



(51) International Patent Classification:

*B65G 49/06* (2006.01)    *H01L 21/67* (2006.01)  
*C23C 14/50* (2006.01)    *H01L 21/677* (2006.01)  
*C23C 14/56* (2006.01)

(21) International Application Number:

PCT/EP2012/067659

(22) International Filing Date:

10 September 2012 (10.09.2012)

(25) Filing Language:

English

(26) Publication Language:

English

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: SUBSTRATE TRANSFER DEVICE AND METHOD OF MOVING SUBSTRATES

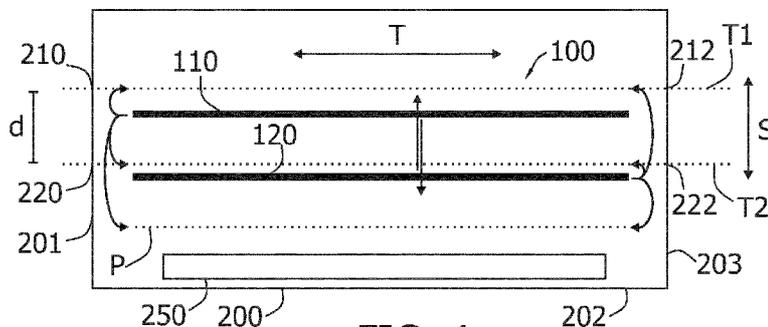


FIG. 4

(57) Abstract: A transfer device is provided for substrate transfer along a transport direction and for change between a first transport path and a second transport path extending along the transport direction. The first transport path is displaced with respect to the second transport path in a switch direction perpendicular to the transport direction. The transfer device includes a first substrate support assembly defining a first track to support a substrate or substrate carrier in a chamber. The transfer device further includes a second substrate support assembly defining a second track to support a substrate or substrate carrier in the chamber. The first substrate support assembly and the second substrate support assembly are moveable relative to each other at least in the switch direction.

WO 2014/037058 A1

## **SUBSTRATE TRANSFER DEVICE AND METHOD OF MOVING SUBSTRATES**

### **FIELD OF THE INVENTION**

[0001] Embodiments of the present invention relate to transfer devices for substrate transfer and to methods of moving substrates in a substrate processing system. Specifically, some embodiments relate to a transfer device for substrate transfer along a transport direction and for moving substrates perpendicularly thereto for aligning them alternatively with a first transport path and a second transport path extending along the transport direction. More specifically, some embodiments relate to a transfer device in a vacuum chamber of a substrate processing system for transferring substantially vertically oriented substrates.

### **BACKGROUND OF THE INVENTION**

[0002] In a number of technical applications, e.g., TFT metallization processes, layers of different materials are deposited onto each other over a substrate. Typically, this is done in a sequence of coating or deposition steps, e.g., sputtering steps, wherein other processing steps like etching or structuring might also be provided before, between, or after the various deposition steps. For example, a multi-layer stack with a sequence of “material one”-“material two”-“material one” can be deposited. Due to different coating rates in different process steps and due to different thicknesses of the layers, the processing time in the processing chambers for depositing different layers may vary considerably.

[0003] In order to deposit a multiple layer stack, a number of configurations of processing chambers can be provided. For example, in-line arrangements of deposition chambers can be used as well as cluster arrangements of deposition chambers. A typical cluster arrangement comprises a central handling chamber and a number of processing or deposition chambers connected thereto. The coating chambers may be equipped to carry out the same or different processes. A typical in-line system includes a number of subsequent processing chambers, wherein processing steps are conducted in one chamber after the other such that a plurality of substrates can continuously or quasi-continuously be processed with the in-line system.

[0004] Cluster tools allow for different cycle times but the handling of substrates may be quite complex, requiring a complicated transfer system provided in the central handling chamber. The processing tact in in-line systems is typically determined by the longest processing time. Two transport paths may be provided so that a first substrate may overtake a second substrate that is being coated. If a change from one transport path to the other is required for a certain process conduct a handling device may be used to transfer the substrate, or a substrate carrier holding the substrate, from one path to the other. However, hooking up the substrate or carrier can cause undesired generation of particles due to the mechanical contact. The handling device also needs additional tact time, so process efficiency is lowered.

#### SUMMARY

[0005] In light of the above, an apparatus and a method according to the independent claims are provided. Further details can be found in the dependent claims, the description, and the drawings.

[0006] According to one embodiment, a transfer device is provided for substrate transfer along a transport direction and for change between a first transport path and a second transport path extending along the transport direction. The first transport path is displaced with respect to the second transport path in a switch direction perpendicular to the transport direction. The transfer device includes a first substrate support assembly defining a first track to support a substrate or substrate carrier in a chamber. The transfer device further includes a second substrate support assembly defining a second track to support a substrate or substrate carrier in the chamber. The first substrate support assembly and the second substrate support assembly are moveable relative to each other at least in the switch direction.

[0007] According to another embodiment, a chamber for a substrate processing system is provided. The chamber includes at least one first substrate transfer port for substrate transfer into our out of the chamber along a first transport path, and at least one second substrate transfer port for substrate transferring into our out of the chamber along a second transport path. The chamber further includes a transfer device arranged in the chamber, the transfer device being configured for substrate transfer along a transport direction and for change between a first transport path and a second transport

path extending along the transport direction. The first transport path is displaced with respect to the second transport path in a switch direction perpendicular to the transport direction. The transfer device includes a first substrate support assembly defining a first track to support a substrate or substrate carrier in a chamber. The transfer device further includes a second substrate support assembly defining a second track to support a substrate or substrate carrier in the chamber. The first substrate support assembly and the second substrate support assembly are moveable relative to each other at least in the switch direction.

[0008] According to a further embodiment, a method of moving a substrate in a substrate processing system is provided. The method includes transferring the substrate into a chamber along a first transport path, and moving the substrate in the chamber at least in a switch direction perpendicular to the first transport path. The method further includes moving support elements of an empty substrate support assembly in the chamber. The substrate and the support elements of the empty substrate support assembly are moved relatively to each other in the switch direction and pass each other.

[0009] The disclosure is also directed to an apparatus for carrying out the disclosed methods, including apparatus parts for performing each of the described method steps. These method steps 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, the invention is also directed to methods by which the described apparatus operates or is manufactured. It includes method steps for carrying out every function of the apparatus.

## **BRIEF DESCRIPTION OF THE DRAWINGS**

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

Figs. 1-2 show schematic illustrations of transfer devices for substrate transfer according to embodiments described herein;

- Figs. 3-4 show schematic illustrations of a chamber including a transfer device according to embodiments described herein;
- Figs. 5-8 illustrate embodiments of a transfer system described herein and illustrate embodiments of a method of moving a substrate described herein;
- Fig. 9 shows a transfer device in a chamber according to embodiments described herein;
- Figs. 10-13 show substrate support elements of a transfer device according to embodiments described herein;
- Figs. 14-19 show substrate support elements of a transfer device according to embodiments described herein; and
- Fig. 20 is a block diagram illustrating a method of moving a substrate according to embodiments described herein.

## **DETAILED DESCRIPTION OF THE INVENTION**

[0011] Reference will now be made in detail to the various exemplary embodiments, one or more examples of which are illustrated in each figure. Each example is provided by way of explanation and is not meant as a limitation. For example, features illustrated or described as part of one embodiment can be used on or in conjunction with other embodiments to yield yet further embodiments. It is intended that the present disclosure includes such modifications and variations.

[0012] Within the following description of the drawings, the same reference numbers refer to the same or similar components. Generally, only the differences with respect to the individual embodiments are described. The structures shown in the drawings are not necessarily depicted true to scale or angle, and may exaggerate features for a better understanding of the corresponding embodiments.

[0013] The term “direction” as used herein is not limited to the meaning of a vectored direction (“from A to B”), but includes both vectored directions in which a straight

line can be followed (“from A to B” and “from B to A”). For example, the vertical direction shall include both the notions of up and down. Directions are therefore indicated by arrows with two arrow heads in the drawings.

[0014] The term “substrate” as used herein shall embrace substrates, such as glass substrates. Thereby, the substrates are typically large area substrates with a size of 1.4 m<sup>2</sup> and above, typically 5 m<sup>2</sup> and above. For example, substrate sizes of 1.43 m<sup>2</sup> (Gen5) and above, such as 5.5 m<sup>2</sup> (Gen8.5), 9 m<sup>2</sup> (Gen10) or larger can be realized.

[0015] Typically, the substrates are vertically oriented or substantially vertically oriented. Thereby, it is to be understood that a substantially vertically oriented substrate can have some deviation from a vertical orientation in a processing system in order to allow for stable transport with an inclination by a few degrees, e.g., at most 15° or at most 10°, e.g., from 5° to 7° or less. The substrates are then said to be substantially or essentially vertically oriented. A substrate is substantially vertically oriented if the normal to its largest surfaces (front and back surfaces) is substantially horizontally oriented, i.e., the normal has a tilt of at most a few degrees, e.g., at most 15° or at most 10°, e.g., from 5° to 7° or less. At least one of the largest surfaces, i.e., at least one of the front and back surfaces, is typically coated in substrate processing systems in which a substrate transfer device according to embodiments described herein may be used. A substantially horizontally oriented substrate has a normal to its largest surfaces that is tilted at most a few degrees from the vertical direction, such as at most 15° or at most 10°, such as from 5° to 7° or less.

