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**SWING APPARATUS, METHOD FOR PROCESSING A SUBSTRATE, SWING
MODULE FOR RECEIVING A SUBSTRATE FROM A TRANSFER CHAMBER,
AND VACUUM PROCESSING SYSTEM**

FIELD

[0001] Embodiments of the present disclosure relate to swing apparatuses and modules for moving a substrate relative to one or more deposition sources. Further, the embodiments of the present disclosure relate to methods for processing a substrate and to vacuum processing systems.

BACKGROUND

[0002] Several methods are known for depositing a material on a substrate. For example, substrates may be coated by using an evaporation process, a physical vapor deposition (PVD) process, such as a sputtering process, a spraying process, etc., or a chemical vapor deposition (CVD) process. The process can be performed in a processing chamber of a deposition apparatus where the substrate to be coated is located. A deposition material is provided in the processing chamber. The sputter deposition process can be used to deposit a material layer on the substrate, for example a layer of insulating material. This involves ejecting material from a target onto a substrate. The target material to be deposited on the substrate is bombarded with ions generated in a plasma region to dislodge atoms of the target material from a surface of the target. The dislodged atoms can form the material layer on the substrate. In a reactive sputter deposition process, the dislodged atoms can react with a gas in the plasma region, for example nitrogen or oxygen, to form an oxide, a nitride or an oxynitride of the target material on the substrate. Further, other processes like etching, structuring, annealing, or the like can be conducted in processing chambers.

[0003] For example, coating processes may be considered for large area substrates, e.g. in display manufacturing technology. Coated substrates can be used in several applications and in several technical fields. For instance, applications may include insulating panels,

microelectronics, such as semiconductor devices, substrates with thin film transistors (TFTs), color filters, or the like.

[0004] The tendency towards larger substrates with more complex and thinner coatings results in larger process modules. Vertical process modules connected in series may have some drawbacks due to the footprint, redundancy and costs. For coating of large area substrates, the glass can be aligned with a mask to avoid coating on the glass edge and/or on the back side and to seal the process room from a glass handle area. Clamps hold the substrate on the edges of the substrate during the process. This may lead to issues with particles and uniformity due to glass mask alignments (shadowing effect), and side deposition on the clamps. Further, the deposition of particles generated in the processing chamber outside the target substrate on components of the process modules, for example on moving mechanical elements, could negatively affect the performance and therefore the reliability of said elements.

[0005] In view of the above, there is a need for apparatuses, modules, methods and systems, which can provide for an improved uniformity of the deposited layer as well as for a reduction of particle generation in or close to the processing chamber.

SUMMARY

[0006] A swing apparatus, a method for processing a substrate, swing module for receiving a substrate from a transfer chamber, and vacuum processing system are provided. Further features, details, aspects and modifications can be derived from the dependent claims, the specification and the drawings.

[0007] According to one embodiment, a swing apparatus for moving a substrate relative to one or more deposition sources having a longitudinal axis is provided. The swing apparatus includes a support body for holding the substrate; a rotation mechanism coupled to the support body for moving the substrate by an angle around a rotational axis to vary the substrate orientation from a transfer or horizontal orientation to a processing or vertical orientation at a processing area; and a linear motion mechanism coupled to the support

body for translating the substrate relative to the longitudinal axis of the deposition source when the substrate is in the processing orientation.

[0008] According to another embodiment, a method for processing a substrate is provided. The method includes holding the substrate on a support body; moving the substrate relative to a deposition source for processing the substrate having a longitudinal axis, the movement of the substrate being carried out by an angle around a rotational axis to vary the substrate orientation from a transfer or horizontal orientation to a processing or vertical orientation by a rotation mechanism coupled to the support body; processing a surface of the substrate with the deposition source; and translating the substrate relative to the longitudinal axis of the deposition source, when the substrate is in the processing orientation by a linear motion mechanism coupled to the support body.

[0009] According to another embodiments, a swing module for receiving a substrate from a transfer chamber of a vacuum processing system and for positioning said substrate in a processing area of a processing chamber of the vacuum processing system is provided. The swing module includes a vacuum chamber, a support body for holding the substrate within the vacuum chamber; a rotation mechanism coupled to the support body for moving the substrate by an angle around a rotational axis to vary the substrate orientation from a transfer or horizontal orientation to a processing or vertical orientation; and a linear motion mechanism coupled to the support body for translating the substrate sideways in relation to the longitudinal axis of the deposition source when the substrate is in the processing orientation.

