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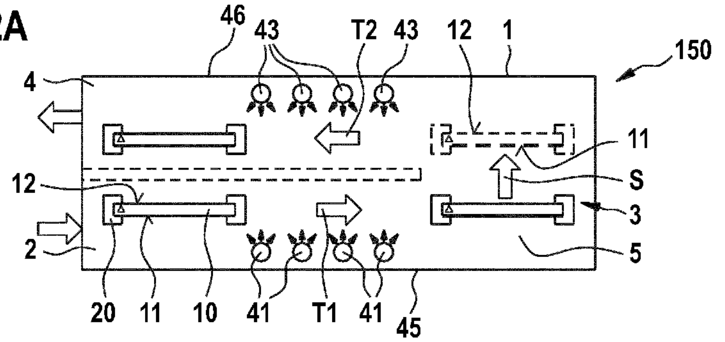
Fig. 2A



(57) Abstract: According to one aspect of the present disclosure, a method of two-side processing of a substrate (10) in a vacuum chamber is provided. The method comprises: attaching a substrate to a carrier (20) for holding the substrate during transport; transporting the carrier along a first transport path section (T1) through a first processing area, where a first main surface (11) of the substrate is processed; transferring the carrier from the first transport path section to a second transport path section (T2) laterally offset from the first transport path section; and transporting the carrier along the second transport path section through a second processing area, where a second main surface (12) of the substrate is processed, wherein transferring the carrier comprises moving the carrier together with the substrate from the first transport path section to the second transport path section. According to a second aspect, a processing system for two-side processing of a substrate is provided. Further, a path switching module for a processing system is provided.

WO 2017/101971 A1

PROCESSING SYSTEM FOR TWO-SIDE PROCESSING OF A SUBSTRATE AND METHOD OF TWO-SIDE PROCESSING OF A SUBSTRATE

TECHNICAL FIELD

[0001] Embodiments of the present disclosure relate to methods of two-side processing of substrates, e.g. methods of two-side coating of large area substrates. Embodiments relate to a processing system for two-side processing of substrates, e.g. to vacuum coating systems for two-side coating of large area substrates in a vacuum chamber. Further embodiments relate to path switching modules for transferring substrates between transport path sections in a vacuum chamber.

BACKGROUND

[0002] Several methods are known for depositing a material on a substrate. For instance, substrates may be coated by a physical vapor deposition (PVD) process, a chemical vapor deposition (CVD) process or a plasma enhanced chemical vapor deposition (PECVD) process. Typically, the process is performed in a processing system, where the substrate to be coated is located. A deposition material is provided in the apparatus. A plurality of materials, but also oxides, nitrides or carbides thereof, may be used for deposition on a substrate.

[0003] Coated materials may be used in several applications and in several technical fields. For instance, an application lies in the field of microelectronics, such as generating semiconductor devices. Also, substrates for displays are often coated by a PVD process. Further applications include insulating panels, organic light emitting diode (OLED) panels, substrates with TFT, color filters, touch panels with and without force touch feature or the like.

[0004] In particular, improvements in display manufacturing in the last years have been able to significantly reduce the manufacturing costs for mobile phones, tablet computers, television screens, and the like. Display manufacturing is conducted on glass substrates, wherein typically large area substrates with a size of 1 m^2 or more are utilized, and layers are deposited on the large area substrates. Even though some aspects of semiconductor manufacturing could be successfully implemented for display manufacturing, there are some significant differences. Some of these differences are based on the much larger substrates, which result in challenges for substrate handling, moving of the substrates within the manufacturing systems and resulting particle generation, layer uniformity over the large areas, or the like.

[0005] For display manufacturing, typically two different concepts are utilized. The large area substrates can be processed in stationary systems, wherein the large area substrates are stationary in the same processing area (small movements might be possible) during processing of the substrate. Another system can be an in-line processing system, in which substrates are moved past a processing tool while the substrate is processed. The uniformity of processing the large area substrate, for example a rectangular glass plate, is provided by a processing tool extending mainly in one direction and the substrate movement in a second, different direction. These in-line systems have the advantage that processing uniformity, for example layer uniformity, in one direction is only limited by the ability to move the substrate at constant speed and to keep the processing tool stable. Accordingly, a good uniformity can be provided in at least one direction and efforts to improve the overall uniformity may focus on the direction perpendicular to the transport direction. Further, these in-line systems have the advantage that a large area substrate can be processed without providing an array of tools. For example, one in-line source for deposition would generally be sufficient. Accordingly, the cost of ownership with respect to processing tools can be reduced.

[0006] For some applications, it may be sufficient to coat only one main surface of a large area substrate with one or several layers to provide a multilayer stack on a front side of the substrate. For some applications, both main surfaces of substrates may be processed, e.g. coated with one layer or with a stack of layers. However, two-side processing of large area substrate may be difficult and costly. For example, after processing of a first main surface of the substrate in a first processing area, the substrate is typically inverted with respect to a substrate carrier, whereupon the second main surface of the substrate can be processed in a second processing area or in the same processing area. Inverting the substrate with respect to a substrate carrier is, however, time consuming, as the substrate is typically taken out of the vacuum chamber, inverted, and put back in the vacuum chamber.

[0007] In view of the above, it is beneficial to provide an in-line processing system that is suitable for two-side processing of substrates, e.g. large area substrates, with a manageable effort and in a reduced period of time.

SUMMARY

[0008] In light of the above, a method of two-side processing of a substrate in a vacuum chamber is provided. Further, a processing system for two-side processing of a substrate in a vacuum chamber as well as a path switching module to be used in a processing system are provided. Further aspects, benefits, and features of the present disclosure are apparent from the claims, the description, and the accompanying drawings.

[0009] According to one aspect of the present disclosure, a method of two-side processing of a substrate in a vacuum chamber is provided. The method comprises: attaching a substrate to a carrier for holding the substrate during transport; transporting the carrier along a first transport path section through a first processing area, where a first main surface of the substrate is processed; transferring the carrier from the first transport path section to a second transport path section laterally offset from the first transport path section; and transporting the carrier along the second transport path section through a second processing area, where a second main surface of the substrate is processed, wherein transferring the carrier comprises moving the carrier together with the substrate from the first transport path section to the second transport path section.

[0011] In some embodiments, processing of the first main surface may comprise coating the first main surface, and processing of the second main surface may comprise coating the second main surface.

[0012] According to a further aspect of the present disclosure, a processing system for two-side processing of a substrate is provided, including: a vacuum chamber with at least a first processing area and a second processing area; at least one carrier configured for holding a substrate; a first transport device configured for transporting the carrier through the first processing area along a first transport path section for processing of a first main surface of the substrate, and a second transport device configured for transporting the carrier through the second processing area along a second transport path section for processing of a second main surface of the substrate, wherein the second transport path section is laterally offset from the first transport path section; and a path switching device for transferring the carrier together with the substrate from the first transport path section to the second transport path section.

[0013] According to a further aspect of the present disclosure, a path switching module for a processing device is provided. The path switching module includes: a carrier configured to hold a substrate such that a first main surface and a second main surface of the substrate can be processed while the substrate is being held by the carrier; and a path switching device for transferring the carrier together with the substrate from a first transport path section in a vacuum chamber to a second transport path section in the vacuum chamber laterally offset from the first transport path section such that an orientation of the substrate before transfer corresponds to the orientation of the substrate after transfer.

[0014] Further aspects, advantages, and features of the present disclosure are apparent from the dependent claims, the description, and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] 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. Typical embodiments are depicted in the drawings and are detailed in the description which follows.

[0016] FIG. 1 shows a schematic view of a processing system according to embodiments described herein that is configured for two-side processing of a substrate in accordance with methods described herein;

[0017] FIG. 2A shows a schematic view of a processing system according to embodiments described herein that is configured for two-side processing of a substrate in accordance with methods described herein;

[0018] FIG. 2B shows a schematic view of a processing system according to embodiments described herein that is configured for two-side processing of a substrate in accordance with methods described herein;

[0019] FIG. 3 shows a schematic view of a processing system according to embodiments described herein that is configured for both one-side processing and two-side processing of a substrate in accordance with methods described herein;

[0020] FIG. 4 shows a comparative example of a processing system configured for one-side processing of a substrate.

[0021] FIG. 5 shows a schematic view of a processing system according to embodiments described herein that is configured for both one-side processing and two-side processing of a substrate in accordance with methods described herein;

[0022] FIG. 6 shows a side part of a carrier holding a substrate to be used in a processing system according to embodiments described herein;

[0023] FIG. 7 shows a side part of a carrier holding a substrate to be used in a processing system according to embodiments described herein;

[0024] FIG. 8A, 8B, 8C show an explosive view (FIG. 8A), a front view (FIG. 8B), and a rear view (FIG. 8C) of a carrier for holding a substrate to be used in a processing system according to embodiments described herein;

[0025] FIG. 9A, 9B show a schematic front view (FIG. 9A) and a schematic side view (FIG. 9B) of a path switching module according to embodiments described herein;

[0026] FIG. 10A, 10B show a schematic front view (FIG. 10A) and a schematic side view (FIG. 10B) of a path switching module according to embodiments described herein; and

[0027] FIG. 11 shows a flow diagram illustrating a method of two-side processing a substrate according to embodiments described herein.

DETAILED DESCRIPTION

[0028] Reference will now be made in detail to the various 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 any other embodiment to yield yet a further embodiment. It is intended that the present disclosure includes such modifications and variations.

[0029] Within the following description of the drawings, the same reference numbers refer to the same or to similar components. Generally, only the differences with respect to the individual embodiments are described. Unless specified otherwise, the description of a part or aspect in one embodiment applies to a corresponding part or aspect in another embodiment as well.

[0030] A substrate used in some embodiments described herein may be an inflexible substrate, e.g., a wafer, slices of transparent crystal such as sapphire or the like, or a glass plate. However, the present disclosure is not limited thereto and the term substrate may also embrace flexible substrates such as a web or a foil.

[0031] Specifically, a “large area substrate” may be used for display manufacturing and be a glass or plastic substrate. For example, substrates as described herein shall embrace substrates which are typically used for an LCD (Liquid Crystal Display), a PDP (Plasma Display Panel), and the like. For instance, a large area substrate can be GEN 4.5, which corresponds to about 0.67 m^2 substrates (0.73 x 0.92m), GEN 5, which corresponds to about 1.4 m^2 substrates (1.1 m x 1.3 m), or larger. A large area substrate can further be GEN 7.5, which corresponds to about 4.29 m^2 substrates (1.95 m x 2.2 m), GEN 8.5, which corresponds to about 5.7m^2 substrates (2.2 m x 2.5 m), or even GEN 10, which corresponds to about 8.7 m^2 substrates (2.85 m × 3.05 m). Even larger generations such as GEN 11 and GEN 12 and corresponding substrate areas can similarly be implemented.