[0016] According to an embodiment, a transfer device is provided. The transfer device is configured for substrate transfer. It may be called a substrate transfer device. The transfer device may be configured for transferring substantially vertically oriented substrates. The transfer device may alternatively be configured for transferring substantially horizontally oriented substrates, e.g., for sputter up or sputter down processing.

[0017] The substrates may be large-area substrates, e.g., glass substrates of Gen5 and higher, or even Gen8 and higher. Substrate transfer with substantially vertical orientation is particularly advantageous for large-area substrates. The problem of particle generation due to handling systems is more pronounced for vertically oriented substrates since particles generated at the top of the substrate due to handling may fall onto the substrate. A transfer device according to embodiments described herein is

therefore particularly advantageous for transfer of substantially vertically oriented substrates.

[0018] The transfer device may be adapted to be arranged in a chamber of a substrate processing system, e.g., in a processing chamber, a transfer chamber, a lock chamber, or a swing module. Typically, the chambers are vacuum chambers. The substrate processing system may be an in-line substrate processing system or may at least partly be an in-line substrate processing system. The substrate processing system may be a system including vacuum deposition chambers for depositing layers onto substrates, e.g., sputter chambers. The substrate processing system may be a system for TFT metallization processes. In-line processing systems typically provide a sequence of chambers for depositing a sequence of layers. Thereby, one layer after the other is deposited in one chamber after the other. For example, a thin layer of molybdenum can be deposited over a substrate, subsequently a thick layer of aluminum is deposited over the molybdenum layer and a further thin layer of molybdenum is deposited over the aluminum layer.

[0019] The transfer device is configured for substrate transfer along a transport direction. The transfer device is further configured for change between a first transport path and a second transport path. In a change between the first and second transport path, a substrate or substrate carrier is moved from the first to the second transport path or vice versa. The first transport path and the second transport path extend along the transport direction. The first transport path and the second transport path are displaced with respect to each other in a switch direction. The switch direction is perpendicular to the transport direction.

[0020] The transfer device includes a first substrate support assembly and a second substrate support assembly. The first substrate support assembly defines a first track to support a substrate or substrate carrier in a chamber. The second substrate support assembly defines a second track to support a substrate or substrate carrier in the same chamber. A track is the space defined by a substrate support assembly that can support a substrate or substrate carrier.

[0021] Sometimes, a substrate or substrate carrier with vertical orientation is said to stand on or be placed on a track even though the substrate or substrate carrier may not only be supported from below, but may also be supported, e.g., held and/or guided, from above at the same time. A single substrate support assembly shall not be

construed as an object simultaneously supporting several substrates or substrate carriers on different transport paths or as an object arranged in several chambers. One substrate support assembly might support more than one substrate or substrate carrier if more than one substrate or substrate carrier should fit in the track defined by the substrate support assembly, but typically supports only one substrate or substrate carrier.

[0022] The first substrate support assembly and the second substrate support assembly are moveable relative to each other at least in the switch direction. A relative movement of the first and second substrate support assemblies relative to each other in the switch direction includes the cases that only the first substrate support assembly is moved in the switch direction, that only the second substrate support assembly is moved in the switch direction, that both substrate support assemblies are moved in the switch direction opposite to each other, or that both substrate support assemblies are moved in the switch direction in the same vectored direction, but at different speeds.

[0023] Fig. 1 shows a schematic illustration of a transfer device 100 according to an embodiment. The transfer device 100 is adapted to transfer substrates or substrate carriers along a first transport path T1 and along a second transport path T2 in a transport direction T. The transport paths T1 and T2 are separated by a distance d from each other in a switch direction S that is perpendicular to the transport direction T. The transfer device 100 includes a first substrate support assembly 110 and a second substrate support assembly 120. These substrate support assemblies are moveable relatively to each other in the switch direction S as indicated by the double-headed arrow between them.

[0024] In particular, when a substrate or substrate carrier is being supported by a track defined by one of the first and second substrate support assemblies, the substrate or substrate carrier can be moved together with said substrate support assembly in the switch direction. This situation may be called a substrate movement on or in the track that is supporting the substrate or substrate carrier. Sometimes it is called movement of a non-empty track or movement of a carrier supporting track or movement of substrate supporting track. The substrate or substrate carrier, when moved in the switch direction with the substrate support assembly, does not leave the track that is currently supporting it. No separate substrate handling device is needed that hooks up the substrate or substrate carrier and moves it from one track to the other. The risk of

producing particles that may disturb subsequent substrate processing is greatly reduced. Further, there is an improvement in the tact time since no extra tact time required by a substrate handling device is needed.

[0025] Further, in particular when the transfer device is arranged in a substrate processing chamber, the capability of relative movement of the substrate support assemblies in the switch direction allows to save space in the processing region where deposition of layers onto the substrate takes place, e.g., as compared to the transferring means of WO 2009/156196 A1 with a rigidly connected, space consuming combination of three tracks. The content of WO 2009/156196 A1 is incorporated herein by reference in as far as it is compatible with the content of the present disclosure. The capability of relative movement also increases the flexibility with respect to process conduct, therefore possibly allowing improved conduct of substrate processing with reduced tact times.

[0026] Fig. 1 can represent both a transfer device for transferring vertically oriented substrates and a transfer device for transferring horizontally oriented substrates. For vertically oriented substrates, Fig. 1 would show a top view. The vertical direction would be into and out of the plane of drawing, the transport paths along the transport direction would be in a first horizontal direction, and the switch direction S would be in a second horizontal direction perpendicular to the first horizontal direction. For horizontally oriented substrates, Fig. 1 would show a side view. The switch direction would be the vertical direction, and the transport direction would a horizontal direction.

[0027] According to some embodiments, the first substrate support assembly may be moveable in the switch direction. The second substrate support assembly may be moveable in the switch direction. The first and second substrate support assemblies may be moveable in the switch direction independently of each other. The first substrate support assembly may be moveable in the switch direction so that the first track, defined by the first substrate support assembly, can be aligned with the first transport path, and can be aligned also with the second transport path at a different time. In other words, the first track is alignable with the first transport path and alternatively with the second transport path. The second substrate support assembly may be moveable in the switch direction so that the second track, defined by the second substrate support assembly, can be aligned with the second transport path, and

can be aligned also with the second transport path at a different time. In other words, the second track is alignable with the second transport path and alternatively with the second transport path.

[0028] The first substrate support assembly and the second substrate support assembly may be moveable relative to each other such that the first track and the second track pass each other in the switch direction. Passing each other means the following. Let X be a plane having a normal that is parallel to the normal of the first and second tracks, where the plane X is not lying between the substrate support assemblies and therefore not between the tracks when viewed in the switch direction. If, at one point in time, the first substrate support assembly (and therefore the first track) is closer to the plane X measured in the switch direction than the second substrate support assembly (and therefore the second track), then the proximity relation is inverted after the first and second substrate support assemblies and therefore the first and second tracks have passed each other. After passing, the second substrate support assembly (and therefore the second track) is closer to the plane X measured in the switch direction than the first substrate support assembly (and therefore the first track). For illustration consider the plane containing the chamber wall 202 of chamber 200 in Fig. 4. The second substrate support assembly 120 and the second track are closer to the wall 202 in the switch direction S than the first substrate support assembly 110 and the first track. When the substrate support assemblies 110, 120 and therefore the first and second tracks pass each other, the first substrate support assembly 110 and the first track will be closer to the chamber wall 202 than the second substrate support assembly 120 and the second track.

[0029] Passing may also be referred to as switching. The direction of relative movement is therefore called switching direction herein. Switching does not necessarily imply that the first track occupies the former position of the second track and vice versa. The first and second substrate support assemblies may exchange their mutual positions, so that the corresponding tracks are exchanged, but this need not necessarily be the case.

[0030] Fig. 2 illustrates alignment and passing. Substrate support assembly 110 has the option to be aligned with the first transport path T1, and has the option to be aligned with the second transport path T2 as indicated by the curved arrows to the left of substrate support assembly 110. The second substrate support assembly 120 also

has the option to be aligned with the first transport path T1, and has the option to be aligned with the second transport path T2 as indicated by the curved arrows to the right of the second substrate support assembly 120. The first substrate support assembly 110 can pass the second substrate support assembly 120, and vice versa, as indicated by the two opposing arrows in the middle of the figure.

[0031] According to further embodiments, a chamber for a substrate processing system is provided, e.g., a processing chamber, transfer chamber, lock chamber, or swing module. The chamber may be a vacuum chamber. The chamber may be a vacuum deposition chamber, e.g., a sputter chamber. The chamber may include at least one substrate transfer port for substrate transfer into or out of the chamber along a transportation path. The transfer port or transfer ports may be configured to allow transfer of substrates therethrough without breaking a vacuum in the chamber. The chamber includes a transfer device for substrate transfer according to any of the embodiments described herein.

[0032] Fig. 3 shows a chamber 200 in which transfer device 100 is arranged. The chamber 200 includes a first substrate transfer port 210 at the position where the first transport path T1 crosses the chamber wall 201, and includes a second substrate transfer port 220 at the position where the second transport path T2 crosses the chamber wall 201. In Fig. 3, the first and second transport paths terminate in the chamber 200. Chamber 200 may, e.g., be the first or last chamber in an in-line substrate processing system. Transport paths T1 and T2 cross the chamber wall opposite chamber wall 201 in other embodiments, and there are further substrate transfer ports in these embodiments.

