device 310 as described herein can benefit from the positive effects of the vacuum system 710, such as an improved accuracy for holding the solar cell arrangement 20 in place,

without suffering from negative effects that could arise in longer devices, such as an increased friction.

[0075] The first support system 312 may include a conveyor 520, e.g. a belt conveyor, including a plurality of through-holes 720, as shown for example in Fig. 7. The through-holes allow air to pass through the through-holes. The plurality of through-holes 720 may be provided in a belt of the belt conveyor. The plurality of through-holes 720 may allow the solar cell arrangement 720 to be held in place on the conveyor 520 by the under-pressure provided by the vacuum system 710.

[0076] An apparatus according to embodiments described herein may include a positioning device 750 for positioning solar cell pieces on the first support system 312, as shown for example in Fig. 7. The positioning device 750, or at least a portion thereof, may be part of the first heating device 310. The positioning device 750 may be arranged above the first support system 312 of the first heating device 310, particularly above the conveyor 520 of the first heating device 310.

[0077] A positioning device 750, as described herein, may be configured for handling individual solar cell pieces. The positioning device 750 may be configured for placing a first solar cell piece on the first support system 312. The positioning device 750 may be configured for placing a second solar cell piece on the first support system 312 in a manner such that the second solar cell piece overlaps with the first solar cell piece. In a region where the first solar cell piece overlaps with the second solar cell piece, the first solar cell piece or the second solar cell piece may include an adhesive as described herein, e.g. an electrically conductive adhesive. At the time of placing the second solar cell piece on the first support system such as to overlap with the first solar cell piece, the adhesive may be in a liquid or uncured, state, e.g. the adhesive may be a conductive paste. After placing the second solar cell piece on the first support system, the positioning device may place a third solar cell piece on the first support system 312 in a manner such that the third solar cell piece overlaps with the second solar cell piece. The third solar cell piece or the second solar cell piece may include a further adhesive in a region where the third solar cell piece overlaps with the second solar cell piece. At the time of placing the third solar cell piece on the first support system such as to overlap with the second solar cell piece, the further adhesive may be in a liquid or uncured, state. Continuing in this way, the positioning

device 750 may be configured to assemble the solar cell arrangement 20 by sequentially placing individual solar cell pieces on the first support system 312 in an overlapping manner. When the assembling of the solar cell arrangement 20 by the positioning device 750 is completed, the solar cell arrangement may include a string of partially overlapping solar cell pieces, wherein adjacent solar cell pieces are connected by uncured adhesives. By heating the solar cell arrangement 20 in the first heating device 310, the adhesives of the solar cell arrangement can be pre-cured, as described herein.

[0078] In light of the short length of the first heating device 310, as described herein, the space above the first support system 312 may be relatively small. By arranging the one or more heating elements 316 below the receiving area 510 of the first support system 312, the space above the first support system 312 is made available for arranging the positioning device 750, as shown for example in Fig. 7. In contrast, a heating device having a short length for allowing the solar cell arrangement to be pre-cured, and wherein the heating is provided by heating elements arranged above the first support system, such as an array of heating lamps arranged above the first support system, would leave insufficient space above the first support system for arranging a positioning device 750 above the first support system 312. In light thereof, embodiments described herein provide a first heating device 310 having a short length allowing for the solar cell arrangement 20 to be pre-cured by the first heating device 310, combined with the possibility of positioning individual solar cell pieces onto the first support system 312 in order to assemble the solar cell arrangement 20 on the first support system 312.

[0079] An apparatus 100 according to embodiments described herein may include a positioning device 750 for positioning one or more solar cell pieces on the first support system 312. The positioning device 750 may be configured to assemble the solar cell arrangement 20 on the first support system 312.

[0080] The first support system 312 may include an actuator 760, e.g. a motor, connected to the second roller 524 for driving a rotation of the second roller 524, as shown for example in Fig. 7.

[0081] Fig. 8 shows an example of a second heating device 320 of an apparatus according to embodiments as described herein.

[0082] A second heating device 320, as described herein, may include one or more heating elements 326 for heating the solar cell arrangement 20, as shown for example in Fig. 8. The second heating device 320 may be a drying device or curing device. The second heating device 320 may be configured to dry at least a portion of the solar cell arrangement 20. The second heating device 320 may be configured to cure one or more adhesives, as described herein, of the solar arrangement 20.

[0083] The second heating device 320 may include a second support system 322 for supporting the solar cell arrangement 20, as shown for example in Fig. 8. The second support system 322 may be configured for transporting the solar cell arrangement 20 in a transport direction of the second heating device 320. The second support system 322 may include a conveyor 820, e.g. a belt conveyor, for transporting the solar cell arrangement 20. The second support system 322 may be adapted for transporting the solar cell arrangement 20 in a continuous movement, e.g. by a continuous rotation of a conveyor belt.

[0084] The one or more heating elements 326 of the second heating device 320 may be arranged above the second support system 322 of the second heating device 320, as shown for example in Fig. 8. The one or more heating elements 326 may include one or more lamps for heating the solar cell arrangement 20.