[0032] According to some embodiments, which can be combined with other embodiments described therein, the substrate is in a substantially vertical orientation during processing, for example, during a deposition or coating process and/or during transportation of the substrate through a vacuum processing system. As used throughout the present disclosure, “substantially vertical” is understood particularly when referring to the substrate orientation, to allow for a deviation from the vertical direction or orientation of ±20° or below, e.g. of ±10° or below. This deviation can be provided for example because a substrate carrier with some deviation from the vertical orientation might result in a more stable substrate position or a facing down substrate orientation might even better reduce particles on the substrate during deposition. Yet, the substrate orientation, e.g., during a layer deposition process, is considered substantially vertical, which is considered different from the horizontal substrate orientation.

[0033] Specifically, as used throughout the present disclosure, terms like “vertical direction” or “vertical orientation” are understood to distinguish over “horizontal direction” or “horizontal orientation”. The vertical direction can be substantially parallel to the force of gravity.

[0034] The substrates of the present disclosure are supported by a substrate carrier during processing and transport, e.g., during layer deposition and/or transport of the substrate in the vacuum processing system. It is noted that the terms “substrate carrier”, “carrier” and “substrate support” can be used synonymously.

[0035] According to some embodiments, which can be combined with other embodiments described herein, the carrier is configured such that the first main surface and the second main surface of the substrate can be processed while the substrate is being held by the carrier. For example, 50% or more, particularly 90% or more of both the first main surface and the second main surface of the substrate may be exposed to allow coating thereof, while the substrate is being held by the carrier. In some embodiments, the carrier may be configured as an open frame carrier, wherein an edge region of both the first and second main surfaces of the substrate is supported directly on the carrier, e.g. sandwiched between two supporting surfaces of the carrier, whereas central areas of both the first and second main surfaces of the substrate are exposed. Therefore, the central areas of both the first and the second main surfaces of the substrate may be coated while the substrate is held by the carrier, and there may be no need to unload the substrate from the carrier, in order to be in a position to process the other main surface of the substrate.

<u>Transport device</u>

[0036] According to embodiments of the present disclosure, the in-line processing system can use one or more transport devices for holding and transporting the carriers together with the substrates along a transport path. In some implementations, the transport device may be provided as a magnetic levitation system for holding the carriers in a suspended state. Optionally, the in-line processing system can use a magnetic drive system configured for moving or conveying the carriers along the transport path in a transport direction. The magnetic drive system can be included in the magnetic levitation system or can be provided as a separate entity.

[0037] In some implementations, a mechanical transport system may be provided. The transport system may include rollers for transporting the carriers in the transport direction, wherein a drive for rotating the rollers may be provided. Mechanical transport systems may be easy to implement and robust, durable and maintenance friendly.

[0038] PVD sputter systems were developed to coat thin substrates, e.g. thin glass substrates, e.g. for display applications, in a vacuum chamber. In typical vacuum processing systems, each substrate may be held by a carrier, and the carriers may be transported through the vacuum chamber by respective transport devices. The carriers may be moved by the transport devices such that first main surfaces of the substrates are exposed to processing devices, e.g. sputter devices. The first main surfaces of the substrates may be processed, e.g. coated with a thin coating layer, while the substrates are transported by the transport devices past the processing devices at a predetermined speed.

[0039] A vacuum rotation module is typically arranged at an end of the vacuum chamber, where the carriers can be rotated by, e.g., 180° and be transported back to an entrance/exit region of the vacuum chamber, where the carriers can be taken off the vacuum chamber, and the substrates can be unloaded from the carriers. When appropriate, the carriers may be fed again through the vacuum chamber or through a second vacuum chamber, where the first main surface of the substrate may be coated again, while the substrate is being held by the same substrate carrier. This is called “single side processing” or “single side coating”.

[0040] For some applications, it may be appropriate to coat both the first and the second main surface of the substrate. This is called “double-side processing” or “double-side coating”. In this case, the carrier may be moved out of the processing system, the substrate may be unloaded from the carrier, turned by 180°, and put again onto the same carrier or onto a different carrier in an inverted orientation. Afterwards, the carrier can be fed again through the vacuum chamber, and the second main surface of the substrate may be processed, e.g. coated with one or more layers.

[0041] According to methods and systems disclosed herein, double-side coating of large area substrates can be improved, and both main surfaces of large area substrates may be processed in a reduced time with a sufficient coating accuracy.

[0042] A processing system 100 for two-side processing of a substrate 10 according to embodiments described herein is illustrated in FIG. 1 in a schematic view. The processing system 100 may include a vacuum chamber 1 with at least a first processing area 2 and a second processing area 4. The first processing area 2 may be configured for processing, e.g. coating, of the first main surface 11 of the substrate, and the second processing area 4 may be configured for processing, e.g. coating, of the second main surface 12 of the substrate which is directed in an opposite direction.

[0043] The processing system 100 includes a carrier 20 configured to hold the substrate 10. The carrier 20 may be configured such that both the first main surface 11 and the second main surface 12 of the substrate can be processed while the substrate 10 is held in the carrier 20. The processing system 100 further includes a transport device configured for transporting the carrier 20 through the first processing area 2 along a first transport path section T1 for processing of the first main surface 11 of the substrate, and for transporting the carrier 20 through the second processing area 4 along a second transport path section T2 for processing of the second main surface 12 of the substrate, wherein the second transport path section T2 is laterally offset from the first transport path section T1. The processing system 100 further includes a path switching device 3 for transferring the carrier 20 from the first transport path section T1 to the second transport path section T2, or vice versa. In some implementations, the path switching device 3 is configured to transfer the carrier such that an orientation of the substrate 10 before transfer corresponds to the orientation of the substrate after transfer.

[0044] In other words, the path switching device 3 may be configured to move the substrate 10, while the substrate is held by the carrier 20, between the first transport path section T1 and the second transport path section T2. The path switching device 3 may be arranged inside the vacuum chamber 1, e.g. in a path switching area 5 of the vacuum chamber 1. The path switching device 3 may be configured for transferring the carrier together with the substrate from the first processing area 2 where the first main surface of the substrate is coated to the second processing area 4 where the second main surface 12 of the substrate is coated. Therefore, there is no need to remove the substrate from the vacuum chamber 1 for inversion purposes. In particular, transfer between the first and second transport path sections may be performed automatically by the path switching device 3 inside the vacuum chamber.

[0045] Further, the path switching device 3 may be configured to transfer the carrier 20 together with the substrate 10 between the first transport path section T1 and the second transport path section T2 without changing the orientation of the substrate. In other words, the first main surface 11 of the substrate before transfer may be directed essentially in the same direction as compared to the situation after transfer (+/- 20°), and the second main surface 12 of the substrate before transfer may be directed essentially in the same direction as compared to the situation after transfer (+/-20°). For example, in the illustration of FIG. 1, the first main surface 11 of the substrate faces downwards both before and after transfer in the path switching direction S. Accordingly, the second main surface 12 of the substrate faces upwards both before and after transfer in the path switching direction S. Therefore, the substrate after transfer may be not or only slightly (+/-20°) rotated as compared to the situation before transfer.

[0046] Transfer between the first and second transport path sections without an orientation change of the substrate may provide the following advantage: Before transfer, the first main surface 11 of the substrate may be directed toward at least one processing device arranged in the first processing area 2 of the vacuum chamber, particularly between the first transport path section T1 and a first outer side wall of the vacuum chamber, as is illustrated in FIG. 2A. After transfer, the second main surface 12 of the substrate may be directed toward at least one second processing device arranged in the second processing area 4, particularly between the second transport path section T2 and a second outer side wall of the vacuum chamber opposite to the first outer side wall, as is illustrated in FIG. 2A. In other words, in some implementations the processing devices may be arranged “outside” the first and second transport path sections T1, T2, and not between the first and second transport path sections T1, T2. One advantage of an “outside” location of the processing devices is that the processing devices can be accessed easily, e.g. for maintenance or target exchange. Access to the processing devices is particularly easy, when the processing devices are arranged near an outer side wall of the vacuum chamber, respectively. For example, the distance between the processing devices and an outer side wall of the vacuum chamber 1 may be 30 cm or less. As the orientation of the substrate after transfer may correspond to the orientation of the substrate before transfer, the first main surface of the substrate may be directed toward the first outer side wall of the vacuum chamber both before and after transfer, and the second main surface of the substrate may be directed toward the second outer side wall of the vacuum chamber both before and after transfer.

[0047] Additionally or alternatively, in some implementations, at least one central processing device may be arranged between the first transport path section T1 and the second transport path section T2, as is illustrated in FIG. 2B. In this case, before transfer, the first main surface 11 of the substrate may be directed toward a first side of the central processing device, and after transfer, the second main surface 12 of the substrate may be directed toward a second side of said central processing device. Therefore, after transfer without orientation change, the second main surface 12 of the substrate may be processed by said central processing device arranged between the first and second transport path sections.

[0048] A particularly compact processing system 100 can be provided, when the first transport device is configured to transport the carrier 20 along the first transport path section T1 in a first transport direction, and the second transport device is configured to transport the carrier 20 along the second transport path section T2 in a second transport direction opposite to the first transport direction. Hence, the second transport device may be configured to transport the carrier back to an entrance/exit region of the vacuum chamber, wherein on the way back to the entrance/exit region of the vacuum chamber 1 the second main surface 12 of the substrate can be processed. In particular, during transport in the first transport direction, the first main surface 11 may be directed toward first processing devices, and, during transport in the opposite second transport direction, the second main surface 12 may be directed toward second processing devices. This is because the path switching device according to embodiments described herein may be configured for path switching without an orientation change of the substrate.

[0049] According to embodiments described herein, a fixed spatial relationship and/or a fixed mutual orientation between the carrier 20 and the substrate 10 may be maintained during the transport of the carrier 20 along the first transport path section T1 in the first transport direction, during the transfer to the second transport path section T2, and during the transport along the second transport path section T2 in the second transport direction opposite to the first transport direction. Time can be saved, because two-side processing of the substrate is possible without inverting the substrate with respect to the carrier.

[0050] As is shown in FIG. 1, the first transport path section T1 may extend essentially parallel with respect to the second transport path section T2. A first distance D1 between the first and the second transport path sections may be 10 cm or more, particularly 30 cm or more, more particularly 50 cm or more. The path switching device 3 may be configured to move the carrier together with the substrate from the first transport path section T1 in a path switching direction S essentially perpendicular to the first transport direction by the distance D1. After transfer to the second transport path section T2, the second transport device may be configured to transport the carrier back along the second transport direction opposite to the first transport direction.

[0051] As is indicated in FIG. 1, the vacuum chamber 1 may have an elongated setup, wherein the first processing area 2 and the second processing area 4 extend parallel to each other in a main extension direction of the vacuum chamber 1, and the path switching device 3 may be provided in the path switching area 5 of the vacuum chamber arranged at an end of the two processing areas. The path switching area 5 may also be referred to as turnaround area, as the transport direction of the carrier may be reversed in the path switching area.