[0033] Fig. 4 shows an embodiment of chamber 200 which is configured as a substrate processing chamber. The chamber 200 includes a transfer device 100, a first substrate transfer port 210 for transferring substrates into or out of the chamber 200 along the first transport path T1, another first substrate transfer port 212 for transferring substrates into or out of the chamber 200 along the first transport path T1, a second substrate transfer port 220 for transferring substrates into or out of the chamber 200 along the second transport path T2, and another second substrate transfer port 222 for transferring substrates into or out of the chamber 200 along the second transport path T2. The chamber also includes a deposition source 250, e.g., a sputter cathode, for depositing a layer onto a substrate. A substrate processing position P is shown into

which a substrate or substrate carrier is moved for coating the substrate. The processing position is typically parallel to the transport paths and different therefrom. Alternatively, the processing position might coincide with a section of one of the transport paths in the chamber, e.g., transport path T2.

[0034] Substrate support assemblies of transfer devices according to embodiments described herein may be alignable with the first and second transport paths and with the substrate processing position. For the first substrate support assembly 110 this is indicated by the three curved arrows to the left of the substrate support assembly 110, and for the second substrate support assembly 120 this is indicated by the three curved arrows to the right of the substrate support assembly 120. The first and second substrate support assemblies 110, 120 may pass each other as indicated by the two opposing arrows in the middle of the figure, so that they can be individually aligned with the first and second transport paths T1, T2 and with the processing position P. The current positions of the substrate support assemblies shown in Figs. 1-4 are randomly chosen simply for illustration.

[0035] The first substrate support assembly may include first support elements, and the second substrate support assembly may include second support elements. Support elements may generally include sets of mechanical and/or magnetic support elements. Mechanical support elements can be, e.g., rollers, belts or mechanical guiding elements such as clamps or grippers. Magnetic support elements can be, e.g., magnetic guiding elements. Support elements are configured to support substrates or substrate carriers, e.g., to hold and/or guide the substrates or substrate carriers. Some support elements may be connected to a drive or a drive system. Driven support elements, e.g., driven rollers or driven belts on which a substrate or substrate carrier stands, can impart motion to the substrate or substrate carrier in the transport direction to perform substrate transfer or aid in substrate transfer.

[0036] A substrate support assembly may include any number and type of support elements suitable to define a track for substrate support. For example, a substrate support assembly may include a belt and/or 2-20 rollers, typically 2-10 rollers, e.g., 3 or 5 rollers. The transfer device may include additional static support elements such as static rollers that will be described further below. The substrate support assembly may additionally or alternatively include 1-20 magnetic support elements, typically 2-10, more typically 5 to 9 magnetic support elements. For processing of vertically oriented

substrates, the rollers and/or belt(s) may be arranged to support a bottom part of a substrate or substrate carrier. The rollers may carry the substrate or substrate carrier. The rollers or belt(s) may at least partly be driven rollers or driven belt(s), allowing active substrate movement in the transport direction. Rollers or other mechanical support elements that contact the substrate or substrate carrier are advantageously arranged at the bottom part of the substrate or substrate carrier. Particles generated due to the mechanical contact will not fall onto the substrate in this case. The magnetic support elements may be arranged to support a top part of the substrate or substrate carrier by magnetic forces. The magnetic support elements may be magnetic guiding elements to guide the top part of the substrate or substrate carrier while the substrate or substrate carrier is carried, and possibly moved, by the rollers. Magnetic support elements at least at the top part of a substrate or substrate carrier allow contactless guiding of the substrate or substrate carrier. No particles are generated which could fall onto the substrate and disadvantageously influence substrate processing.

[0037] Figs. 5-8 illustrate a transfer device and transfer system according to further embodiments, and a method how substrates are moved by the transfer device or transfer system. Fig. 5 shows a first substrate support assembly 310 which includes first support elements 312, and a second substrate support assembly 320 which includes second support elements 322. Fig. 5 and also Figs. 6-8 are schematic drawings to illustrate the working principle, so the actual number and type of support elements are not necessarily reflected in the drawings. The support elements shown may, e.g., be magnetic guiding elements.

[0038] As shown in Fig. 5, the first substrate support assembly 310 supports a substrate 50. Support is provided at least partly through the first support elements 312. The support elements 312 are moved to the process position P while supporting the substrate 50 or its carrier. The second support elements 322 of the second substrate support assembly are moved to the first transport path T1. The substrate 50 is moved supported in its track, and there is no additional handling of the substrate or its carrier. The substrate 50 and the first support elements 312 pass the second support elements 322 on their way to the processing position P. The first and second support elements 312, 322 may move simultaneously. Alternatively, only one of the sets of support elements moves. For example, the first support elements 312 supporting substrate 50 may move to the process position P first, and then the second substrate support elements 322 move into alignment with the first transport path T1. In any case, there is

relative movement between the first and second support elements in the switch direction.

[0039] Fig. 6 shows the situation where the substrate 50 is in the processing position P and receives a coating layer from the deposition source 250. After deposition of a layer onto the substrate 50, the first support elements 312 and the substrate 50 move to the second transport path T2 as shown in Fig. 7. Fig. 7 also shows a further chamber 500, which might be another substrate processing chamber or a transfer chamber, a lock chamber, or a swing module. The further chamber 500 includes a second transfer device that may be a transfer device according to any of the embodiments described herein.

[0040] The second transfer device includes two further substrate support assemblies 410, 420, including substrate support elements 412 and 422, respectively. A second substrate 60 is supported by the substrate support elements 412 in alignment with the first transport path T1. Fig. 8 illustrates a simultaneous transfer of the first substrate 50 from chamber 200 to chamber 500 along the second transport path T2 and of the second substrate 60 from chamber 500 to chamber 200 along the first transport path T1. Support elements 422 of the previously empty support assembly 420 receive the first substrate 50 in chamber 500, and support elements 322 of the previously empty support assembly 320 receive the second substrate 60 in chamber 200. Similarly as in Figs. 5-7, the substrate processing may continue with substrate 60 being moved and coated in a similar way as previously substrate 50.

[0041] Two or more transport devices according to embodiments described herein can form a transport system for substrate transfer in or through a substrate processing system. Further embodiments relate to a transport system including at least two transport devices, relate to at least two chambers, typically vacuum chambers, including such a transport system, and relate to a substrate processing system including a transport system or including at least two chambers that include a transport system. The substrate processing system typically is a vacuum substrate processing system, e.g. an inline vacuum substrate processing system. Chambers of a substrate processing system may be connected to each other in vacuum-tight fashion, and may include corresponding substrate transfer ports for transferring substrates into or out of the chambers wherein the transfer ports may be connected by locks. Substrate processing systems are described in the PCT application entitled "Substrate Processing

System and Method of Processing Substrates”, filed on the same day and assigned to the same assignee, attorney docket number 17507P-WO, the content of which is incorporated by reference in its entirety.

[0042] A transport device according to embodiments described herein may include more than two substrate support assemblies, e.g., three, four, five or more than five substrate support assemblies. In typical embodiments, the transport device has exactly two substrate support assemblies. Such a transport device is called a dual-track switching transport device, in contrast to the rigid triple and dual track devices of WO 2009/156196 A1. A chamber including a dual-track switching transport device is called a dual-track switching chamber. A transport system including only dual-track transport devices (switchable or rigid) is called a dual-track transport system, and a substrate processing system including only dual-track chambers or including a dual-track transport system is called a dual-track substrate processing system. If the dual-track transport system or dual-track substrate processing system includes at least one dual-track switching transport device, it is called a dual-track switching transport system or dual-track switching substrate processing system.

[0043] Fig. 9 shows a transport device including a first substrate support assembly 310 and second substrate support assembly 320, both being movable independently of each other in the switch direction S as indicated by the double-headed arrows to the left of assembly 320 and to the right of assembly 310. The first substrate support assembly 310 includes first support elements including a set of first rollers 314, and the second substrate support assembly 320 includes second support elements including a set of second rollers 324. The first and second sets of rollers 314, 324 are moveable in the switch direction. A substrate 60 is supported by the rollers 324 in Fig. 9.

[0044] The transport device may additionally include static support elements that are not movable in the switch direction, e.g., static rollers. The transport device may include, e.g., 1-10 static rollers per track, typically 2-4 static rollers per track, such as 2 static rollers per track. Static rollers may be driven rollers. Fig. 9 shows two first static rollers 394 in alignment with the first transport path T1, and two second static rollers 384 in alignment with the second transport path T2. For instance, the substrate 60 may have entered the chamber from the right along the transport direction T through a corresponding substrate transfer port, passed over roller(s) 394 to be now supported by the rollers 324.

[0045] The rollers 314 and 324 of Fig. 9 may be moved in a way similar to that shown in Figs. 5-8. In particular, the rollers 314, 324 can pass each other in the switch direction S, even if one set of rollers, e.g., set of rollers 324, supports a substrate. While Figs. 5-8 schematically illustrate any kind of support elements, assume as an example that magnetic guiding elements are represented by the set of support elements 312 and 322, and that they support a top part of a vertically oriented substrate or substrate carrier. Then the view of chamber 200 of Fig. 8 can be considered as a horizontal cut through the chamber 200 in a plane through top parts of the substrate 60 or its carrier. Fig. 9 could then represent a horizontal cut through the same chamber 200 in lower plane through bottom parts of the substrate 60 or its carrier.

[0046] According to some embodiments, the support elements of one support assembly may be moved in the switch direction as a group. The track defined by the support elements of one support assembly is then lying in a plane whose normal substantially is the switch direction. A substrate or substrate carrier can thus be moved on a track substantially without tilt, e.g., with a tilt of at most  $10^\circ$  or at most  $7^\circ$ .