[0085] The second support system 322 may have a receiving area 810 for receiving a solar cell arrangement 20, as shown for example in Fig. 8. The receiving area 810 of the second support system 322 may correspond to a total area of the second support system 322 configured for supporting a solar cell arrangement 20. While the solar cell arrangement 20 is heated by the second heating device 320, the solar cell arrangement may be transported from a first end of the receiving area 810 to a second end of the receiving area 810, the second end being opposite the first end. When the solar cell arrangement 20 reaches the second end of the receiving area 810, the heating process by the second heating device 320 may be completed. The length of the receiving area 810 in the transport direction of the second heating device 320 may correspond, or be equal to, the second transportation length 420, as described herein, of the second heating device 320.

[0086] According to a further embodiment, a heating device for heating a solar cell arrangement 20 comprising a plurality of overlapping solar cell pieces is provided. The

heating device includes a first support system 312 for supporting the solar cell arrangement 20. The heating device includes one or more heating elements 316 for heating the solar cell arrangement 20. The heating device is configured to pre-cure the solar cell arrangement 20. The heating device may be the first heating device 310 of the apparatus 100 according to
5 any embodiment described herein.

[0087] The heating device may have a first transportation length 410 in a transport direction of the heating device. The first transportation length 410 may be 2 m or less, particularly 1 m or less. For example, the first transportation length may be 800 mm.

[0088] According to a further embodiment, a heating device for heating a solar cell arrangement 20 comprising a plurality of overlapping solar cell pieces is provided. The heating device includes a conveyor 520 for transporting the solar cell arrangement 20 in a transport direction. The conveyor 520 defines a receiving area 510 for receiving the solar cell arrangement 20 on the conveyor 520. The heating device includes one or more heating elements 316 for heating the solar cell arrangement 20, the one or more heating elements
10 316 being arranged below the receiving area 510. The heating device includes a vacuum system 710 for holding the solar cell arrangement 20 on the conveyor 520. The heating device has a first transportation length 410 in the transport direction of 2 m or less. The heating device may be the first heating device 310 of the apparatus 100 according to any embodiment described herein.
15

[0089] According to another embodiment, and as illustrated in Fig. 9, a method 900 for processing a solar cell arrangement 20 including a plurality of overlapping solar cell pieces is provided. As indicated by block 910 in Fig. 9, the method includes pre-curing the solar cell arrangement 20 by a first heating device 310 as described herein. As indicated by block 920, the method includes curing the pre-cured solar cell arrangement by a second
20 heating device 320 as described herein.
25

[0090] The apparatus 100 according to embodiments described herein may be adapted to carry out the method according to embodiments described herein.

[0091] Pre-curing the solar cell arrangement 20 may include transporting the solar cell arrangement 20 over a first transportation length 410 while heating the solar cell arrangement.

5 [0092] Curing the solar cell arrangement 20 may include transporting the solar cell arrangement 20 over a second transportation length 420 while heating the solar cell arrangement 20.

[0093] The first transportation length 410 may be shorter than the second transportation length 420. The first transportation length may be 50% or less, particularly 40% or less, of the second transportation length.

10 [0094] Pre-curing the solar cell arrangement 20 may include heating the solar cell arrangement 20 by one or more heating elements 316 arranged below the solar cell arrangement.

[0095] The first heating device 310 may include a first support system 312 as described herein for transporting the solar cell arrangement 20. The method may include holding the
15 solar cell arrangement 20 on the first support system 312 by a vacuum system 710 as described herein.

[0096] The solar cell arrangement may include a first solar cell piece. The solar cell arrangement may include a second solar cell piece. The solar cell arrangement may include an adhesive connecting the first solar cell piece to the second solar cell piece.

20 [0097] Pre-curing the solar cell arrangement 20 may include pre-curing the adhesive. Additionally or alternatively, curing of the solar cell arrangement 20 may include curing the adhesive.

[0098] The method may include assembling the solar cell arrangement 20 on a first support system 312, e.g. a belt conveyor, of the first heating device 310. Assembling the
25 solar cell arrangement 20 may include placing a first solar cell piece on the first support system 312. Assembling the solar cell arrangement 20 may include placing a second solar cell piece on the first support system 312 in a manner such that the second solar cell piece overlaps with the first solar cell piece. In a region where the first solar cell piece overlaps

with the second solar cell piece, the first solar cell piece or the second solar cell piece may include an adhesive as described herein, e.g. an electrically conductive adhesive, for connecting the first solar cell piece to the second cell piece. At the time of placing the second solar cell piece on the first support system 312 such as to overlap with the first
5 solar cell piece, the adhesive may be in a liquid or uncured state, e.g. the adhesive may be a conductive paste. Assembling the solar cell arrangement 20 may include placing a plurality of individual solar cell pieces one after the other on the first support system 312 such that adjacent solar cell pieces overlap with each other.

[0099] While the foregoing is directed to embodiments of the disclosure, other and
10 further embodiments of the disclosure may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

CLAIMS

1. An apparatus (100) for processing a solar cell arrangement (20) comprising a plurality of overlapping solar cell pieces (10a, 10b, 10c, 10d, 10), the apparatus comprising:

a first heating device (310) for pre-curing the solar cell arrangement; and

5 a second heating device (320) for curing the solar cell arrangement, the second heating device being arranged downstream of the first heating device relative to a processing direction (1) of the apparatus.