[0052] It is indicated in FIG. 1 that the path switching device 3 may be configured to laterally displace the carrier 20 together with the substrate 10 from the first transport path section T1 to the second transport path section T2 in a path switching direction S perpendicular to the first and second transport path sections. Paths may be switched essentially without changing the orientation of the substrate during transfer. For example, the first transport device may be configured to linearly transport the carrier through the first processing area 2, the path switching device 3 may be configured to linearly transport the carrier in the path switching direction S perpendicular to the first transport direction, and the second transport device may be configured to linearly transport the carrier in the second transport direction opposite to the first transport direction. Transport of the carrier without orientation change of the substrate is possible.

[0053] The processing system shown in FIG. 1 is configured for two-side processing of a substrate 10, e.g. a large area glass substrate, according to processing methods described herein. A method of two-side processing of a substrate in a vacuum chamber according to embodiments may include: attaching the substrate 10 to the carrier 20 for holding the substrate during transport; transporting the carrier 20 along the first transport path section T1 through the first processing area 2, where a first main surface 11 of the substrate is processed, transferring the carrier from the first transport path section T1 to the second transport path section T2 laterally offset from the first transport path section; transporting the carrier along the second transport path section T2 through the second processing area 4, where the second main surface 12 of the substrate is processed, wherein transferring the carrier 20 comprises moving the carrier together with the substrate from the first transport path section T1 to the second transport path section T2. In some implementations, an orientation of the substrate 10 after the transfer corresponds to the orientation of the substrate before the transfer.

[0054] In some embodiments which may be combined with other embodiments disclosed herein, transferring the carrier may comprise laterally displacing the carrier together with the substrate from the first transport path section T1 to the second transport path section T2 in a path switching direction S essentially perpendicular to the first and second transport path sections. During transfer, the orientation of the substrate may remain essentially constant. In other words, the substrate may be transported essentially without rotating the substrate.

[0055] FIG. 2A shows a processing system 150 for two-side processing of a substrate 10 according to embodiments described herein. Details of the first and second transport devices and of the path switching device 3 of the processing system 150 may correspond to the above described details, so that reference can be made to the above explanations.

[0056] The processing system 150 is a vacuum coating system for two-side coating of a substrate 10, e.g. a large area glass substrate. For example, the processing system 150 may be configured as an in-line PVD coating system, where the main surfaces of the substrates are coated while the substrates are transported past coating devices arranged next to the substrate transport path.

[0057] The first main surface 11 of the substrate 10 may be coated in the first processing area 2 by first coating devices 41 arranged in the first processing area 2, and the second main surface 12 of the substrate may be coated in the second coating area by second coating devices 43 arranged in the second processing area 4. The first coating devices 41 may be arranged between the first transport path section T1 and a first outer side wall 45 of the vacuum chamber 1, and the second coating devices 43 may be arranged between the second transport path section T2 and a second outer side wall 46 of the vacuum chamber 1 opposite to the first outer side wall. This location of the first and second coating devices in a side region of the vacuum chamber 1, respectively, facilitates easy service and maintenance of the coating devices.

[0058] The coating devices may include, or be, sputter deposition sources. In some embodiments, coating devices with cylindrical cathodes, e.g. rotatory cylindrical cathodes may be used. In some embodiments, coating devices with planar cathodes may be used.

[0059] The first and second processing areas may be a scalable chamber section. The scalable chamber section may be provided in various sizes in order to allow for a varying amount of coating devices or other processing devices to be provided in the scalable chamber section. FIG. 2A shows a scalable chamber section with four first coating devices

41 in the first processing area 2 and four second coating devices 43 in the second processing area 4, in the form of sputter deposition sources. The first coating devices 41 can provide a first material, and the second coating devices can provide a second material. Alternatively first and second coating devices may provide the same coating material.

[0060] According to embodiments, which can be combined with other embodiments described herein, the number of cathodes per material and/or the power provided to the individual cathodes can be varied to tune the thickness relation between the respective layers. Accordingly, the number of cathodes and the power to the individual cathodes are the variables to tune to achieve the thickness of each layer at the same passing speed of the large area substrate moving past the cathodes.

[0061] The processing system 150 for dynamic processing according to embodiments of the present disclosure, and as exemplary shown in FIG. 2A, is an in-line processing system, i.e. a system for dynamic deposition, particularly for dynamic vertical deposition. An in-line processing system or a dynamic deposition system according to embodiments described herein is defined by having a uniformity of processing the large area substrate, for example a rectangular glass plate, by a processing tool extending mainly in one direction and the substrate movement in a second, different direction (right-left-direction in FIG. 2A). These in-line systems have the advantage that processing uniformity, for example layer uniformity, in one direction is only limited by the ability to move the substrate at constant speed and to keep the processing tool stable. Accordingly, the deposition process of an in-line processing system or a dynamic deposition system is defined by the movement of the carriers past the coating devices. Accordingly, for an in-line processing system or a dynamic deposition system, the deposition area or processing area could be an essentially linear area for processing, for example a large area rectangular substrate.

[0062] A further difference of an in-line processing system, for example for dynamic deposition, as compared to a stationary processing system, can be formulated by the fact that the processing system 150 has one single vacuum chamber 1, with different areas, wherein the vacuum chamber does not include a vacuum tight sealing of one area of the vacuum chamber with respect to another area of the vacuum chamber. Contrary thereto, a stationary processing system may have the first vacuum chamber and a second vacuum chamber which can be vacuum tight sealed with respect to each other.

[0063] This may be further understood by the fact that the substrates 10, as for example shown in FIG. 2A, have a continuous or quasi-continuous flow along the coating devices 40. As is further shown in FIG. 2A, the substrates 10 can be supported by carriers 20 which are transported through the vacuum chamber. The carriers 20 may be provided as open frame carriers, which allow coating of both the first and the second main surfaces of the substrates held thereon. The carriers 20 may enter the system through a load lock chamber (not shown). As is illustrated in FIG. 2A, a carrier 20 with a substrate 10 held thereon moves along the first transport path section T1 past the first coating devices 41 in the first processing area 2 of the vacuum chamber 1 in a first transport direction. The carrier enters a path switching area 5 with a path switching device 3 located at an end of the vacuum chamber 1. The carrier is transferred from the first transport path section T1 to the second transport path section T2 in a path switching direction S perpendicular to the first transport direction. Then, the carrier moves along the second transport path section T2 past the second coating devices 43 in the second processing area 4 of the vacuum chamber 1 in the second transport direction opposite to the first transport direction. The second main surface 12 of the substrate is coated in the second processing area 4.

[0064] The path switching module may be configured to transfer the carrier together with the substrate from the first transport path section T1 to the second transport path section T2 so that an orientation of the substrate after transfer corresponds to the orientation of the substrate before transfer. For example, transfer may include laterally displacing the carrier together with the substrate in the path switching direction S which may extend in an essentially perpendicular direction (+/-20°) with respect to the first and second transport path sections.

[0065] FIG. 2B shows a processing system 200 for two-side processing of a substrate 10 according to embodiments described herein. Most features of the processing system 200 correspond to the respective features of the processing system 150 shown in FIG. 2A so that reference can be made to the above explanations which are not repeated here.

[0066] The first main surface 11 of the substrate 10 may be coated in the first processing area 2 by central coating devices 40 which are arranged between the first transport path section T1 and the second transport path section T2. The second main surface 12 of the substrate may be coated in the second processing area 4 by central coating devices 40 which are arranged between the first transport path section T1 and the second transport path section T2. In some embodiments, both the first and the second main surfaces of the substrate may be coated by the same coating devices 40. For example, the first main surface 11 may be coated while the substrate is transported past a first side of the coating devices along the first transport path section T1, and the second main surface 12 may be coated while the substrate is transported past a second side of the coating devices 40 along the second transport path section T2 in an opposite transport direction.

[0067] For example, the central coating devices 40 may include cathodes with a double magnetron system so that the central coating devices 40 may be configured for layer deposition in two opposing directions, as is indicated by the arrows in FIG. 2B. Alternatively or additionally, the central coating devices 40 may include double planar cathodes, which may be installed backside against backside in a central region between the first transport path section T1 and the second transport path section T2.

[0068] Between sputter deposition sources for providing different materials on the large area substrate, gas separation units 42 can be provided. The gas separation units 42 can provide for separating a first deposition area from a second deposition area, wherein the first deposition area has a different environment, for example different processing gases and/or a different pressure, as compared to the second deposition area.

[0069] FIG. 2B shows an in-line coating system 200, in which substrates 10 can be double-side coated. The first processing area 2 which is configured to coat the first main surfaces 11 of the substrates 10 and the second processing area 4 which is configured to coat the second main surfaces 12 of the substrates 10 may share common coating devices 40. The common coating devices 40 for depositing material onto first and second main surfaces of different substrates simultaneously allow for higher throughput and provide a plurality of further advantages.

[0070] The path switching module may be configured to transfer the carrier 20 together with the substrate 10 from the first transport path section T1 to the second transport path section T2 so that an orientation of the substrate after transfer corresponds to the orientation of the substrate before transfer. For example, transfer may include laterally displacing the carrier together with the substrate in the path switching direction S which may extend in an essentially perpendicular direction (+/-20°) with respect to the first and second transport path sections.

[0071] FIG. 3 shows a processing system 300 for two-side processing of a substrate 10 according to embodiments described herein. The processing system 300 is similar to the processing system 100 explained above with reference to FIG. 1, and corresponding details are not repeated here.

[0072] According to some embodiments, the processing system 300 may be a vacuum coating system for two-side coating of a substrate 10, e.g. a large area glass substrate. For example, the processing system 300 may be an in-line PVD coating system, where both main surfaces of the substrates are coated, while the substrates are transported past coating devices arranged next to the substrate transport path.

[0073] The processing system 300 according to embodiments described herein may include a path switching device 103 configured for moving the carrier 20 together with the substrate 10 between the first transport path section T1 and the second transport path section T2 so that an orientation of the substrate 10 before transfer corresponds to the orientation of the substrate after transfer. The path switching device 103 may be arranged in a path switching area 5 of the vacuum chamber 1.

[0074] According to some embodiments, which may be combined with other embodiments described herein, the path switching device 103 comprises a rotation module for rotating the substrate 10. In some embodiments, the rotation module may be configured for moving the substrate around a pivot axis A1 which extends at a center position between the first transport path section T1 and the second transport path section T2. The pivot axis may extend in a vertical direction (perpendicular to the paper plane of FIG. 3). Alternatively or additionally, the rotation module may be configured for inverting the substrate by rotating the substrate around a rotation axis A2. The rotation axis A2 may extend in a vertical direction and/or parallel to the pivot axis A1. For example, the rotation module may be configured to conduct two sequential rotational movements of the substrate, wherein the first rotational movement R1 results in an orientation change of the substrate, e.g. by 180°, and the second rotational movement R2 results in a further orientation change of the substrate, e.g. by another 180°. The orientation changes may cancel each other out so that the orientation of the substrate after the second rotational movement R2 may correspond to the orientation of the substrate before the first rotational movement R1.