[0047] When an empty substrate support assembly, i.e., a substrate support assembly currently not supporting a substrate or substrate carrier, and a loaded substrate support assembly, i.e., a substrate support assembly currently supporting a substrate or substrate carrier, pass each other in the switch direction, three situations may occur. The empty substrate support assembly, respectively its support elements, may be able to pass both the substrate and the support elements of the loaded substrate support assembly without collision. Typically, however, the support elements of the empty substrate support assembly would collide with the substrate and/or with the substrate support elements of the loaded substrate support assembly upon trying to pass the latter in the switch direction. Then, the support elements of the empty substrate support assembly can perform an evasion movement to avoid such a collision. If the support elements of both support assemblies could pass each other without collision if they were both empty, e.g., because they are offset with respect to each other, then the evasion movement only needs to avoid a collision with the substrate. Otherwise, both a collision with the substrate and with the support elements of the loaded substrate support assembly needs to be avoided.

[0048] According to further embodiments, the first substrate support assembly includes first support elements, the second substrate support assembly includes second

support elements, and at least part of the first support elements and at least part of the second support elements are moveable relative to each other in an evasion direction. The evasion direction is perpendicular to the transport direction and perpendicular to the switch direction. For vertically or substantially vertically oriented substrates or substrate carriers, the evasion direction is the vertical direction. The relative motion in the evasion direction is enabled at least during relative movement of the first substrate support assembly and the second substrate support assembly in the switch direction. The first support elements of the first substrate support assembly and the second support elements of the second substrate support assembly may be moveable relatively to each other both in the switch direction and in the evasion direction.

[0049] The first support elements, or at least parts thereof, may be moveable in the evasion direction. Additionally or alternatively, the second support elements, or at least parts thereof, may be moveable in the evasion direction. The first and second support elements, or at least respective parts thereof, may be moveable independently of each other in the evasion direction.

[0050] For the evasion movement, support elements may be configured to be tilted or pivoted. The support elements may take up a displacement in the evasion direction through tilting or pivoting. Therein, the amount of displacement by tilting or pivoting may be such that the tilted or pivoted support elements can either pass a substrate supported by a loaded support assembly or pass the support elements of the loaded support assembly or both, depending upon need as described above. Typically, an evasion movement for avoiding only collision with the substrate needs less displacement by tilting or pivoting as compared to a movement for avoiding collision with the support elements of the loaded substrate support assembly. The amount of tilting or pivoting, and therefore the amount of displacement in the evasion direction is determined accordingly.

[0051] The first support elements and second support elements can be dimensioned such that they can pass each other without collision when moved in the switch direction in the absence of a substrate. In this way, the evasion movement can be made smaller, requiring less tilting or pivoting. Alternatively, the first support elements and second support elements can be dimensioned such that they collide when moved in the switch direction in the absence of a substrate. This allows larger dimensions of the

support elements in the transport direction, which can be particularly advantageous for guiding elements such as magnetic guiding elements.

[0052] The first support elements may include a first set of upper support elements. Upper support elements are configured to support an upper part of a substantially vertically oriented substrate or substrate carrier. The second support elements may include a second set of upper support elements. The first support elements may include a first set of lower support elements. Lower support elements are configured to support a lower part of a substantially vertically oriented substrate or substrate carrier. The second support elements may include a second set of lower support elements. Upper support elements may, e.g., be magnetic support elements such as magnetic guiding elements, or may be mechanical support elements such as rollers. Lower support elements may, e.g., be mechanical support elements such as rollers or belts. The upper and/or lower support elements may be pivotable or tiltable.

[0053] The first support elements may include a first set of magnetic support elements and the second support elements may include a second set of magnetic support elements. At least one of the first and second sets of magnetic support elements may be configured to be pivoted or tilted for taking up a displacement in the evasion direction relative to the respective other set of magnetic support elements. The first support elements may include a first set of roller support elements. The second support elements may include a second set of roller support elements. At least one of the first and second set of roller support elements may be configured to be pivoted or tilted for taking up a displacement in the evasion direction relative to the respective other set of roller support elements.

[0054] The first and second sets of magnetic support elements may be arranged to support top parts of substantially vertically oriented substrates or substrate carriers by magnetic forces, i.e., they may be upper support elements. The first and second sets of roller support elements may be arranged to support bottom parts of substantially vertically oriented substrates or substrate carriers, i.e., they may be lower support elements. The evasion direction is the vertical direction for vertically oriented substrates or substrate carriers. The first and second sets of magnetic support elements are adapted to be raised, i.e., moved up along the vertical direction, and the first and second sets of roller elements are adapted to be lowered, i.e., moved down along the vertical direction. The up and down motion are such that the first set of magnetic

support elements and the first set of roller support elements, when holding a substrate or substrate carrier, can be passed by the second set of magnetic roller elements and the second set of roller support elements during relative movement of the first and second substrate support assemblies in the switch direction. The up and down motion are such that the second set of magnetic support elements and the second set of roller support elements, when holding a substrate or substrate carrier, can be passed by the first set of magnetic roller elements and the first set of roller support elements during relative movement of the first and second substrate support assemblies in the switch direction.

[0055] Figs. 10-13 schematically illustrate an evasion movement by tilting. The example shown relates to a vertically aligned substrate 60 and substrate carrier 62. The example can be considered as a specific embodiment realizing a movement of substrate 60 similar to the movement of substrate 50 shown in Figs. 5 and 6. The tilting angles and other dimensions are exaggerated for illustration.

[0056] Fig. 10 shows a vacuum chamber 200 including a deposition source 250. The vacuum chamber 200 has a wall 204 opposite the deposition source 250. A transport device includes first and second substrate support assemblies 310, 320. The first substrate support assembly 310 includes a set of rollers 314 and a set of magnetic guiding elements 312. The second substrate support assembly 320 includes a set of rollers 324 and a set of magnetic guiding elements 322, which currently support the substrate carrier 62 that is holding the substrate 60. Axes of the rollers extend through openings in the wall 204 of the vacuum chamber 200 into a non-vacuum region 600. Seals such as bellow seals may for example be provided at the points where the axes run through the wall 204. The seals may seal the openings in a vacuum-tight way. The openings and seals are dimensioned to allow tilting of the axes. The openings and seals may be dimensioned to allow tilted movement of the axes in the switch direction S.

[0057] Substrate 60 in its carrier 62 is in alignment with the first transport path in Fig. 10. For instance, substrate 60 and substrate carrier 62 may have been transferred into the chamber along the first transport path, e.g., similarly as shown in Fig. 8. The currently empty support elements 312 and 314 of the first substrate support assembly are moved in the evasion direction E by tilting the axes on which they reside. As a general feature, the center of rotation for a tilting movement may be located in each

opening in a chamber wall through which axes of support elements go. In the embodiment shown in Fig. 10, the magnetic guiding element(s) 312 are moved upwards, and the roller elements 314 are moved downwards, leading to the situation shown in Fig. 11.

[0058] In the embodiment shown in Figs. 10-13, the rollers 314 and 324 could pass each other without collision if no substrate was in the chamber. As shown in Fig. 11, the rollers 314 are tilted only so far that they can pass under the lowest part of the carrier 62. The magnetic guiding elements 312 and 322 would not be able to pass each other in the untilted state without collision even if there was no substrate in the chamber. They are tilted so far that they can pass each other, which, as shown in Fig. 11, may require a larger tilting angle as compared to the situation where only collision with the uppermost part of the substrate carrier 62 would have to be avoided.

[0059] Tilting angles  $\alpha$  depend on the desired displacement  $e$  and the length  $l$  between the center of rotation and the point of the support element that is to assume a displaced position to allow passing of other support elements, namely  $\sin\alpha=e/l$ . Tilting angles may be, e.g., from 0.5 to 20°. Tilting angles may be from 1° to 5° for support elements at the bottom of substrates or substrate carriers, typically from 2° to 4°, e.g., about 2.5°. Tilting angles may be from 10° to 20° for support elements at the top of substrates or substrate carriers, typically from 12° to 16°, e.g. about 14°.

[0060] The first substrate support assembly 310 with tilted support elements 312 and 314 is moved in the switch direction S towards the wall 204 as shown in Fig. 11, and the second substrate support assembly 320 with the support elements 322 and 324 supporting substrate carrier 62 is moved in the switch direction S towards the deposition source 250. In Fig. 12, the substrate carrier 62 and substrate 60 have been moved to the processing position while being supported by the second track. The tilted support elements 312 and 314 can be un-tilted, i.e., their axes can be brought back into a horizontal position once they have passed the substrate 60 and support elements 322, 324 of the second substrate support assembly 320. Fig. 13 shows the situation where the first track is aligned with the first transport path, and the second track with the substrate 60 is aligned with the processing position. The first track defined by the first substrate support assembly 310 and the second track defined by the second substrate support assembly 320 have passed each other. After processing the substrate is complete, the substrate 60 and substrate carrier 62 could be moved to the left into

alignment with the second transport path, whereupon an exchange of substrates with a neighboring chamber could take place, similarly as in Figs. 7 and 8.

[0061] Alternatively, tilted support elements may not be moveable. In such embodiments, empty support elements would be tilted, a loaded substrate support assembly would pass them, then the empty support elements would be un-tilted and optionally be moved thereafter. Especially when the center of rotation for the tilting movement resides in the openings in the chamber wall 204 as shown in Fig. 11, the diameter of the openings in the wall 204 and the necessary tolerance provided by vacuum seals is reduced as compared to embodiments allowing movement in the tilted state. This makes it easier to maintain the vacuum conditions. Embodiments allowing movement in the tilted state might complete a motion pattern faster, possibly leading to faster processing tact depending on how the process is conducted.