2. The apparatus of claim 1, wherein the first heating device comprises a first support
10 system (312) for supporting the solar cell arrangement and the second heating device comprises a second support system (322) for supporting the solar cell arrangement.

3. The apparatus according to claim 2, wherein the first heating device has a first
15 transportation length (410) in a transport direction (314) of the first heating device, the first support system being configured to transport the solar cell arrangement over the first transportation length,

wherein the second heating device has a second transportation length (420) in a
transport direction (324) of the second heating device, the second support system being
configured to transport the solar cell arrangement over the second transportation length,

20

wherein the first transportation length is shorter than the second transportation
length, particularly wherein the first transportation length is 50% or less of the second
transportation length.

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4. The apparatus according to claim 2 or claim 3, wherein the first support system has a
receiving area (510) for receiving the solar cell arrangement, the first heating device
comprising one or more heating elements (316) for heating the solar cell arrangement, the
one or more heating elements being arranged below the receiving area.

5. The apparatus according to any of claims 2 to 4, wherein the first heating device comprises a vacuum system (710) for holding the solar cell arrangement on the first support system.

5

6. The apparatus according to any of claims 2 to 5, the apparatus further comprising a positioning device (750) for positioning one or more solar cell pieces on the first support system, the positioning device being configured to assemble the solar cell arrangement on the first support system.

10

7. The apparatus according to any of the preceding claims, wherein the solar cell arrangement comprises a first solar cell piece (10a), a second solar cell piece (10b) and an adhesive (5a, 5) connecting the first solar cell piece to the second solar cell piece, the first heating device being configured to pre-cure the adhesive, the second heating device being configured to cure the adhesive.

15

8. A heating device (310) for heating a solar cell arrangement (20) comprising a plurality of overlapping solar cell pieces, the heating device comprising:
a first support system (312) for supporting the solar cell arrangement; and
one or more heating elements (316) for heating the solar cell arrangement,
the heating device being configured to pre-cure the solar cell arrangement.

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9. The heating device according to claim 8, wherein the heating device has a first transportation length (410) in a transport direction (314) of the heating device, the first transportation length being 2 m or less.

30

10. A heating device (310) for heating a solar cell arrangement (20) comprising a plurality of overlapping solar cell pieces, the heating device comprising:

5 a conveyor (520) for transporting the solar cell arrangement in a transport direction (314), the conveyor defining a receiving area (510) for receiving the solar cell arrangement on the conveyor;

one or more heating elements (316) for heating the solar cell arrangement, the one or more heating elements being arranged below the receiving area; and

a vacuum system (710) for holding the solar cell arrangement on the conveyor,

10 the heating device having a first transportation length (410) in the transport direction of 2 m or less.

11. A method for processing a solar cell arrangement (20) comprising a plurality of overlapping solar cell pieces, the method comprising:

15 pre-curing the solar cell arrangement by a first heating device (310); and

curing the pre-cured solar cell arrangement by a second heating device (320).

12. The method according to claim 11, wherein the pre-curing of the solar cell arrangement
20 comprises transporting the solar cell arrangement over a first transportation length (410) while heating the solar cell arrangement,

wherein the curing of the solar cell arrangement comprises transporting the solar cell arrangement over a second transportation length (420) while heating the solar cell arrangement,

25 wherein the first transportation length is shorter than the second transportation length, particularly wherein the first transportation length is 50% or less of the second transportation length.

13. The method according to claim 11 or claim 12, wherein the pre-curing of the solar cell
30 arrangement comprises heating the solar cell arrangement by one or more heating elements (316) arranged below the solar cell arrangement.

14. The method according to any of claims 11 to 13, wherein the first heating device comprises a first support system (312) for transporting the solar cell arrangement, the method further comprising holding the solar cell arrangement on the support system by a
5 vacuum system (710).

15. The method according to any of claims 11 to 14, wherein the solar cell arrangement comprises a first solar cell piece (10a), a second solar cell piece (10b) and an adhesive (5, 5a) connecting the first solar cell piece to the second solar cell piece,

10 wherein the pre-curing of the solar cell arrangement comprises pre-curing the adhesive and/or wherein the curing of the solar cell arrangement comprises curing the adhesive.