[0075] In other words, transferring the carrier from the first transport path section T1 to the second transport path section T2 may comprise a sequence of at least two rotational movements of the carrier together with the substrate. The first rotational movement R1 may be around a pivot axis A1 and the second rotational movement R2 may be around a rotation axis A2 different from the pivot axis.

[0076] The first rotational movement R1 may include moving the substrate around the pivot axis A1 along a curved or semicircular turnaround path, as is indicated in FIG. 3. The diameter of the semicircular turnaround path may correspond to the first distance D1 between the first transport path section T1 and the second transport path section T2 so that, after the first rotational movement, the carrier may be located on the second transport path section T2, however, in an inverted orientation.

[0077] The second rotational movement R2 may include rotating the carrier together with the substrate by an angle of 180° around the rotation axis A2 which may extend through the center of the carrier and/or the substrate in a vertical direction. For example, the rotation axis A2 may be a vertical axis which may be parallel to the pivot axis A1 of the first rotational movement. The second rotational movement A2 may lead to an inversion of the orientation of the substrate while maintaining an approximately stationary position of the substrate.

[0078] In some embodiments, the substrate is first inverted by rotating the carrier around a rotation axis, e.g. by 180°, and then moved along a curved or semicircle turnaround path around the pivot axis A1 toward the second transport path section T2. In some embodiments, a sequence of more than two rotational movements may result in the transfer of the carrier from the first transport path section T1 to the second transport path section T2, or vice versa.

[0079] Rotational movements of substrates, e.g. of large area glass substrates, may be easier to implement under vacuum conditions as compared to (discontinuous or angled) linear movements. For example, the carriers may be transported along a semicircular or a curved switching path at an approximately constant speed. Therefore, in some implementations, a sequence of two or more rotational movements of the carrier may be advantageous as compared to a lateral displacement of the carrier in a path switching direction S which may be perpendicular to a previous transport direction of the substrate.

[0080] Further, if appropriate, the second rotational movement R2 may be omitted so that the orientation of the substrate after transfer may remain inverted as compared to the orientation of the substrate before transfer. In this case, the first main surface of the substrate may be processed again during transport of the substrate along the second transport path section T2. For example, in some applications, a multilayer stack including four or more layers may be deposited on the first main surface 11 of the substrate.

[0081] Processing flexibility may be increased, because the processing system 300 shown in FIG. 3 is suitable for both one-side processing of a substrate (only first rotational movement R1 performed by the path switching device 103) and for two-side processing of a substrate (two rotational movement R1, R2 performed by the path switching device 103). For single side coating, the rotation motion with a pivot axis A1 which is offset by half the distance between the first and second transport path sections is used. For double-side coating, an additional rotation motion is used with a rotation axis A2 which is the vertical center axis of the carrier.

[0082] FIG. 4 shows an example of a processing system 1000 configured for one-side processing of a substrate. The substrate 10 is supported on a carrier 1100 which is configured for one-side processing of the substrate 10. For example, the carrier 1100 may include a flat support surface which covers and supports more than 50% or more than 80% of the second main surface 12 of the substrate 10. The first main surface 11 of the substrate is exposed so that the substrate can be processed both during transport along the first transport path section T1 and during transport along the second transport path section T2.

[0083] The processing system 1000 may include a rotation module 1030 which is configured for moving the substrate around a pivot axis A1 on a curved turnaround path so that the substrate orientation is inverted after transfer. Therefore, the first main surface 11 of the substrate can be processed again during transport along the second transport path section.

[0084] FIG. 5 shows a processing system 500 for both two-side processing and one-side processing of a substrate 10 according to embodiments described herein. The processing system 500 is similar to the processing system 100 explained above with reference to FIG. 1, and corresponding details are not repeated here.

[0085] According to some embodiments, which may be combined with other embodiments described herein, a path switching device 104 of the processing system 500 may be configured to laterally displace the carrier 20 together with the substrate 10 from the first transport path section T1 to the second transport path section along a path switching direction S which may extend perpendicular to the first and second transport path sections. The orientation of the substrate 10 may remain constant during lateral displacement. Additionally, the path switching device 104 may be configured to rotate the substrate during transfer. For example, the path switching device 104 may be configured to move the substrate around a pivot axis A1, e.g. along a curved or semicircular path. The pivot axis A1 may be offset by half the distance between the first and second transport path sections.

[0086] Single-side and double-side processing of a substrate 10 is possible with the processing system 500. The carrier 20 may be configured such that both the first and the second main surface of the substrate held by the carrier can be coated. For double-side processing, the carrier can be transferred along the path switching direction S in a transversal motion. For single-side processing, the carrier can be transferred along a curved turnaround path in a rotational motion which leads to an inversion of the orientation of the substrate. Processing flexibility can be increased.

[0087] FIG. 6 and FIG. 7 show a part of a carrier 20 for holding a substrate 10 in a sectional view, respectively. The carrier 20 is configured to hold the substrate 10 such that both the first and the second main surface of the substrate can at least partially be coated while the substrate is held in the carrier 20. For example, 50% or more, particularly 80% or more, more particularly 90% or more of both the first main surface 11 and the second main surface 12 of the substrate 10 are exposed, while the substrate is held by the carrier.

[0088] In some embodiments, which may be combined with other embodiments described herein, an edge region 15 of the substrate 10 is directly supported on the carrier, while a center region of the substrate may be exposed. For example, both the edge of the first main surface 11 and the edge of the second main surface 12 are supported on a respective support surface of the carrier 20. In some embodiments, a circumferential edge exclusion for both the first main surface 11 and the second main surface 12 of the substrate are provided by the carrier 20, and the carrier may cover a circumferential edge of both main surfaces of the substrate entirely.

[0089] In some implementations, the carrier 20 includes a first frame member 21 configured to cover a first edge of the first main surface 11 of the substrate and a second frame member 22 configured to cover a second edge of the second main surface of the substrate. The first frame member may be configured to provide for a circumferential edge exclusion for the first main surface of the substrate, and/or the second frame member may be configured to provide for a circumferential edge exclusion for the second main surface of the substrate, or vice versa.

[0090] When attaching the substrate 10 to the carrier 20, the substrate may be placed on the first frame member 21 such that the first edge of the first main surface 11 is covered by the first frame member, particularly entirely covered by the first frame member. For example, in the case of a rectangular substrate, all four side edges of the first main surface 11 of the rectangular substrate may be covered by the first frame member. Then, the second frame member 22 may be attached to the first frame member 21 such that the second edge of the second main surface 12 of the substrate is covered by the second frame member 22, particularly entirely covered by the second frame member. For example, in the case of a rectangular substrate, all four side edges of the second main surface of the rectangular substrate may be covered by the second frame member.

[0091] The width (second distance D2) of the edge region 15 of the substrate which is covered by the carrier may be 1 mm or more and/or 30 mm or less, particularly 3 mm or more and/or 15 mm or less. In some implementations, e.g. in the case of substrates to be used for color filters and touch panel applications, the width of the edge region 15 of the substrate which is covered by the carrier in order to not be coated may be 3 mm or more and 8 mm or less.

[0092] In some implementations, the edge region 15 of the substrate may be sandwiched between the first frame member and the second frame member. A third distance D3 between the first frame member 21 and the second frame member 22 in a region configured for reception of the substrate edge region 15 may essentially correspond to the thickness of the substrate (+/-20%), which may be 5 mm or less, particularly 3 mm or less. For example, the substrate edge region 15 may be clamped between the first and second frame members, as is indicated in FIG. 7.

[0093] In some embodiments, which may be combined with other embodiments described herein, a first outer surface 26 of the first frame member 21 which frames the first main surface 11 of the substrate and which is directed essentially in the same direction as the first main surface 11 does not have any sharp edges and/or discontinuities. For example, a thickness of the first frame member 21 may gradually increase in a radial direction R. The radial direction R extends parallel to the substrate main surfaces from the center of the substrate in an outward direction. In particular, sharp edges, discontinuities, moveable parts arranged at the first outer surface 26 in the vicinity of the exposed substrate surface 11 would lead to a flaking off of the coating which may adhere to the first outer surface 26 of the first frame member during processing. Sharp surface edges adjacent to the substrate surface to be coated may lead to a deterioration of the coating layer and to particle forming on the substrate.

[0094] Similarly, in some embodiments, a second outer surface 27 of the second frame member 22 which frames the second main surface 12 of the substrate does not have any sharp edges and/or discontinuities, in order to prevent flaking off of the coating from the second outer surface 27. For example, a thickness of the second frame member 22 may gradually increase in a radial direction R. Coating quality may be improved.

[0095] In some embodiments, the first outer surface 26 of the first frame member may be symmetric to the second outer surface 27 of the second frame member, wherein the substrate may constitute the symmetry plane. In particular, edge exclusion on the first main surface may essentially correspond to edge exclusion on the second main surface and/or the profile of the first frame member in the vicinity of the substrate may correspond to the profile of the second frame member.

[0096] As is illustrated in FIG. 7, the thickness of both the first frame member 21 and the second frame member 22 may gradually increase in a radial direction from the inner edge of the respective frame member. Further, no projecting fixing device, e.g. a clamp, clip, or bracket for holding the substrate on the carrier should be provided on either side of the substrate. This is because projecting fixing devices may deteriorate the coating quality, as the coating may flake off therefrom and fall onto the coated substrate surface. For example, the substrate may simply be sandwiched between the first and second frame members in at least one of a form-fit and force-fit connection.

[0097] FIG. 8A shows an explosive view of a carrier 20 configured for holding a large area substrate 10. FIG. 8B shows a front view of the carrier 20 of FIG. 8A, and FIG. 8C shows a rear view of the carrier 20 of FIG. 8A.

[0098] The carrier 20 may include a first frame member 21 configured to cover and hold an edge of the first main surface of the substrate, and the carrier may include a second frame member 22 configured to cover and hold an edge of the second main surface of the substrate. In some implementations, the first frame member 21 may be configured to be transported by a transport device in a vertical orientation. For example, the first frame member 21 may include a support rail 25 at a lower end thereof to be supported on one or more rollers or tracks of a transport device. Alternatively or additionally, the first frame member 21 may include a guiding rail 126 at an upper end thereof to be guided by a guiding device of the transport device.

[0099] The second frame member 22 of the carrier 20 may include four flat bars in a rectangular setup which fit into a corresponding circumferential recess of the first frame member 21 configured to receive the edge of the substrate. When attaching the substrate to the carrier, the edge of the substrate is arranged in the circumferential recess of the first frame member, whereupon the second frame member is arranged on top of the edge of the substrate. The carrier can then be arranged in an essentially vertical orientation and transported along the transport path through the vacuum chamber 1.

[00100] In some embodiments, the carrier 20 may have a different setup. For example, the carrier may be provided as an electrostatic chuck carrier.

[00101] FIG. 9A shows a schematic front view of a path switching module 900 according to embodiments described herein. FIG. 9B shows the path switching module 900 of FIG. 9A in a schematic side view. The path switching module 900 may, e.g., be used in any of the processing systems shown in FIGS. 1, 2, 3, or 5.