[0062] A tiltable support element may include a substrate support part, e.g., the actual roll of a roller or the actual magnetic head of a magnetic guiding element, and a shaft connected to the support part. The support element may further include a shaft, e.g. a ball spline shaft, and a ball spline bushing with bearings. The support element may include an excenter arranged on the shaft for providing a deviation that is turned into the tilt. The excenter may include a drive shaft that can be driven by an excenter drive. The support element may include seals, e.g., membrane bellow seals and/or ferro seals, which may be vacuum-tight.

[0063] An advantage of tilting a support element is that no additional mechanism is needed in the vacuum chamber, and mechanical components necessary for tilting can be arranged outside in non-vacuum region. A further advantage, in particular for support elements arranged above the substrate, is that no mechanical interaction between any parts of the support element takes place which could generate particles that could fall onto the substrate.

[0064] Figs. 14-19 show an embodiment in which magnetic guiding elements 322 and 312 are pivotable. Magnetic guiding elements 322 and 312 are adapted to support top parts of substrate carriers, such as substrate carriers 62 and 72. In Figs. 14-19, the support elements in form of the magnetic guiding elements are pivotable around a pivot point in the switch direction S. However, they could alternatively be pivotable in the transport direction, i.e., into or out of the plane of drawing, if space between neighboring support elements of the same substrate support assembly permits.

[0065] In Fig. 14, magnetic guiding element 322 contributes to supporting a substrate carrier 62 on a second track, while magnetic guiding element 312 belongs to a currently empty first substrate support assembly that defines a first track. The first magnetic guiding element 312 includes a shaft 313 leading through an opening in a chamber wall into an adjacent non-vacuum region, a pivot point 315, and a bar 316 connected to the shaft 313 via the pivot point 315. The bar 316 has an orientation perpendicular to the shaft 313 in Fig. 14, such that the magnetic guiding element can support a top part of a vertically oriented substrate carrier. The pivot point 315 may be a ball joint or similar component. The second magnetic guiding element 322 may be similarly formed.

[0066] The magnetic guiding element 312 may be pivoted, meaning that its bar 316 is pivoted around pivot point 315. In Fig. 15, the bar 316 is pivoted by 90° into alignment with the shaft 313. Pivoting angles may, e.g., be from 45° to 110°, more typically from 80° to 100°, e.g., about 90°. This movement in the evasion direction E relative to the second magnetic guiding element 322 displaces the first magnetic guiding element 312 in the evasion direction. As shown in Fig. 16, the displacement is such that a relative motion in the switch direction between the first magnetic guiding element 312 on the one side and the second magnetic guiding element 322 and substrate carrier 62 on the other side is possible without collision. The support elements in form of the first and second magnetic guiding elements may pass each other in the switch direction.

[0067] The magnetic guiding element 312 may then be un-pivoted or pivoted back so that the bar 316 and shaft 313 again form a right angle, and the first magnetic guiding element 312 is ready to receive a substrate carrier. For instance, a substrate held by the carrier 62 may be in a processing position in Fig. 17, and then moved to a second transport path in Fig. 18. The carrier 62 with its substrate is then transferred to a second chamber, and a different carrier 72 with its substrate is simultaneously or subsequently received on the first transport path from the second chamber or from another, third chamber. The situation in Fig. 19 is similar to that of Fig. 14, only with the first and second substrate support assemblies and corresponding magnetic guiding elements exchanged.

[0068] Support elements may be connected to individual transversal drives or a transversal drive system for movement in the switch direction. Driven support

elements, which are able to move a substrate or substrate carrier in the transport direction, may be connected to individual drives or to a drive system for substrate transport into or out of a chamber, such as a belt system. Tilttable support elements may be connected to individual excenter drives or an excenter drive system for providing the tilting movement. All these drives may be controlled by a control system. The movements of the support elements and the entire process conduct of substrate processing may be controlled by the control system in a fully automatic way.

[0069] According to further embodiments, as shown in Fig. 20, a method of moving a substrate in a substrate processing system, 800, is provided. The method may be performed by a transport device, a transport system, a chamber or a substrate processing system according to any of the embodiments described herein.

[0070] The method includes transferring the substrate into a chamber along a first transport path, 810. The first transport path may be along a transport direction, and the substrate is transferred into the chamber along the transport direction. The method includes moving the substrate in the chamber at least in a switch direction perpendicular to the first transport path, 820.

[0071] The method includes moving support elements of an empty substrate support assembly in the chamber, 830. Movement of the support elements of the empty substrate support assembly may include a movement in an evasion direction. The evasion direction is perpendicular to the first transport path, respectively the transport direction, and perpendicular to the switch direction. Movement of the support elements of the empty substrate support assembly may additionally or alternatively include a movement in the switch direction.

[0072] According to the method of embodiments described herein, the substrate and the support elements of the empty substrate support assembly are moved relatively to each other in the switch direction, 840. The substrate and the support elements may pass each other.

[0073] Transferring the substrate into the chamber may include transferring the substrate into the chamber so as to be supported by a first track defined by first support elements of a first substrate support assembly. The empty substrate support assembly is a second substrate support assembly and the support elements of the empty substrate support assembly are second support elements in such embodiments. The second,

empty substrate support assembly, respectively its support elements, define(s) a second track. In these embodiments, moving the substrate includes moving the first track supporting the substrate, i.e., moving the first track while it is supporting the substrate. The first track supporting the substrate and the second track may be moved relatively to each other in the switch direction and may pass each other.

[0074] The method may include pivoting or tilting at least part of the second support elements. The method may include pivoting or tilting at least part of the first support elements. Pivoting and tilting may be performed as described hereinbefore, e.g., with respect to Figs. 10-19.

[0075] The chamber may be a substrate processing chamber having a substrate processing position. Moving the substrate may include moving the substrate to the substrate processing position. The method may include depositing a layer on the substrate in the processing position.

[0076] The method may further include transferring the substrate out of the chamber along a second transport path. Simultaneously or subsequently, a second substrate may be transferred into the chamber along the first transport path. The second substrate may be received by the support elements of the empty substrate support assembly. The substrate exchange between different chambers may be performed as previously described herein, e.g., with respect to Figs. 7-8 and 18-19.

[0077] According to a further embodiment, a method of moving substrates in a vacuum processing system is provided. The method includes transferring a first substrate into a vacuum chamber along a first transport path, moving a first substrate support assembly in the vacuum chamber in a switch direction perpendicular to the first transport path to move the first substrate into a vacuum process position. The method includes moving a second substrate support assembly in the vacuum chamber opposite to the switch direction to receive a second substrate while the first substrate is in the vacuum process position. The method further includes moving the second substrate support assembly in the vacuum chamber in the switch direction to move the second substrate into the vacuum process position.

[0078] The terms and expressions which have been employed herein are used as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described or

portions thereof. While the foregoing is directed to embodiments, other and further embodiments may be devised without departing from the scope, and the scope is determined by the claims that follow.

## CLAIMS

1. A transfer device (100) for substrate transfer along a transport direction (T) and for change between a first transport path (T1) and a second transport path (T2) extending along the transport direction, wherein the first transport path is displaced with respect to the second transport path in a switch direction (S) perpendicular to the transport direction, the transfer device comprising:
  - a first substrate support assembly (110) defining a first track to support a substrate or substrate carrier in a chamber;
  - a second substrate support assembly (120) defining a second track to support a substrate or substrate carrier in the chamber,wherein the first substrate support assembly and the second substrate support assembly are moveable relative to each other at least in the switch direction.
2. The transfer device according to claim 1, wherein
  - the first substrate support assembly is moveable at least in the switch direction, wherein the first track is alignable with the first transport path and alternatively with the second transport path; and
  - the second substrate support assembly is moveable at least in the switch direction, wherein the second track is alignable with the first transport path and alternatively with the second transport path.
3. The transfer device according to any of the preceding claims, wherein the first substrate support assembly and the second substrate support assembly are moveable relative to each other wherein the first track and the second track pass each other in the switch direction.
4. The transfer device according to any of the preceding claims, wherein
  - the first substrate support assembly comprises first support elements (310);
  - and
  - the second substrate support assembly comprises second support elements (320),wherein at least part of the first support elements and at least part of the second support elements are moveable relative to each other in an evasion direction (E) perpendicular to both the transport direction and the switch direction.
5. The transfer device according to claim 4, wherein

- the first support elements comprise a first set of magnetic support elements (312); and
- the second support elements comprise a second set of magnetic support elements (322),
- wherein at least one of the first and second sets of magnetic support elements is configured to be pivoted or tilted for taking up a displacement in the evasion direction relative to the respective other set of magnetic support elements.
6. The transfer device according to any of claims 4 to 5, wherein
- the first support elements comprise a first set of roller support elements (314); and
- the second support elements comprise a second set of roller support elements (324),
- wherein at least one of the first and second set of roller support elements is configured to be pivoted or tilted for taking up a displacement in the evasion direction relative to the respective other set of roller support elements.
7. The transfer device according to claim 6 when depending on claim 5, wherein the first and second sets of magnetic support elements are arranged to support top parts of substantially vertically oriented substrates (50, 60) or substrate carriers (52, 62) by magnetic forces, and the first and second sets of roller support elements are arranged to support bottom parts of substantially vertically oriented substrates (50, 60) or substrate carriers (52, 62), and
- wherein the first and second sets of magnetic support elements are adapted to be raised and the first and second sets of roller elements are adapted to be lowered, wherein the first sets of magnetic and roller support elements (312, 314), when holding a substrate (50) or substrate carrier (52), can be passed by the second sets of magnetic and roller support elements (322, 324) during relative movement of the first and second substrate support assemblies (310, 320) in the switch direction, and vice versa.
8. A chamber (200) for a substrate processing system, comprising:
- at least one first substrate transfer port (210, 212) for substrate transfer into our out of the chamber along a first transport path (T1),
- at least one second substrate transfer port (220, 222) for substrate transferring into our out of the chamber along a second transport path (T2); and