[0010] According to another embodiment, a vacuum processing system for processing a substrate is provided. The system includes at least a processing chamber including a deposition source with a longitudinal axis for processing the substrate; at least a swing module, operatively coupled to the processing chamber, for positioning the substrate in a processing area of the processing chamber; and a transfer chamber operatively coupled to the swing module, for moving the substrate to the swing module. The swing module includes a vacuum chamber; a support body for holding the substrate within the vacuum chamber; a rotation mechanism coupled to the support body for moving the substrate by an angle around a rotational axis to vary the substrate orientation from a transfer or horizontal orientation to a processing or vertical orientation; and a linear motion mechanism coupled

to the support body for translating the substrate sideways in relation to the longitudinal axis of the deposition source, when the substrate is in the processing orientation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] So that the manner in which the above recited features of the present disclosure can be understood in detail, a more particular description of the disclosure, briefly summarized above, may be had by reference to embodiments. The accompanying drawings relate to embodiments of the disclosure and are described in the following:

FIG. 1 shows a schematic view of a swing apparatus for moving a substrate relative to a deposition source:

FIG. 2A shows a schematic upper view of the swing apparatus of FIG. 1;

FIG. 2B shows a schematic rear view of the swing apparatus of FIG. 1;

FIG. 2C shows an exploded schematic view of the swing apparatus;

FIG. 3 shows a schematic view of a swing module including a swing apparatus;

FIG. 4 shows a schematic side view of a vacuum processing system;

FIG. 5 shows a schematic upper view of a vacuum processing system; and

FIG. 6 shows a flow diagram of a method for processing a substrate.

DETAILED DESCRIPTION OF EMBODIMENTS

[0012] Reference will now be made in detail to the various embodiments of the disclosure, one or more examples of which are illustrated in the figures. Within the following description of the drawings, the same reference numbers refer to same components. Only the differences with respect to individual embodiments are described. Each example is provided by way of explanation of the disclosure and is not meant as a

limitation of the disclosure. Further, features illustrated or described as part of one embodiment can be used on, or in conjunction with, other embodiments to yield yet a further embodiment. It is intended that the description includes such modifications and variations.

[0013] 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.

[0014] The embodiments described herein can be utilized for inspecting large area coated substrates, e.g., for manufactured displays. The substrates or substrate receiving areas for which the apparatuses and methods described herein are configured can be large area substrates having a size of e.g. 1 m² or above. For example, a large area substrate or carrier can be GEN 4.5, which corresponds to about 0.67 m² substrates (0.73x0.92m), GEN 5, which corresponds to about 1.4 m² substrates (1.1 m x 1.3 m), GEN 7.5, which corresponds to about 4.29 m² substrates (1.95 m x 2.2 m), GEN 8.5, which corresponds to about 5.7m² substrates (2.2 m x 2.5 m), or even GEN 10, which corresponds to about 8.7 m² substrates (2.85 m x 3.05 m). Even larger generations such as GEN 11 and GEN 12 and corresponding substrate areas can similarly be implemented. For example, for OLED display manufacturing, half sizes of the above mentioned substrate generations, including GEN 6, can be coated by evaporation of an apparatus for evaporating material. The half sizes of the substrate generation may result from some processes running on a full substrate size and subsequent processes running on half of a substrate previously processed.

[0015] The term "substrate" as used herein may particularly embrace substantially inflexible substrates, 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 embrace flexible substrates such as a web or a foil. According to embodiments, which can be combined with any other embodiments described herein, the substrate can be made from any material suitable for material deposition. For instance, the substrate can be made from a material selected from the group consisting of glass, such as soda-lime glass or borosilicate glass, metal, polymer, ceramic, compound materials, carbon fiber material, mica or any other material or combination of materials capable of being coated by a deposition process. For example a thickness of the substrate in a direction perpendicular to the main surface of the substrate can be within a range from 0.1 mm to 1.8

mm, such as 0.7 mm, 0.5 mm, or 0.3 mm. In some embodiments, the thickness of the substrate may be 50 μm or more. The thickness of the substrate can be 900 μm or less.