[00102] The path switching module 900 may comprise a path switching device 3, 103, 104 according to any of the previously described embodiments. For example, the path switching device 3 may be configured for transferring the carrier 20 together with the substrate 10 from a first transport path section T1 in a vacuum chamber 1 to a second transport path section T2 in the vacuum chamber 1 laterally offset from the first transport path section such that an orientation of the substrate 10 before transfer corresponds to the orientation of the substrate 10 after transfer. Further, the path switching module 900 may include a carrier 20 configured to hold the substrate 10 such that the first main surface 11 and the second main surface 12 of the substrate can be processed.

[00103] The path switching device 3 shown in FIG. 9A and FIG. 9B is configured to move the carrier 20 together with the substrate 10 in a path switching direction S which is perpendicular to the first transport path section T1 and the second transport path section T2.

[00104] In some embodiments, which may be combined with other embodiments described herein, the path switching device 3 may comprise a movable enclosure which is located arranged inside the vacuum chamber 1. The movable enclosure may be movable in the path switching direction S (left-right-direction in FIG. 9A, and perpendicular to the

paper plane in FIG. 9B). In some implementations, the movable enclosure may be an atmosphere box 910 (ATM-box).

[00105] The atmosphere box 910 may be provided with two or more rollers, e.g. with four rollers 912, so that the atmosphere box 910 can be moved on tracks 914 which are provided inside the vacuum chamber 1 and which extend in the path switching direction S. Further, a drive, e.g. a second electric motor M2, may be provided inside the atmosphere box 910 for rotating the rollers 912 so that the atmosphere box moves from the first transport path section T1 which is depicted on the left side in FIG. 9A to the second transport path section T2 which is depicted on the right side in FIG. 9A.

[00106] For example, two rollers 912 which are arranged on opposite sides of the atmosphere box 910 on a respective track 914 may be connected by an axle extending through the atmosphere box, respectively (see FIG. 9B), wherein the axle can be driven by the motor M2 via respective gears.

[00107] The pressure within the atmosphere box 910 may be higher than the pressure inside the path switching area 5 of the vacuum chamber 1. For example, the pressure in the atmosphere box may be 100 mbar or more, or the pressure may correspond to atmosphere pressure (approx. 1 bar). The atmosphere box may be provided as a gas-tight enclosure so that the pressure inside the path switching area 5 of the vacuum chamber 1 can be held at process pressure, in particular as low as appropriate, e.g. below 1 mbar or below 1 10^{-5} bar, in spite of the higher pressure within the atmosphere box 910.

[00108] In some implementations, the atmosphere box 910 is connected to the outside of the vacuum chamber 1 via at least one flexible connection, e.g. a vacuum tight hose. Supply lines, e.g. electric supply lines, control lines, fluid lines such as water hoses and/or gas lines such as compressed air lines may be fed through the flexible connection into the atmosphere box 910.

[00109] In some implementations, carrier transport rollers 920 for supporting the carrier 20 on the atmosphere box 910 may be provided. The carrier transport rollers 920 may be arranged outside the atmosphere box, e.g. on an outer side wall of the atmosphere box. Each carrier transport roller 920 may be held on a respective axis which may penetrate through the side wall of the atmosphere box via a gas-tight connection. The carrier transport

rollers 920 may be configured to move the carrier with respect to the atmosphere box 910 in the first transport direction and in the second transport direction which may be perpendicular to the path switching direction S. During transfer from the first transport path section T1 to the second transport path section T2, the carrier may be supported on the carrier transport rollers 920 which are standing still during transport.

[00110] A further drive, e.g. a first electric motor M1, for driving the carrier transport rollers 920 may be arranged inside the atmosphere box 910. The carrier transport rollers 920 may transport the carrier onto the atmosphere box 910 along the first transport path section T1 before transfer, and the carrier transport rollers 920 may move the carrier off the atmosphere box 910 along the second transport path section T2 after transfer. Geared belt drives may be provided for driving the carrier transport rollers 920. FIG. 9B shows an atmosphere box 910 provided with four carrier transport rollers 920. In dependence of the substrate size, more or less than four carrier transport rollers 920 may be provided.

[00111] The carrier 20 may be provided in accordance with any of the carriers disclosed herein, e.g. the carrier 20 described with reference to FIG. 8A. Details are not repeated here.

[00112] FIG. 10A shows a schematic front view of a path switching module 950 according to embodiments described herein. FIG. 10B shows the path switching module 950 of FIG. 10A in a schematic side view.

[00113] The path switching module 950 includes a path switching device 3 which is configured to transfer the carrier 20 together with the substrate 10 from the first transport path section T1 in the vacuum chamber 1 to the second transport path section T2 in the vacuum chamber 1 along a path switching direction S. Further, the path switching module 950 includes a carrier 20 configured to hold the substrate 10 such that a first main surface 11 and a second main surface 12 of the substrate can be processed, e.g. coated with one or more coating layers.

[00114] In some embodiments, which may be combined with other embodiments described herein, the path switching device 3 may include a movable enclosure which is arranged inside the vacuum chamber 1. The movable enclosure may be movable in the path switching direction S (left-right-direction in FIG. 10A, and perpendicular to the paper plane

of FIG. 10B). In some implementations, the movable enclosure may be an atmosphere box 910 (ATM-box). Reference is made to the explanations with view to the ATM-box shown in FIG. 9A and FIG. 9B which are not repeated here.

[00115] The atmosphere box 910 may be laterally displaceable in the path switching direction S together with the carrier 20 supported thereon. The drive for moving the atmosphere box in the path switching direction S may, e, g, be or include an electric motor, a magnetic drive, a contactless drive.

[00116] The atmosphere box 910 may be provided with two or more rollers, e.g. with four rollers 912, so that the atmosphere box 910 can be moved on tracks 914 which are provided inside the vacuum chamber 1, e.g. on the floor of the vacuum chamber 1, and which may extend along the path switching direction S. Further, a drive may be provided for moving the atmosphere box 910 between the first transport path section T1 which is depicted on the left side of FIG. 10A and the second transport path section T2 which is depicted on the right side of FIG. 10A.

[00117] The drive for moving the atmosphere box in the path switching direction S may be a contactless drive 960, e.g. a magnetic force drive. For example, a magnetic force may act between a first magnetic element 961, e.g. a magnet or a ferromagnetic element, arranged on the atmosphere box and a second magnetic element 962, e.g. a ferromagnetic element or a magnet, which is movable with respect to the atmosphere box 910 so that the atmosphere box follows the movement of the second magnetic element 962. The second magnetic element 962 may be movable via an electric motor arranged outside the vacuum chamber 1.

[00118] In the embodiment shown in FIG. 10A, the contactless drive 960 for moving the atmosphere box 910 includes a magnet piston (second magnetic element 962) arranged in a tubular passage, e.g. in tube 963, which extends through the vacuum chamber 1 along the path switching direction S. The tube 963 may be welded between two opposing outer side walls of the vacuum chamber 1. The interior of tube 963 may be open to the atmosphere. The magnet piston which is arranged inside the tube 963 may be movable

through the tube 963 in the path switching direction S essentially frictionless. For example, the inner wall of the tube 963 may be coated with a friction-reduction coating, e.g. PTFE.

[00119] The magnet piston may be driven by an (endless) drive belt, which may extend through the tube 963 and be connected to a drive, e.g. an electric motor (third electric motor M3), arranged outside the vacuum chamber 1. In some implementations, the drive belt may be redirected via several deflector rolls, so that the drive belt may enter the tube 963 on both sides and be fixed to both sides of the magnet piston (second magnetic element 962) inside the tube 963. The third motor M3 may be connected to one of the deflector rolls, e.g. to deflector roll 965.

[00120] A rotation of the deflector roll 965 via the third motor M3 leads to a movement of the drive belt, so that the second magnetic element 962 moves through the tube 963 in the path switching direction.

[00121] The atmosphere box 910 may be provided with a passage 964 for the tube 963. A small gap may be provided between the outer wall of the tube 963 and the inner wall of the passage 964. In some embodiments, the passage 964 may be connected to the atmosphere box in a vacuum tight connection and/or may be concentric with respect to the tube 963.

[00122] In some implementations, the first magnetic element 961 may be arranged outside the atmosphere box, e.g. fixed to an outer wall of the atmosphere box. In this case, no passage 964 through the atmosphere box 910 may be provided.

[00123] Further, the first magnetic element 961, e.g. a ferromagnetic sleeve such as an iron sleeve, which is fixed to the atmosphere box 910 may enclose the tube 963 at a distance from the tube 963. For example, the first magnetic element 961 may be fixed to a wall of the passage 964.

[00124] When the magnet piston moves inside the tube 963, the iron sleeve which is fixed to the atmosphere box 910 follows said movement, so that the atmosphere box 910 will move along the path switching direction S together with the carrier 20 supported thereon.

[00125] In some implementations, the tube 963 may alternatively be arranged on a side or below the atmosphere box 910. Arranging the tube 963 below the atmosphere box may have the advantage that vacuum feedthroughs and/or vacuum sealing for the rollers 912 of the ATM-box and/or no passage 964 may be avoided.

[00126] FIG. 11 shows a flow diagram of a method of two-side processing of a substrate in a vacuum chamber according to embodiments described herein. In box 1201, the substrate 10 is attached to the carrier for holding the substrate during transport. In box 1202, the carrier is transported along the first transport path section T1 through the first processing area 2, where the first main surface of the substrate 10 is processed, e. g. coated. In box 1203, the carrier is transferred from the first transport path section T1 to the second transport path section T2 laterally offset from the first transport path section. In box 1204, the carrier is transported along the second transport path section T2 through the second processing area 4, where the second main surface of the substrate is processed, e.g. coated.

[00127] In some implementations, transferring the carrier may include moving the carrier together with the substrate from the first transport path section to the second transport path section such that an orientation of the substrate after the movement corresponds to the orientation of the substrate before the movement.

[00128] For example, transferring the carrier may include laterally displacing the carrier together with the substrate from the first transport path section to the second transport path section in a path switching direction, wherein the path switching direction S may be perpendicular to the first and second transport path sections.

[00129] For example, transferring the carrier may include a sequence of at least two rotational movements of the carrier together with the substrate.

[00130] In some implementations, transferring the carrier may include moving the carrier together with the substrate from the first transport path section to the second transport path section such that an orientation of the substrate after the movement is inverted with respect to the orientation of the substrate before the movement. For example, the first main surface of the substrate after transfer may be directed in an opposite direction as compared to the situation before the transfer. In some embodiments, transferring the carrier

may include a single rotational movement of the carrier along a curved or semicircular path switching path, so that the substrate is inverted by 180° after the transfer. In this case, the first main surface of the substrate may be processed again, e.g. coated with further layers.

[00131] According to a further aspect of the present disclosure, a carrier 20 is provided, wherein the carrier may be configured for holding a large area substrate during transport, and wherein the carrier is configured such that two-side processing of the substrate is possible while the substrate is held by the carrier. Reference is made to the above details, particularly the explanation with view to Figures 6 to 8.