15

20

Fig. 1

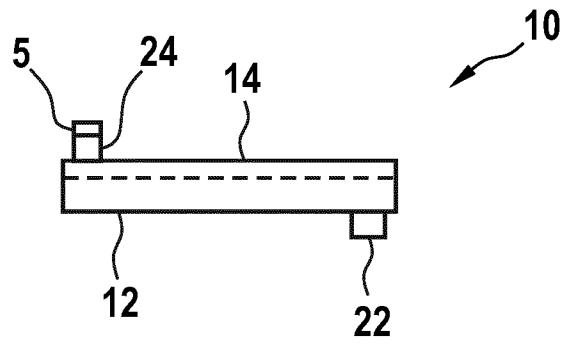


Fig. 2

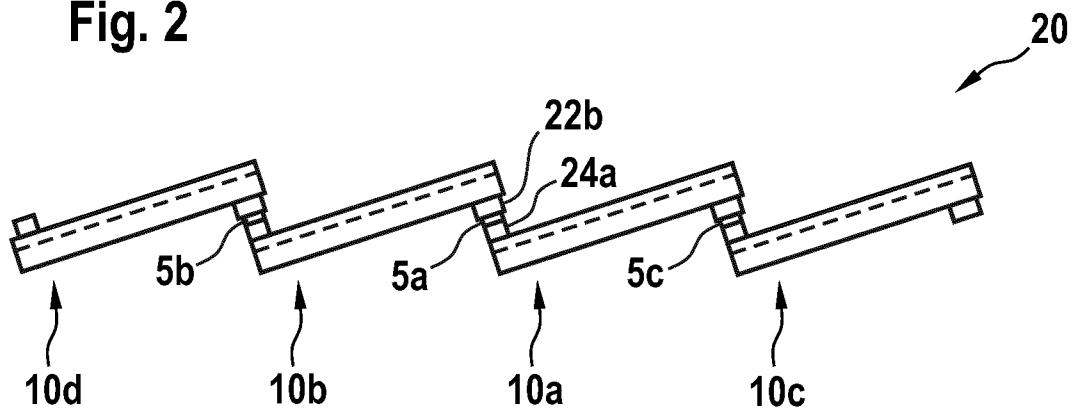


Fig. 3a

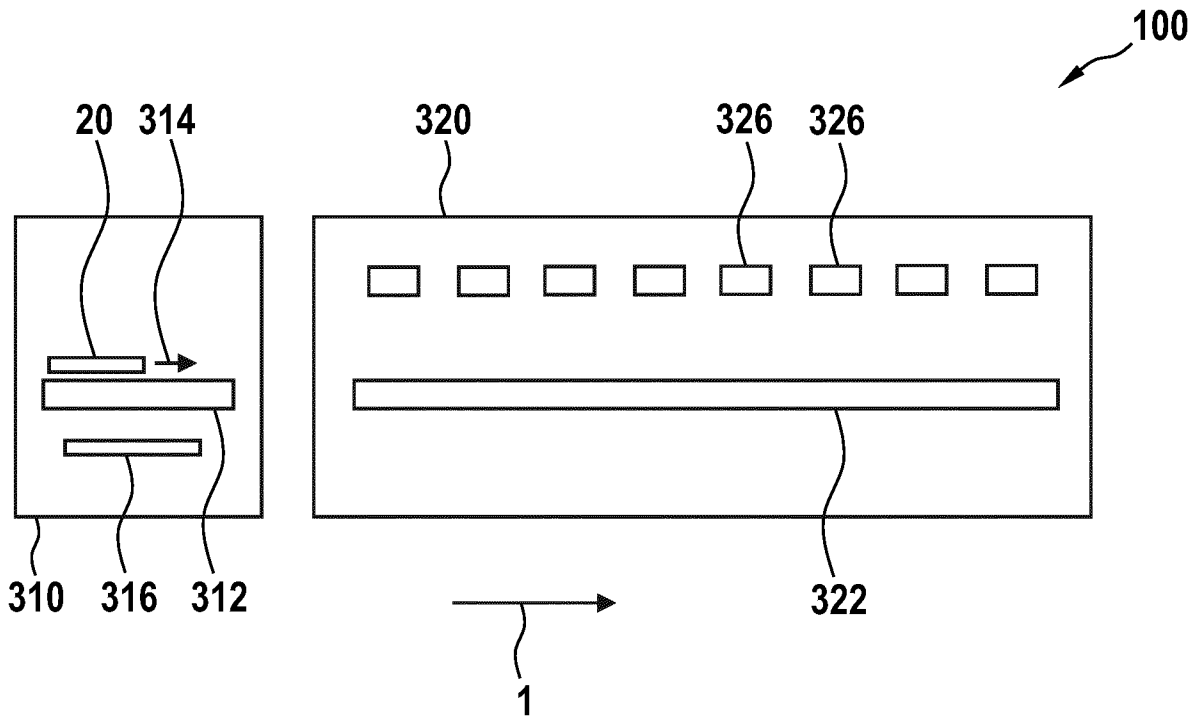


Fig. 3b

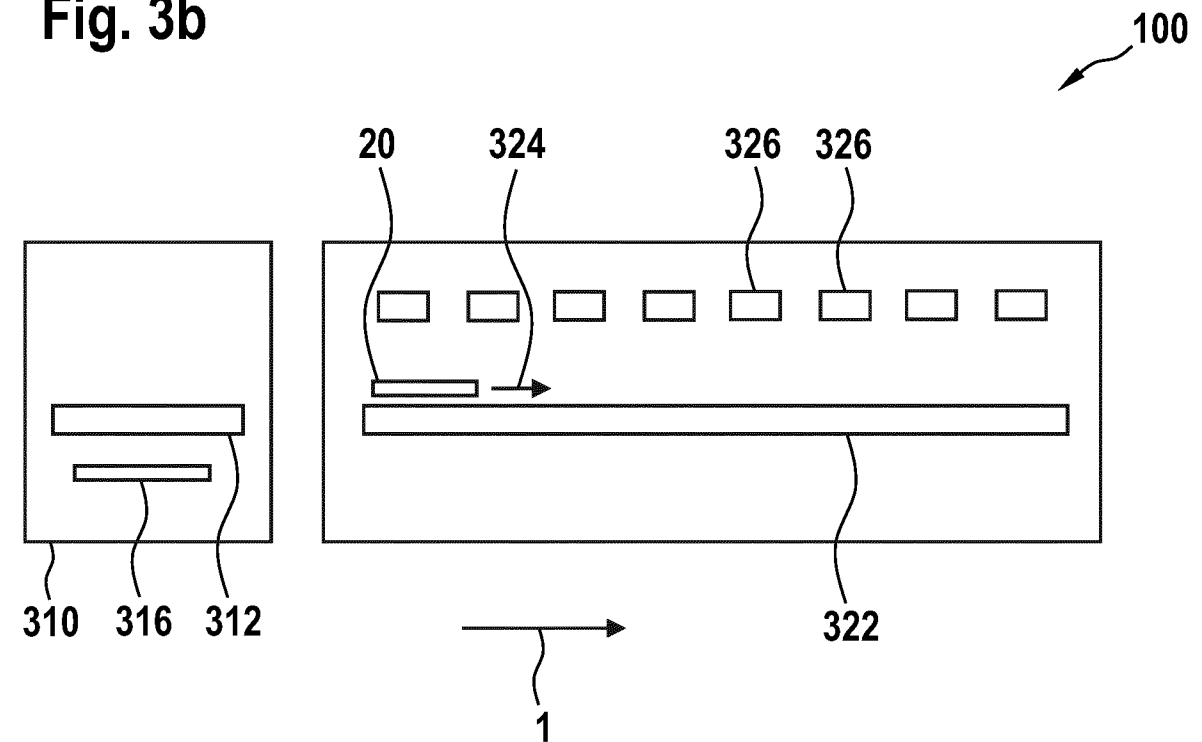


Fig. 4

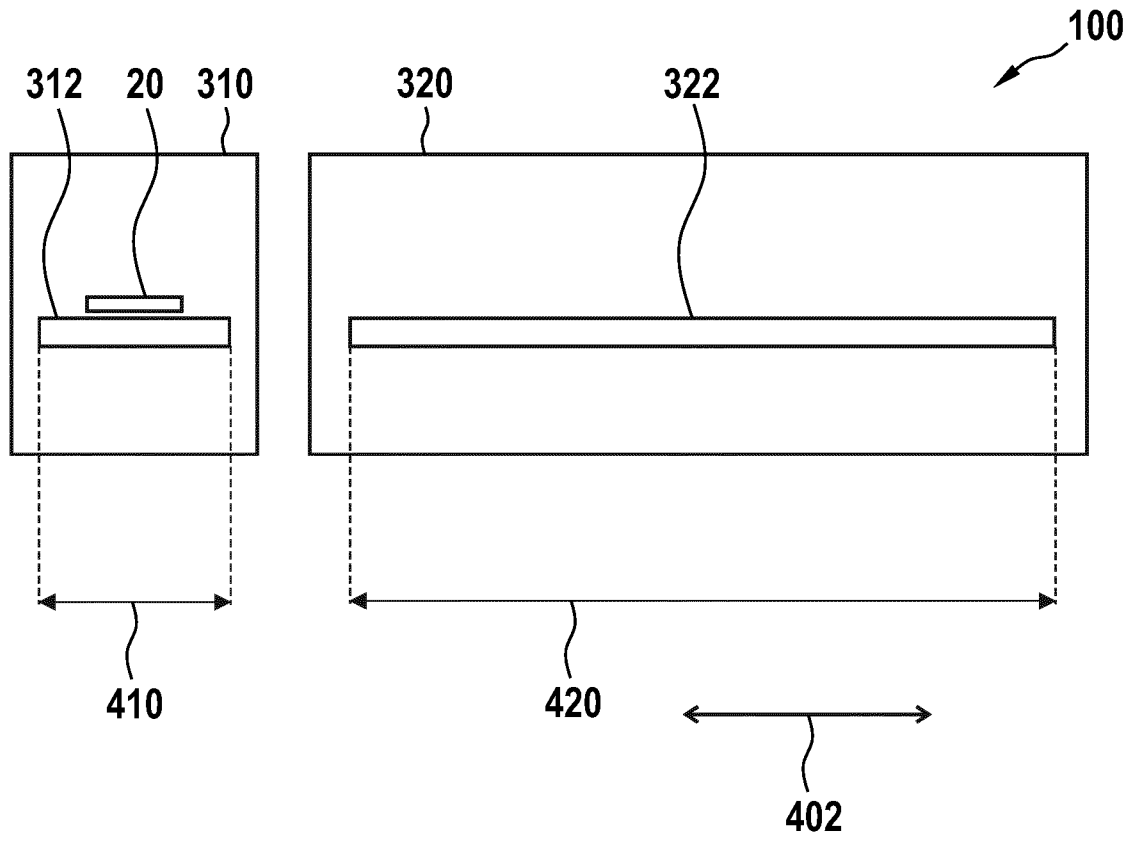


Fig. 5

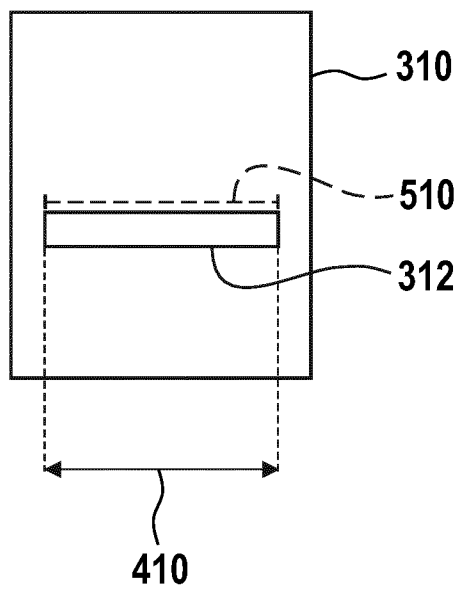


Fig. 6

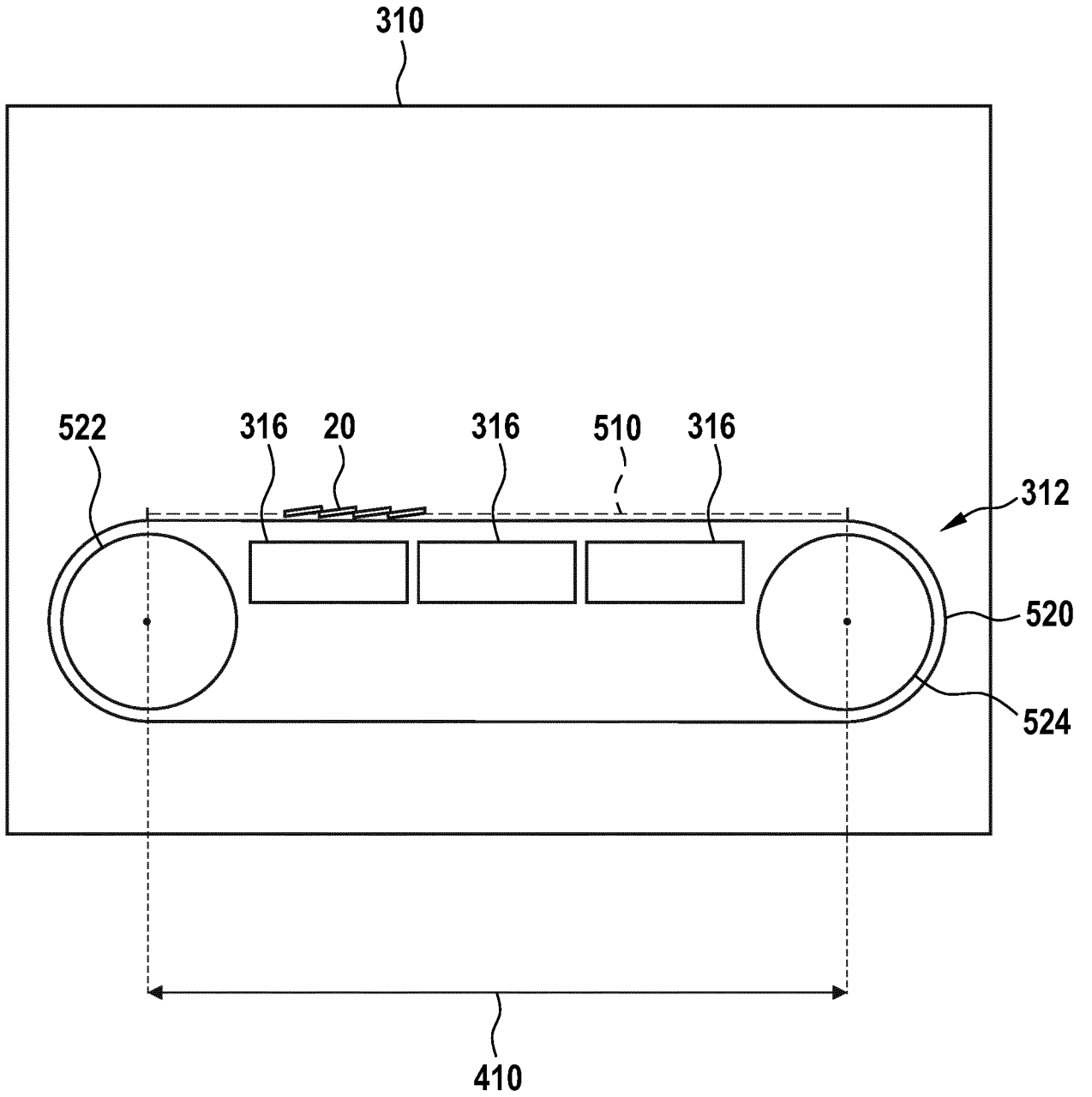