- a transfer device (100) according to any of the preceding claims arranged in the chamber.
9. The chamber of claim 8, wherein the chamber is a substrate processing chamber for deposition of a layer onto a substrate, wherein a substrate processing position (P) is located in the substrate processing chamber, the substrate processing position either being located remote from the first and second transport paths or being located on one of the first or second transport paths, and wherein the first and second tracks are individually alignable with the substrate processing position.
  10. A method of moving a substrate (50) in a substrate processing system, the method comprising:
    - transferring the substrate (50) into a chamber (200) along a first transport path (T1);
    - moving the substrate in the chamber at least in a switch direction (S) perpendicular to the first transport path (T1); and
    - moving support elements (322, 324) of an empty substrate support assembly (320) in the chamber, wherein the substrate (50) and the support elements (322, 324) of the empty substrate support assembly are moved relatively to each other in the switch direction and pass each other.
  11. The method according to claim 10, wherein the movement of the support elements of the empty substrate support assembly includes at least one of the following:
    - a movement in an evasion direction (E) perpendicular to both the first transport path and the switch direction, and
    - a movement in the switch direction.
  12. The method according to any of the claims 10 to 11, wherein transferring the substrate comprises transferring the substrate to be supported by a first track defined by first support elements (312, 314) of a first substrate support assembly (310), wherein the empty substrate support assembly is a second substrate support assembly and the support elements of the empty substrate support

assembly are second support elements defining a second track, wherein moving the substrate comprises moving the first track supporting the substrate; and wherein the first track supporting the substrate and the second track defined by the second support elements are moved relatively to each other in the switch direction and pass each other.

13. The method according to claim 12, comprising pivoting or tilting at least part of the second support elements (322, 324).
14. The method according to any of claims 10 to 13, wherein the chamber has a processing position (P), and wherein moving the substrate comprises moving the substrate to the processing position, the method further comprising:
  - depositing a layer on the substrate in the processing position.
15. The method according to any of claims 10 to 14, further comprising:
  - transferring the substrate out of the chamber along a second transport path (T2); and
  - simultaneously transferring a second substrate (60) into the chamber along the first transport path (T1), wherein the second substrate is received by the support elements (322, 324) of the empty substrate support assembly (320).

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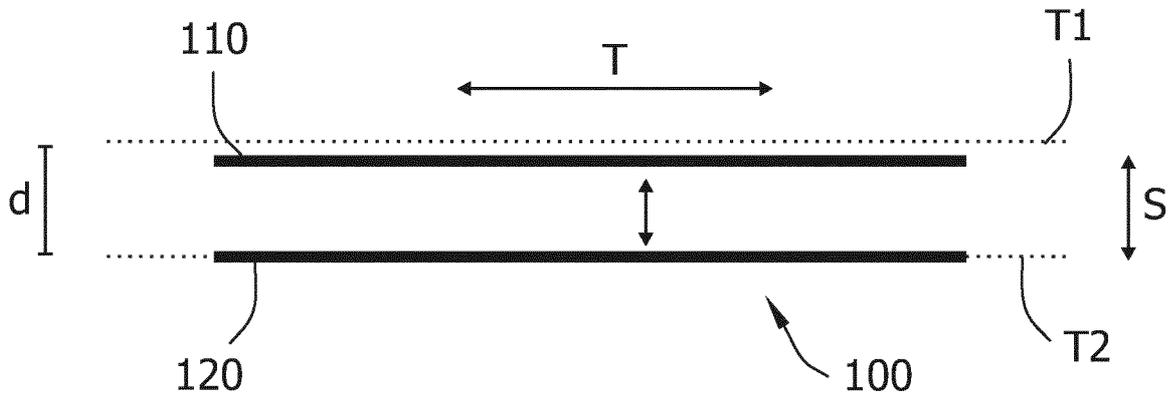