[00132] While the foregoing is directed to embodiments of the disclosure, other and 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. A method of two-side processing of a substrate in a vacuum chamber (1), comprising:

attaching a substrate (10) to a carrier (20) for holding the substrate during transport;

transporting the carrier (20) along a first transport path section (T1) through a first processing area (2), where a first main surface (11) of the substrate is processed;

transferring the carrier (20) from the first transport path section (T1) to a second transport path section (T2) laterally offset from the first transport path section; and

transporting the carrier (20) along the second transport path section (T2) through a second processing area (4), where a second main surface (12) of the substrate is processed,

wherein transferring the carrier comprises moving the carrier (20) together with the substrate from the first transport path section (T1) to the second transport path section (T2).

2. The method of claim 1, wherein the carrier is moved together with the substrate from the first transport path section (T1) to the second transport path section (T2) such that an orientation of the substrate (10) after the movement corresponds to the orientation of the substrate before the movement.

3. The method of claim 1 or 2, wherein the carrier is transported along the first transport path section (T1) in a first transport direction and along the second transport path section (T2) in a second transport direction opposite to the first transport direction.

4. The method of any of claims 1 to 3, wherein transferring the carrier comprises laterally displacing the carrier together with the substrate from the first transport path section to the second transport path section in a path switching direction (S).

5. The method of any of claims 1 to 3, wherein transferring the carrier comprises a sequence of at least two rotational movements (R1, R2) of the carrier together with the substrate.

6. The method of claim 5, wherein a first rotational movement (R1) comprises moving the carrier together with the substrate around a pivot axis (A1) which extends at a center position between the first and the second transport path sections, and wherein a second rotational movement (R2) comprises inverting the substrate by rotating the carrier together with the substrate around a rotation axis (A2).

7. The method of any of claims 1 to 6, wherein attaching the substrate (10) to the carrier (20) comprises placing the substrate (10) on a first frame member (21) such that a first edge of the first main surface (11) of the substrate is covered by the first frame member, and attaching a second frame member (22) to the first frame member such that a second edge of the second main surface (12) of the substrate is covered by the second frame member, or vice versa.

8. A processing system (100, 150, 200, 300) for two-side processing of a substrate (10), comprising:

a vacuum chamber (1) comprising at least a first processing area (2) and a second processing area (4);

at least one carrier (20) configured for holding a substrate;

a first transport device configured for transporting the carrier (20) through the first processing area (2) along a first transport path section (T1) for processing of a first main surface (11) of the substrate, and a second transport device configured for transporting the carrier (20) through the second processing area (4) along a second transport path section (T2) for processing of a second main surface (12) of the substrate, wherein the second transport path section (T2) is laterally offset from the first transport path section (T1); and

a path switching device (3, 103) for transferring the carrier together with the substrate from the first transport path section (T1) to the second transport path section (T2).

9. The processing system of claim 8, wherein the path switching device is configured to transfer the carrier together with the substrate from the first transport path section (T1) to the second transport path section (T2) such that an orientation of the substrate before transfer corresponds to the orientation of the substrate after transfer.

10. The processing system of claim 8 or 9, further comprising at least one first coating device (41) arranged in the first processing area (2) for coating the first main surface (11) of the substrate and at least one second coating device (43) arranged in the second processing area (4) for coating of the second main surface (12) of the substrate, particularly wherein the first coating device (41) is arranged between the first transport path section (T1) and a first outer side wall (45) of the vacuum chamber and wherein the second coating device (43) is arranged between the second transport path section (T2) and a second outer side wall (46) of the vacuum chamber (1) opposite to the first outer side wall (45).

11. The processing system of any of claims 8 to 10, wherein the path switching device (3) is configured to laterally displace the carrier (20) together with the substrate from the first transport path section (T1) to the second transport path section (T2) in a path switching direction (S).

12. The processing system of any of claims 8 to 11, wherein the path switching device (3) comprises an enclosure, particularly an atmosphere box, located within the vacuum chamber (1), wherein the enclosure is laterally displaceable in the path switching direction (S) together with the carrier (20), and wherein a drive configured to transport the carrier (20) to and from the path switching device is arranged within the enclosure.

13. The processing system of any of claims 8 to 10, wherein the path switching device (103) comprises a rotation module for rotating the substrate, particularly for moving the substrate around a pivot axis (A1) which extends at a center position between the first transport path section and the second transport path section and/or for inverting the substrate by rotating the substrate around a rotation axis (A2).

14. The processing system of any of claims 8 to 13, wherein the carrier (20) comprises a first frame member (21) configured to cover a first edge of the first main surface (11) of the substrate and a second frame member (22) configured to cover a second edge of the second main surface (12) of the substrate, particularly wherein the first frame member (21) and the second frame member (22) are configured to provide for a circumferential edge exclusion of both the first main surface and the second main surface.

15. A path switching module for a processing device, particularly a processing device

of any of claims 8 to 14, comprising:

a carrier (20) configured to hold a substrate (10) such that a first main surface (11) and a second main surface (12) of the substrate can be processed while the substrate is held by the carrier; and

a path switching device (3, 103) for transferring the carrier together with the substrate from a first transport path section (T1) in a vacuum chamber to a second transport path section (T2) in the vacuum chamber laterally offset from the first transport path section such that an orientation of the substrate (10) before transfer corresponds to the orientation of the substrate after transfer.