Fig. 7

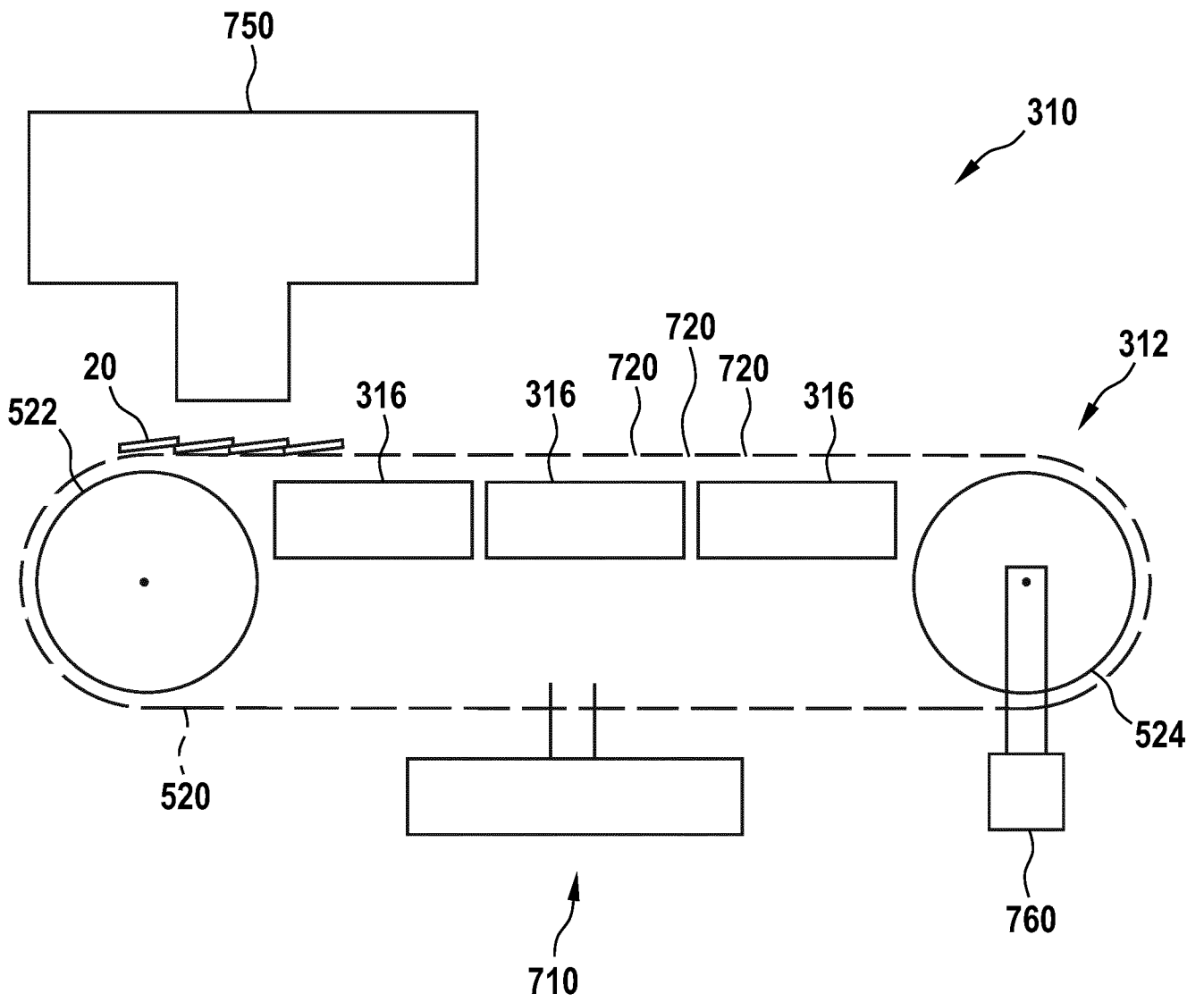
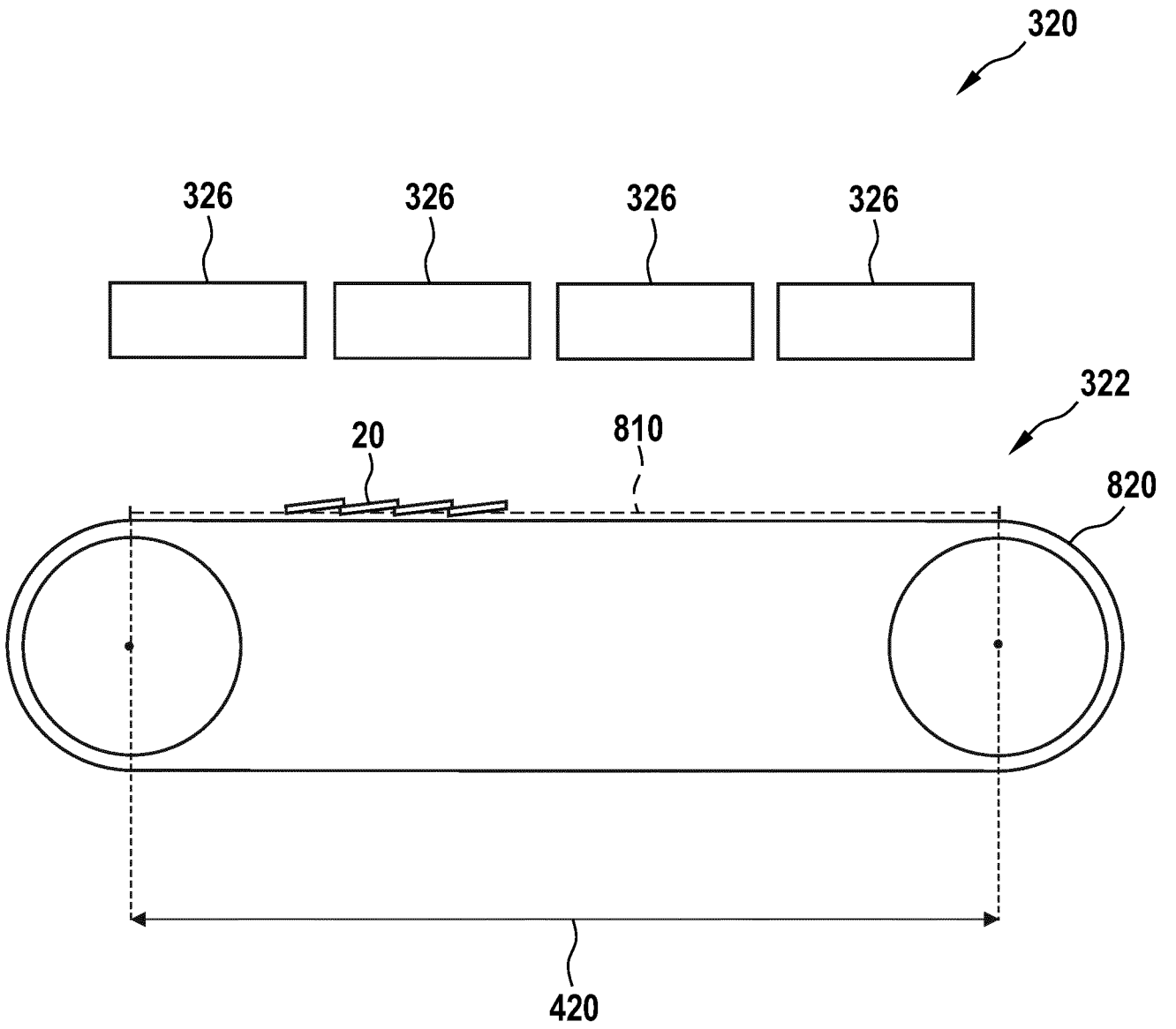
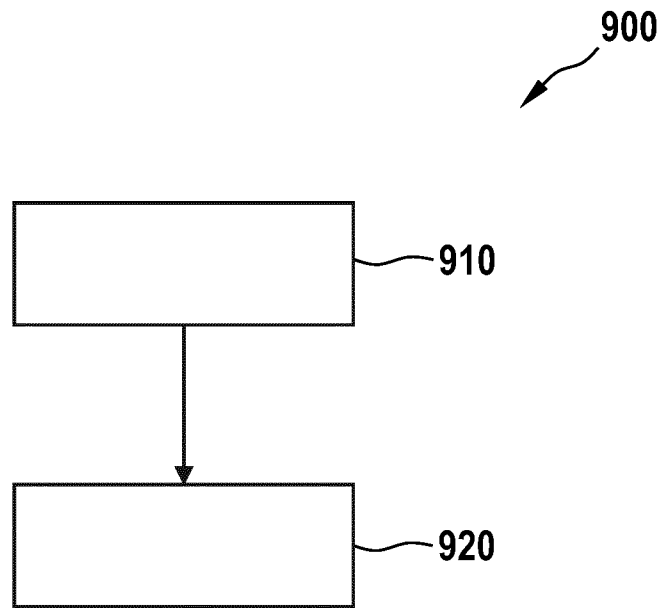


Fig. 8



7 / 7

Fig. 9



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/074601

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L31/18
ADD.

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

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
H01L

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003/127124 A1 (JONES BERNARD D [US] ET AL) 10 July 2003 (2003-07-10) paragraphs [0077], [0103] - [0104] -----	1-15
X	US 2013/048047 A1 (FUJII TAKAHIRO [JP] ET AL) 28 February 2013 (2013-02-28) paragraph [0048] - paragraph [0059]; figures 4,5 -----	1-15
A	EP 1 291 929 A1 (STRELA GMBH [CH]) 12 March 2003 (2003-03-12) paragraph [0015] - paragraph [0025]; figures 1-5 -----	1-15

Further documents are listed in the continuation of Box C.

See patent family annex.

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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

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Date of the actual completion of the international search 26 June 2019	Date of mailing of the international search report 02/07/2019
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Stirn, Jean-Pierre

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2018/074601

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