FIG. 1

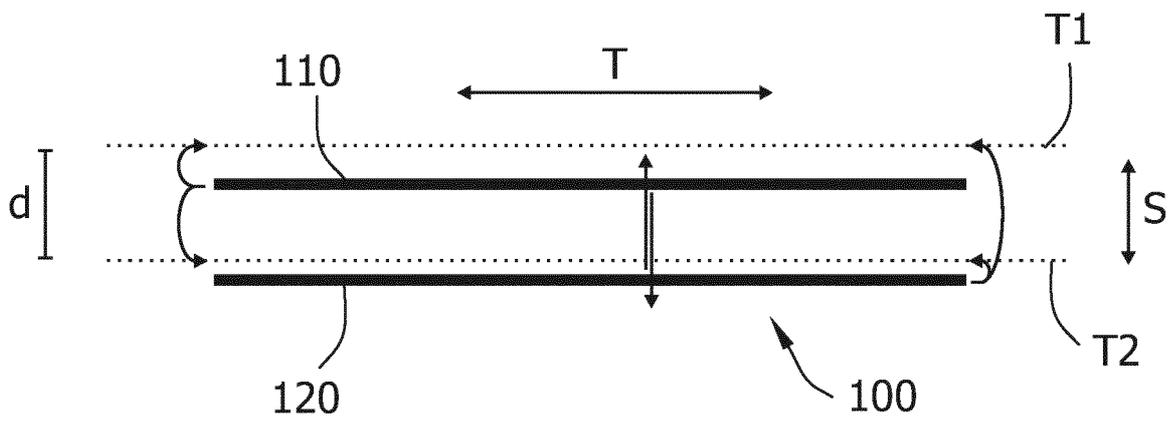


FIG. 2

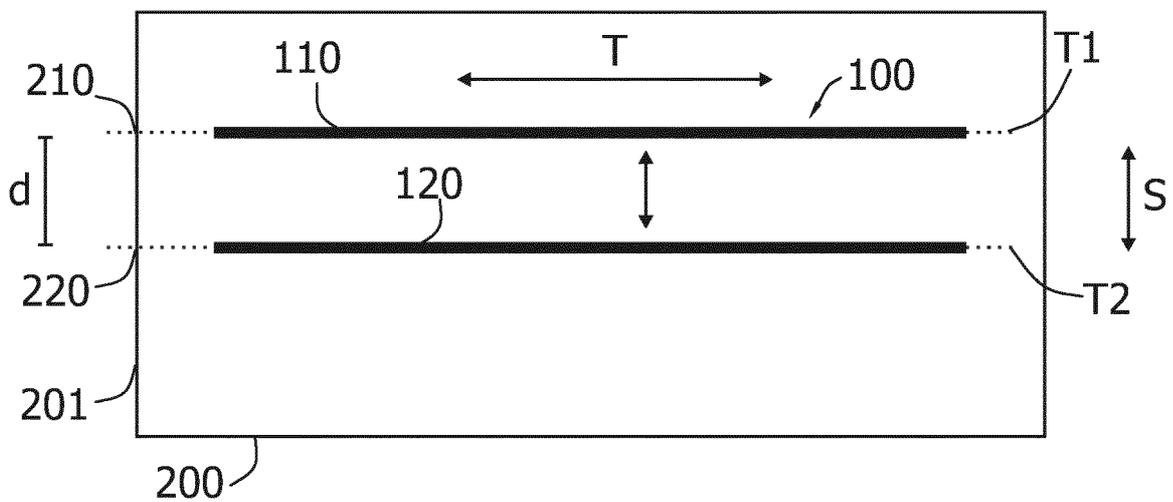


FIG. 3

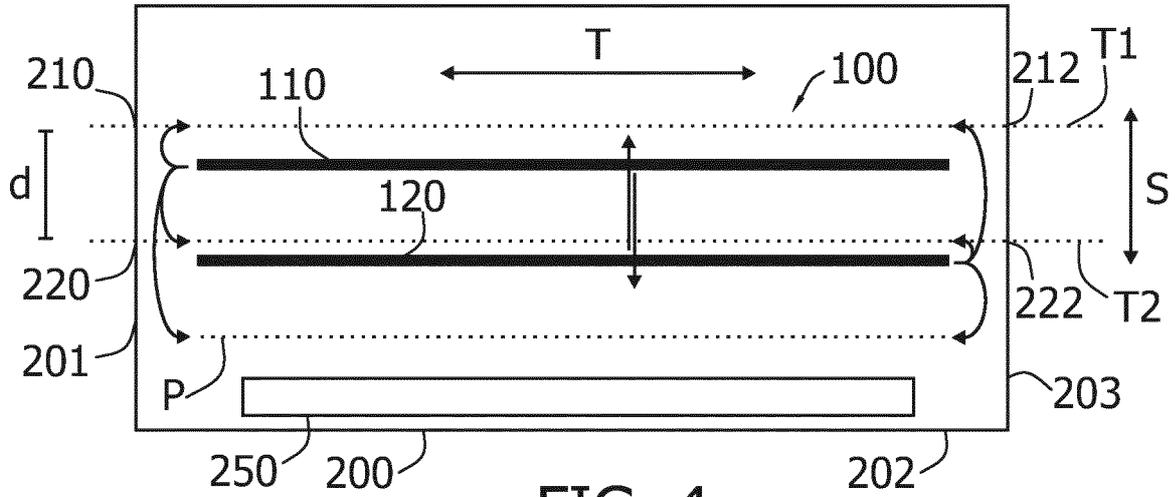


FIG. 4

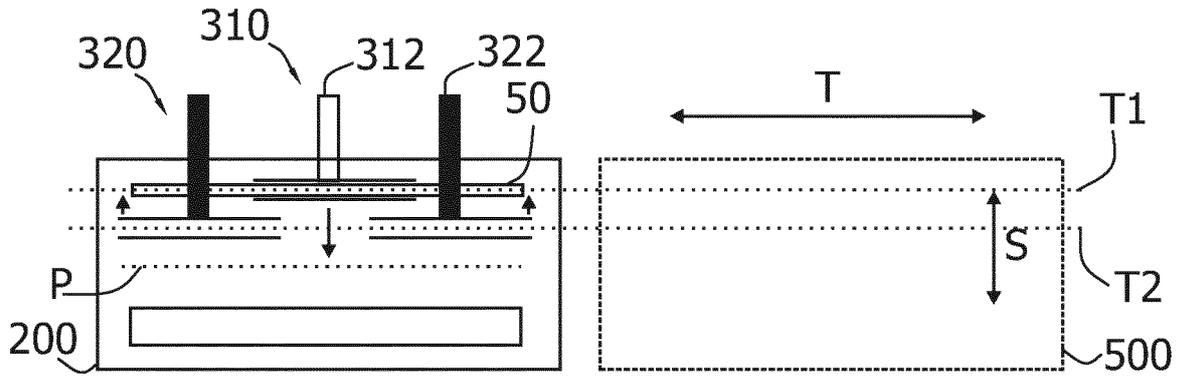


FIG. 5

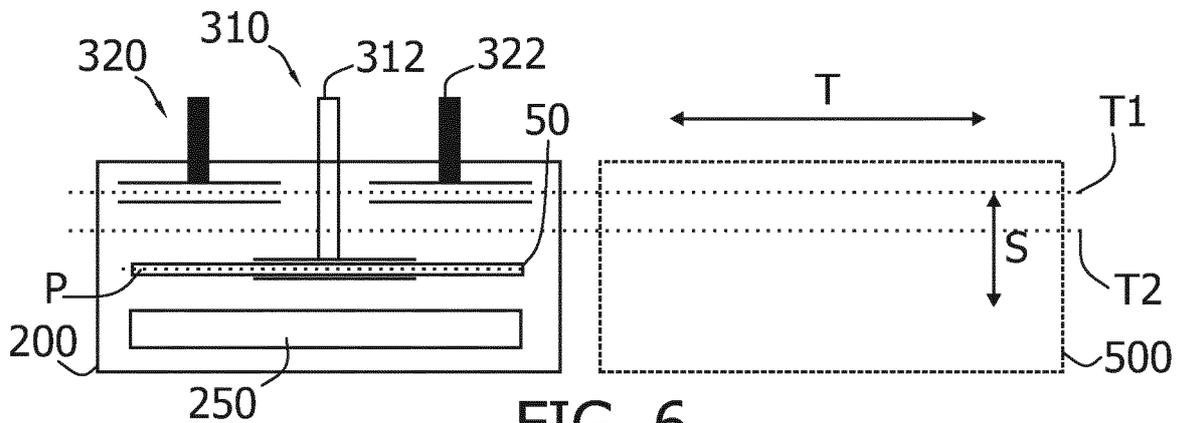


FIG. 6

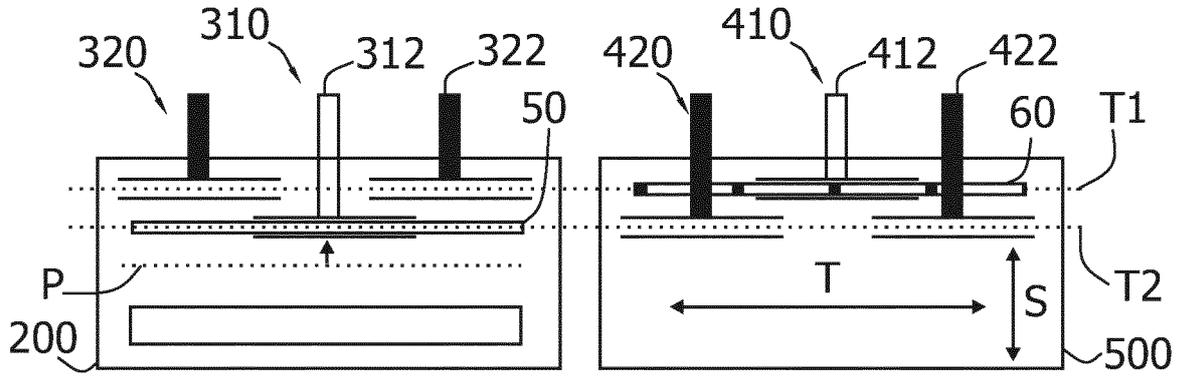


FIG. 7

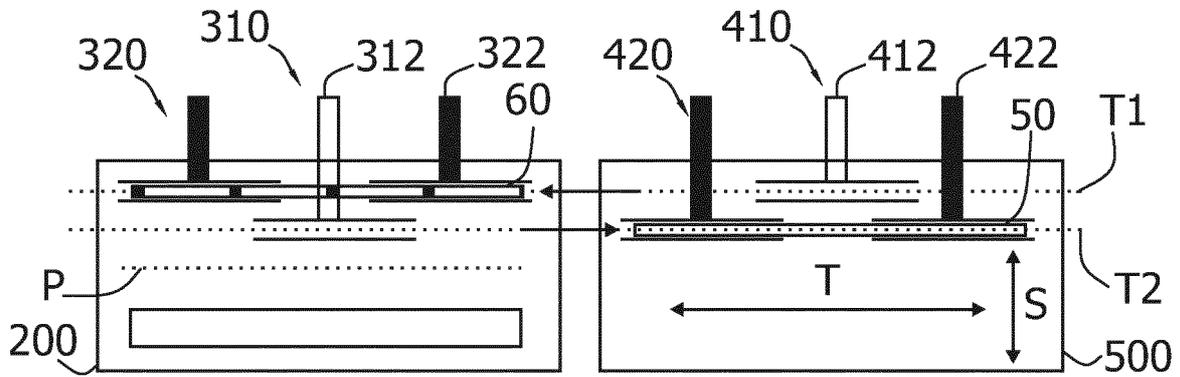


FIG. 8

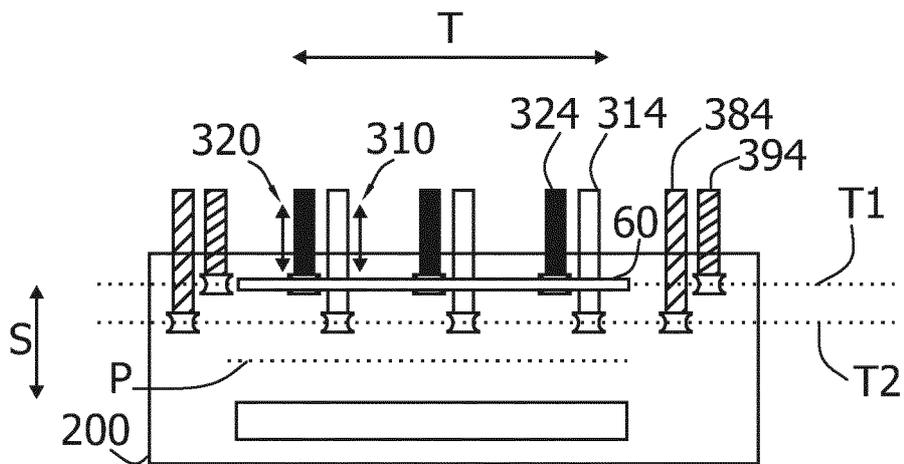


FIG. 9

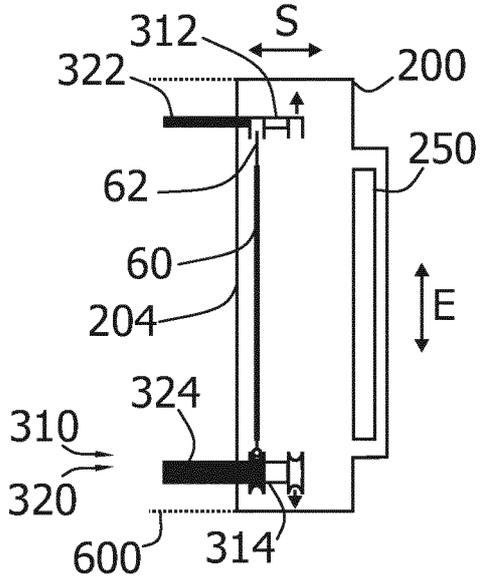


FIG. 10

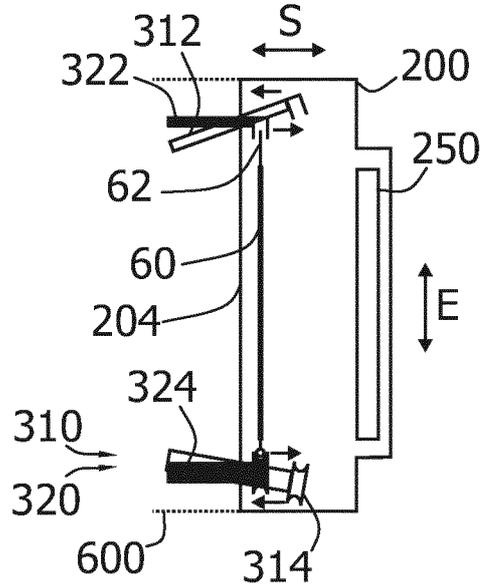


FIG. 11

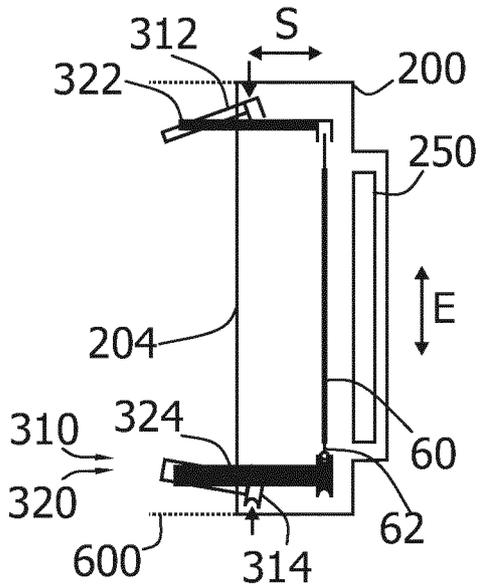


FIG. 12

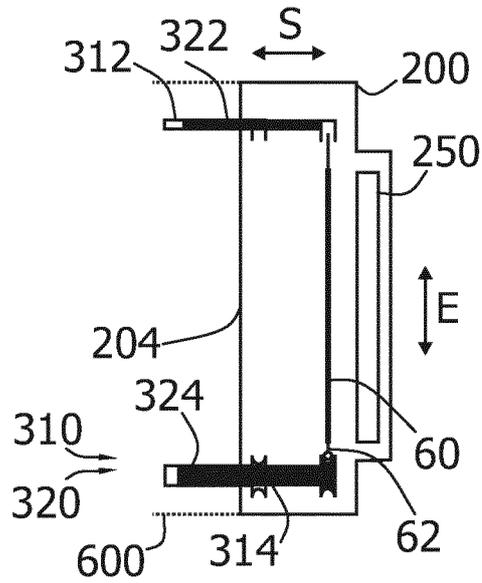


FIG. 13

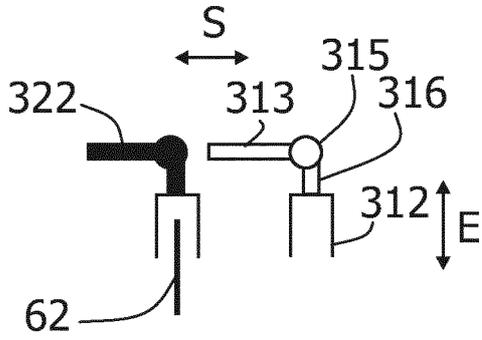


FIG. 14

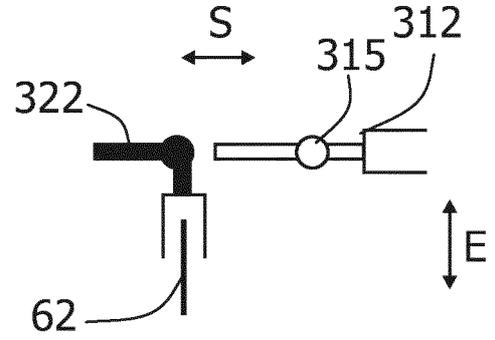


FIG. 15

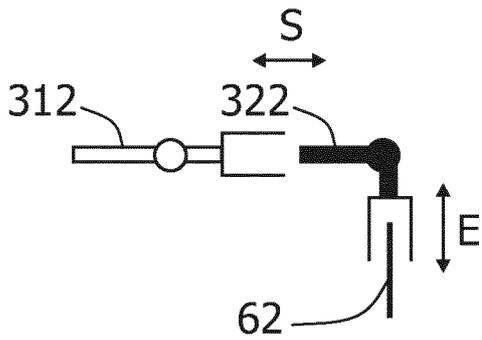


FIG. 16

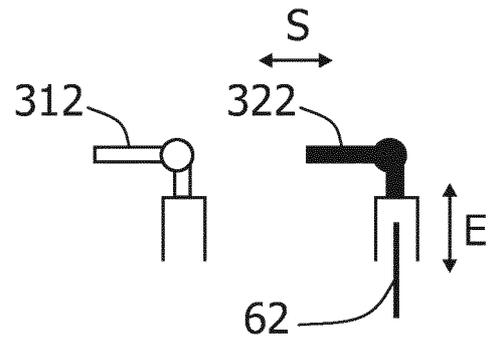


FIG. 17

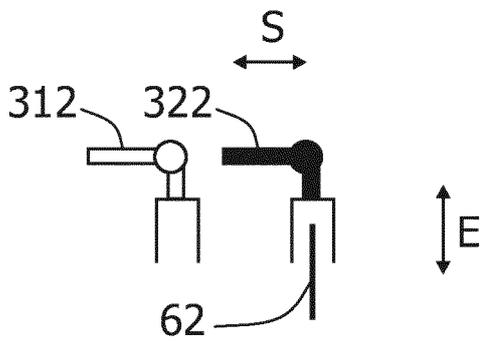


FIG. 18

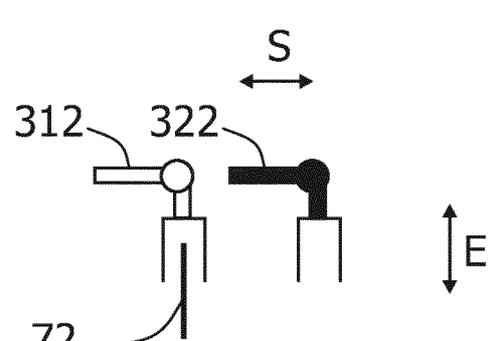


FIG. 19

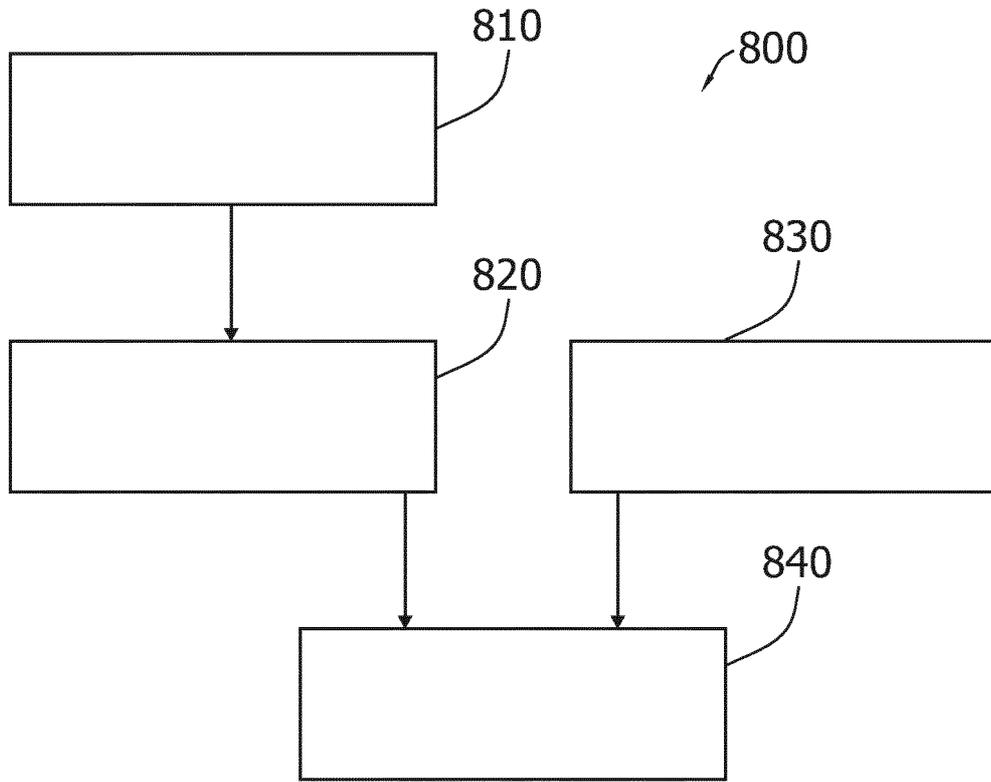


FIG. 20

**INTERNATIONAL SEARCH REPORT**

International application No  
PCT/EP2012/067659

A. CLASSIFICATION OF SUBJECT MATTER  
 INV. B65G49/06 C23C14/50 C23C14/56 H01L21/67 H01L21/677  
 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)  
 B65G C23C 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, INSPEC, 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	WO 2009/156196 A1 (APPLIED MATERIALS INC [US]; LINDENBERG RALPH [DE]; KOPARAL ERKAN [DE];) 30 December 2009 (2009-12-30) cited in the application page 16 - page 18	1-9, 11-15
A	WO 2009/119580 A1 (TOSHIMA MASATO [US]; CAN LINH [US]) 1 October 2009 (2009-10-01) figures 11, 12	1,8,10

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
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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

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search <b>22 May 2013</b>	Date of mailing of the international search report <b>29/05/2013</b>
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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 <b>Schumacher, Jörg</b>
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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2012/067659

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2009156196 A1	30-12-2009	CN 102112647 A	29-06-2011
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