Fig. 1

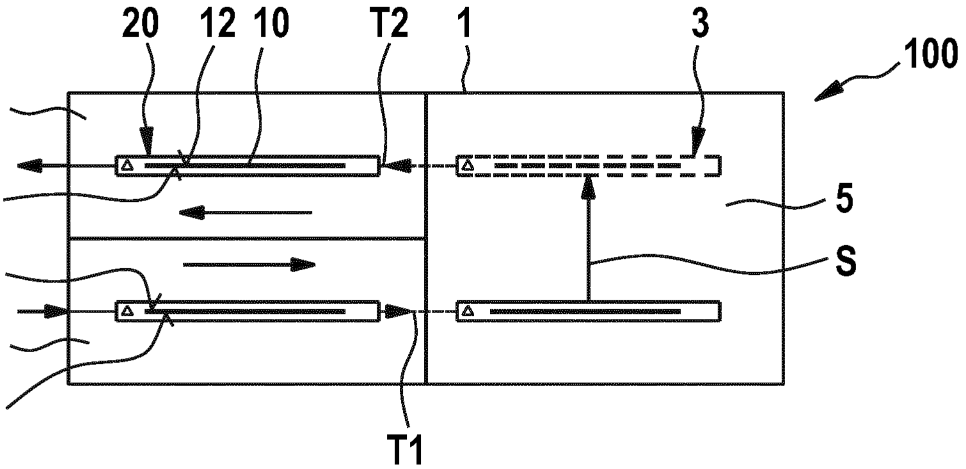


Fig. 2A

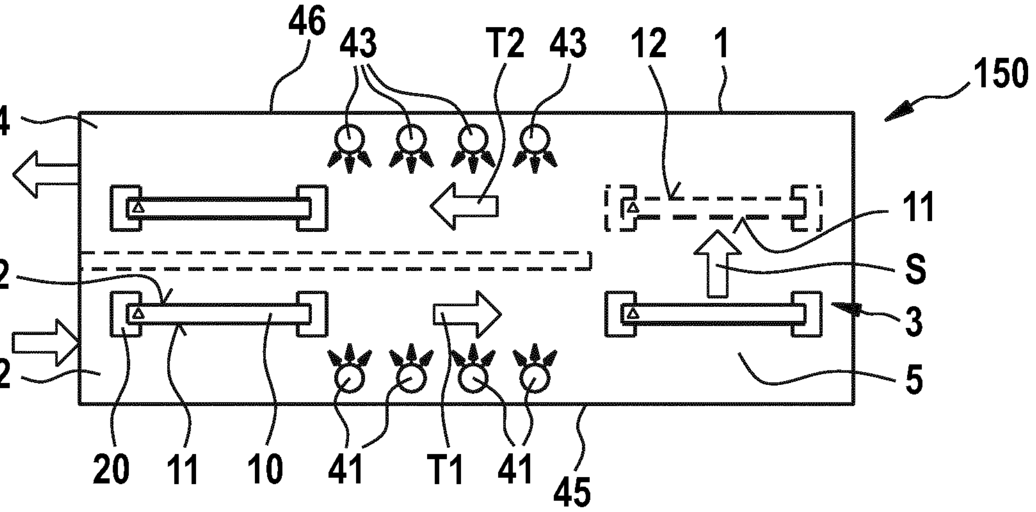


Fig. 2B

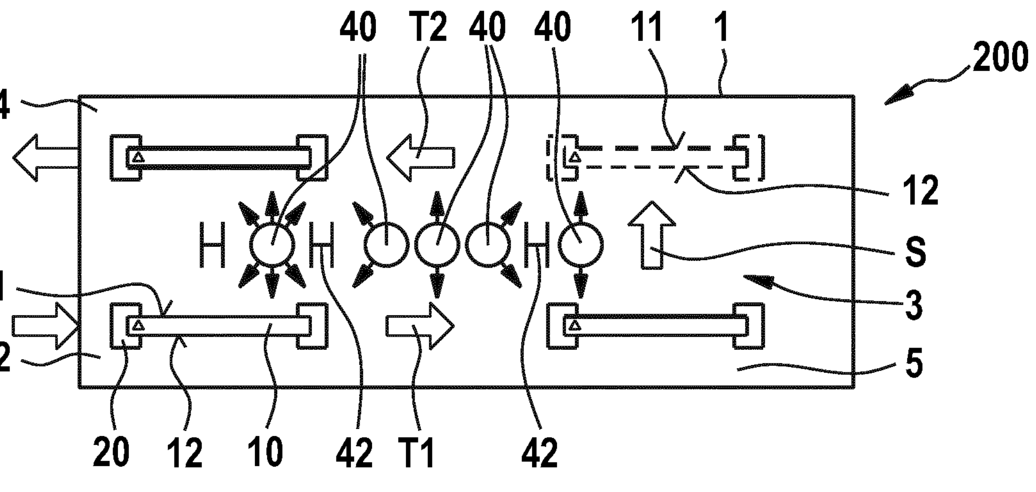


Fig. 3

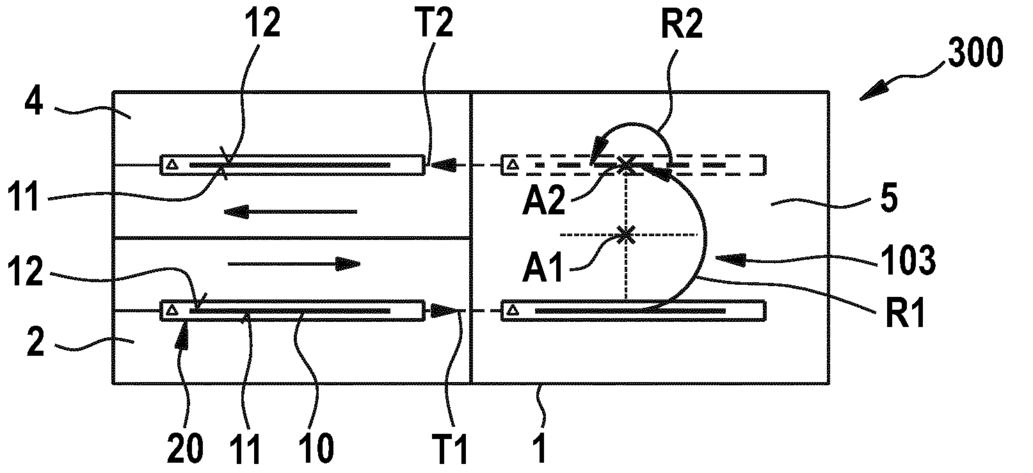


Fig. 4

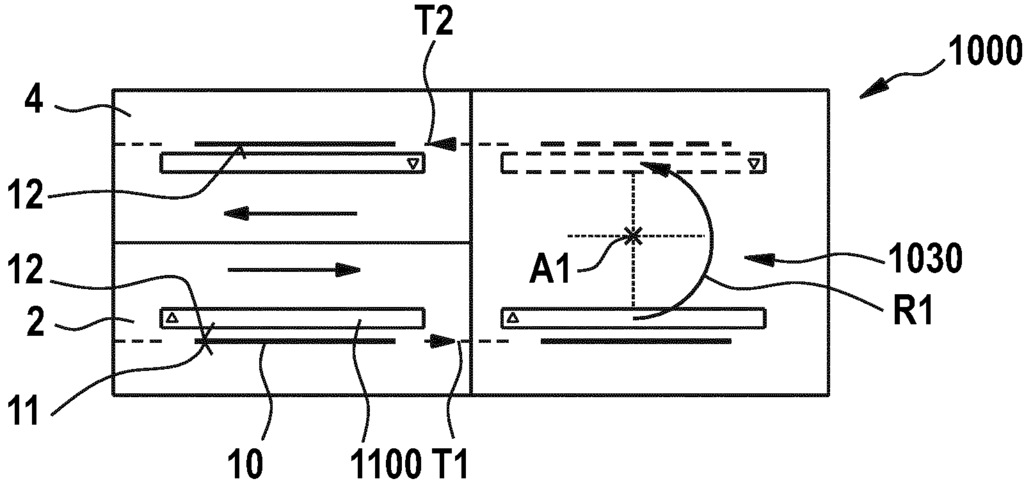


Fig. 5

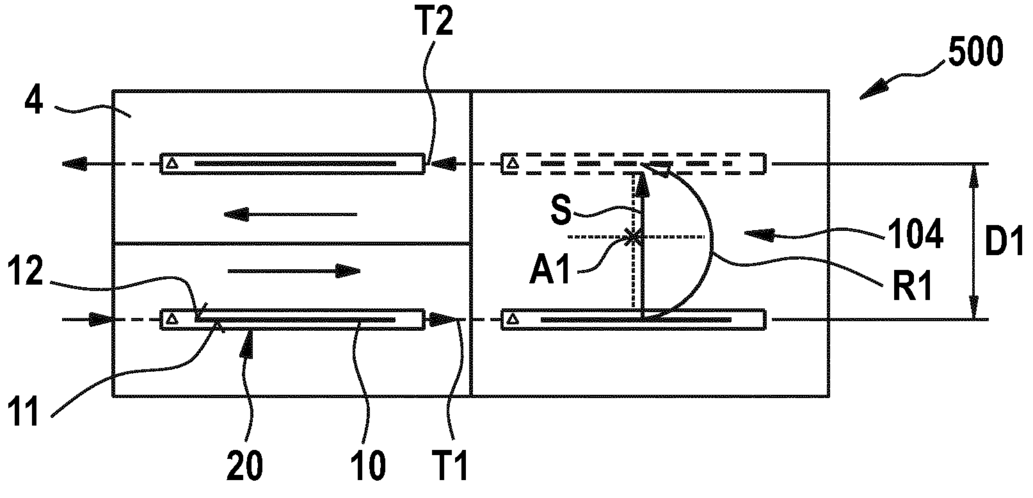


Fig. 6

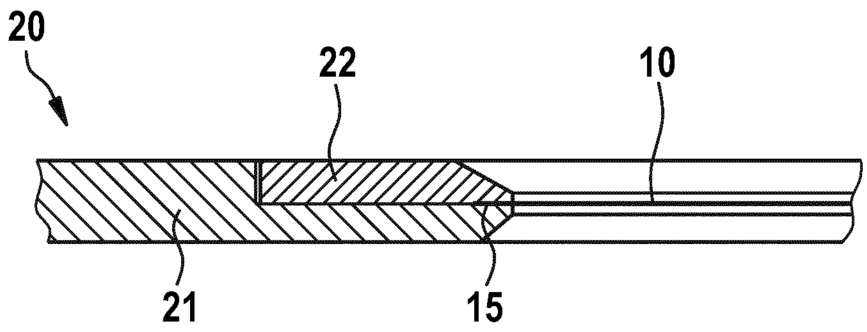


Fig. 7

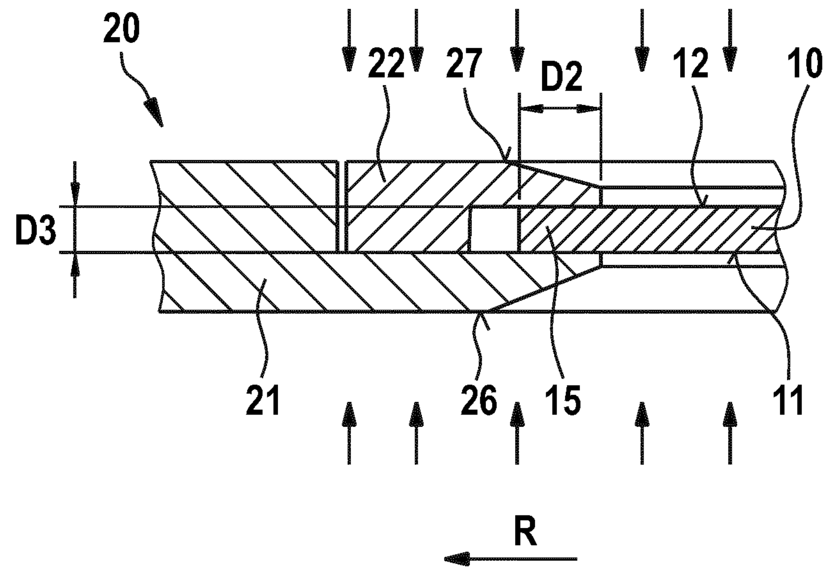


Fig. 8A

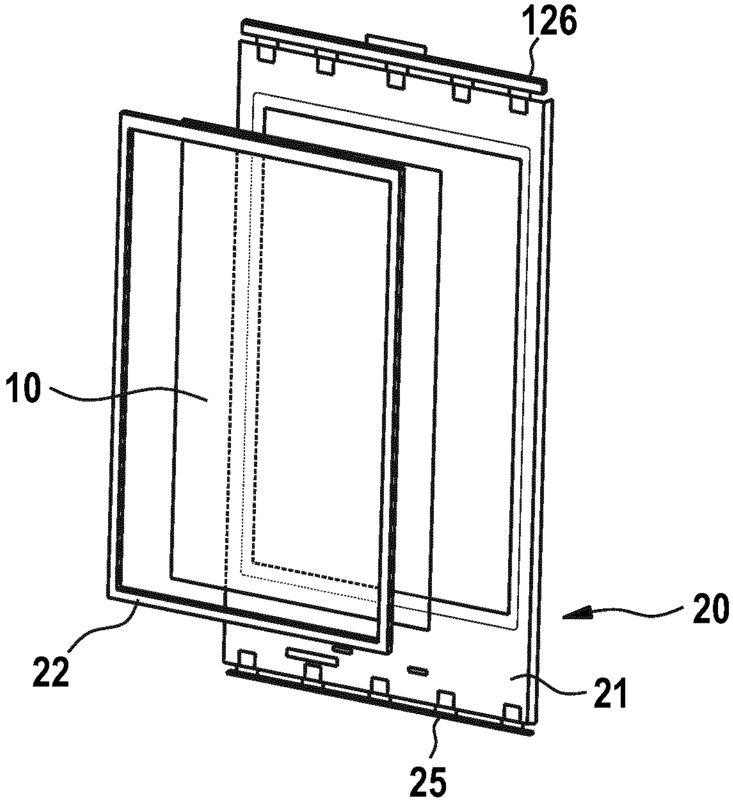


Fig. 8B

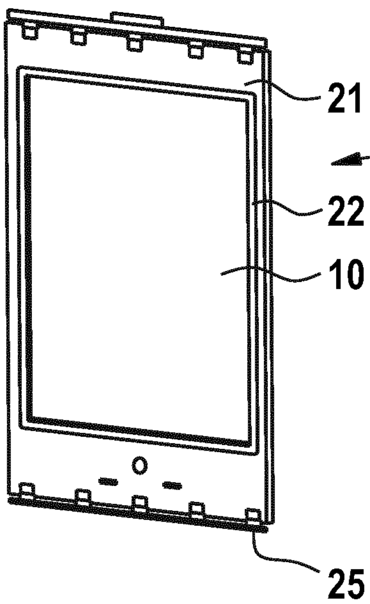


Fig. 8C

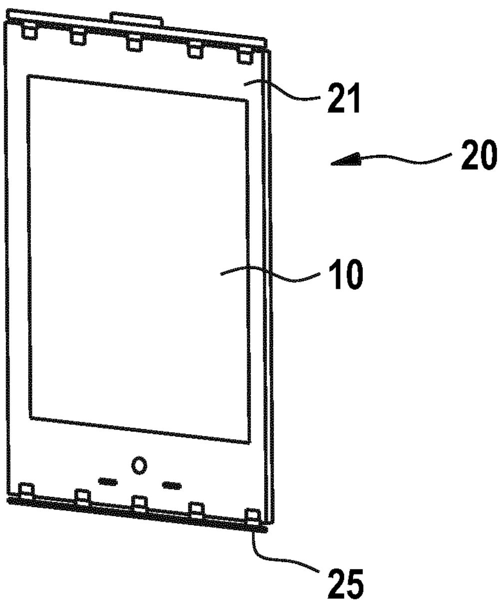


Fig. 9A

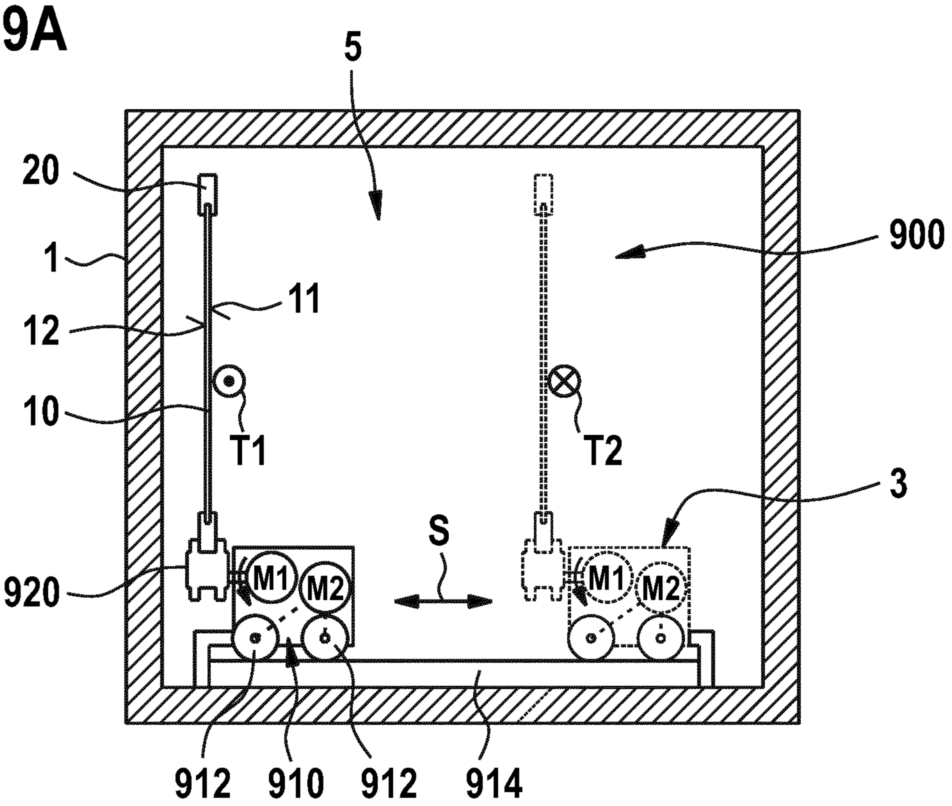
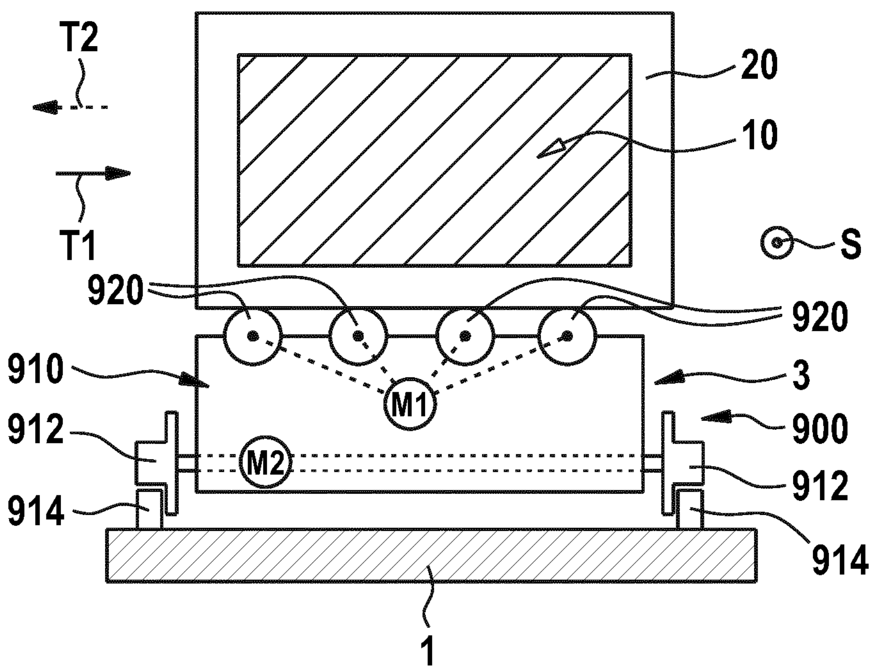

5
20
900
1
11
12
10
T1
T2
3
S
920
M1
M2
M1
M2
912
910
912
914

Fig. 9B


T2
20
10
T1
S
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920
910
3
M1
900
912
M2
912
914
914
1

Fig. 10A

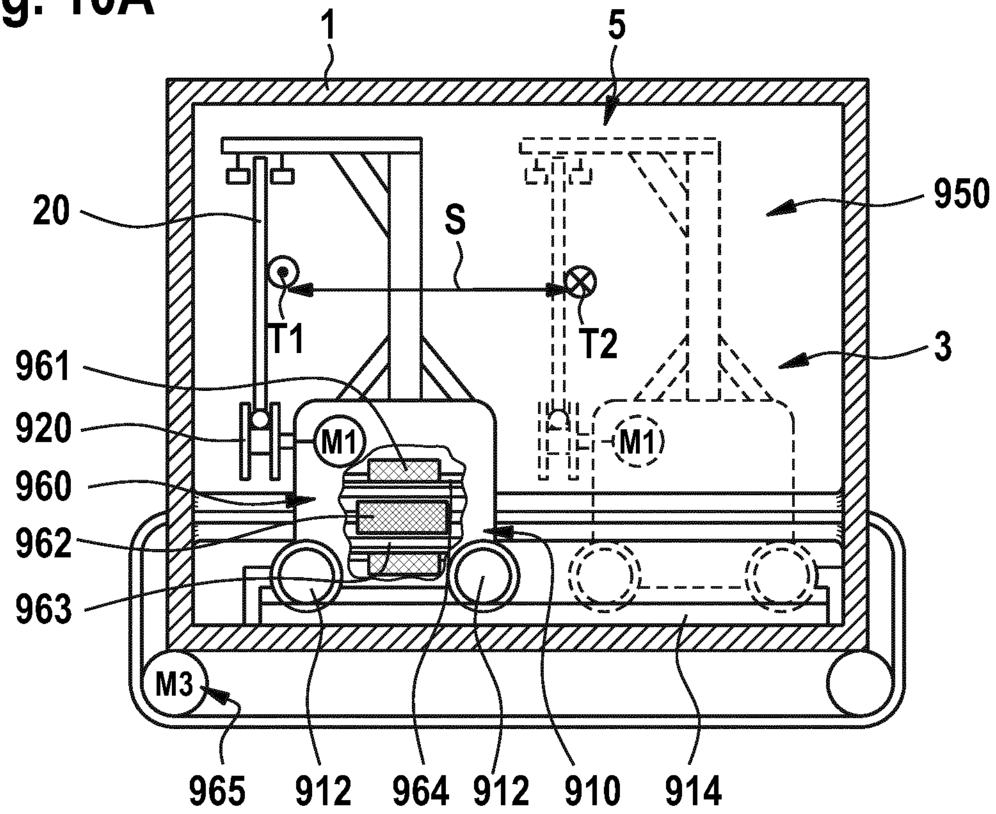


Fig. 10B

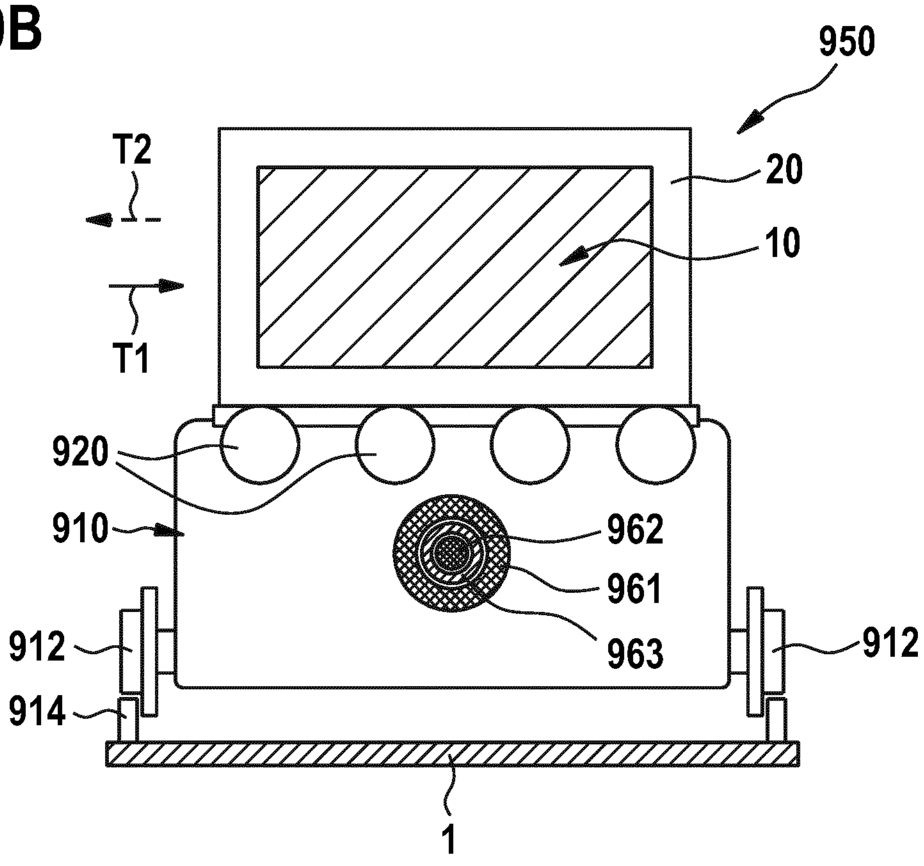
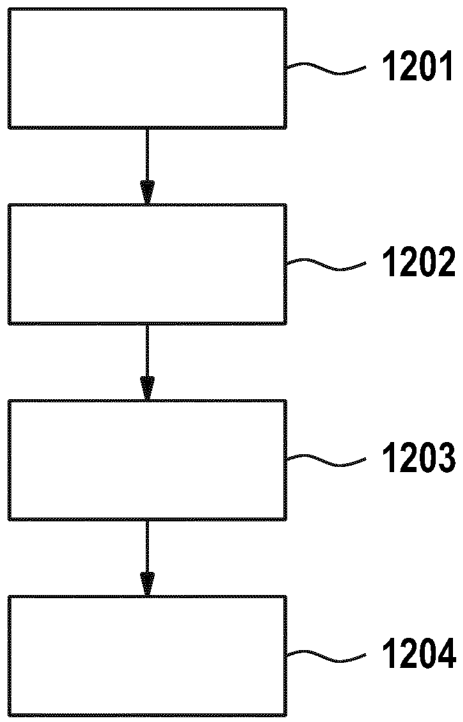


Fig. 11



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/079629

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L21/677 C23C14/56
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 C23C

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 4 261 808 A (WALTER HEINZ) 14 April 1981 (1981-04-14) column 3, line 9 - column 6, line 47; figures 1-5	1-12,14, 15
X	JP 2000 319779 A (SANYO SHINKU KOGYO KK) 21 November 2000 (2000-11-21) figures 1-4 abstract	1-4, 8-11,15
A	US 2015/170947 A1 (BLUCK TERRY [US] ET AL) 18 June 2015 (2015-06-18) figures 7, 24,25 figures 24,25	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

"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	Date of mailing of the international search report
30 August 2016	07/09/2016

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2015/079629

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