[0016] FIG. 1 shows a schematic side view of a swing apparatus 10 according to an embodiment of the present disclosure. The swing apparatus 10 is used for moving a substrate 20 relative to a deposition source 30. The deposition source 30 has a longitudinal axis 31 and is intended for processing the substrate 20, in particular for processing one surface of the substrate 20, i.e. the front surface. According to some embodiments, one or more vertically oriented sputter sources may be provided. According to some embodiments of the present disclosure, which can be combined with other embodiments described herein, a deposition source may be a line source. For example, one or more rotatable sputter cathodes can be provided. A rotatable sputter cathode may have a cylindrical target, such as a target of the material to be deposited. Two or more sputter cathodes may form an array. An array of rotational cathodes may generate a ripple for the coated material layer.

[0017] The swing apparatus 10 includes a support body 40 for holding the substrate 20. For example, the back surface of the substrate 20, opposite to the front surface, treated by the deposition source 30, is in contact with the support body 40. The swing apparatus 10 further includes a rotation mechanism 42 coupled to the support body 40 for moving the substrate 20 by an angle 12 around a rotational axis 44 from a transfer or horizontal orientation I to a processing or vertical orientation II at a processing area. In addition, the swing apparatus 10 includes a linear motion mechanism 46 coupled to the support body 40 for translating the substrate 20 sideways relative to the longitudinal axis 31 of the deposition source 30, when the substrate 20 is in the processing orientation II (better described in FIG. 2A and 2B).

[0018] The movement of the support body 40 can be described by a rotation around a joint 43 arranged at the rotation mechanism 42, wherein the joint 43 forms an axis 44 of rotation. The movement of the support body 40 can also be understood as a folding up or a flap up movement. The dashed contours 10' in FIG. 1 show the support body 40 being moved around the angle 12, e.g. about 90 degrees, from a transfer or horizontal orientation I to a processing or vertical orientation II. With the term "transfer orientation" is intended to describe an orientation, wherein the front surface of substrate 20 is directed upwards so

that the substrate 20 can easily be transferred to or from another chamber. With the term "processing orientation" is intended to describe an orientation, wherein the front surface of the substrate 20 faces the deposition source 30 so that target material can be deposited on the substrate 20. The arrows 32 in FIG. 1 show the direction of the ejected material or ions from the source.

[0019] The substrate 20 is moved by angle 12, e.g. by a rotation about an axis 44, into a processing area 72. The movement of the substrate 20 by an angle 12 into a processing area 72 can be described as including an angular displacement. In embodiments, the movement of the substrate 20 by an angle 12 can include a translation motion. For example, the axis of rotation can be offset to an edge of the substrate providing for a translational movement during movement of the substrate by the angle. The axis of rotation may additionally be displaced, in particular towards the processing area 72. A support body 40 configured to move the substrate 20 by an angle 12 can be understood as a rotatable mounted support body 40 configured at least to rotate or swing around an axis 44, e.g. around a joint 43 to change the orientation of the substrate surface being attached to the support body 40.

[0020] According to embodiments, which can be combined with other embodiments described herein, the support body 40 is configured to move the substrate 20 from a non-vertical orientation I to a non-horizontal orientation II. A non-vertical orientation I can be understood particularly when referring to the substrate 20 orientation, to allow for a deviation from the horizontal direction or orientation of ± 20 degrees or below, e.g. ± 10 degrees below. Likewise, a non-horizontal orientation II can be understood to allow for a deviation from the vertical direction or orientation of ± 20 degrees or below, e.g. ± 10 degrees below. A deviation from a vertical orientation II of a substrate support might result in a more stable substrate orientation, e.g. during a substrate processing, in particular during a layer deposition process. Furthermore, it can be beneficial to have a deviation of a horizontal orientation I of the substrate to facilitate the transport and/or the alignment of the substrate 20, in particular before moving the substrate 20 in a processing area 72.

[0021] FIG. 2A and 2B show the swing apparatus of FIG. 1 according to an upper view and a rear view, respectively. It is noted that the support body 40 and therefore the substrate 20 can be translated sideways relative to the deposition source 30 and specifically relative to the longitudinal axis 31 of said deposition source 30. The double arrows 14 of

the figures indicate that the support body 40 can translate on the right side and on the left side of the deposition source 30. The sideways translation is carried out when the substrate 20 is in the processing orientation II, i.e. when the front surface of the substrate 20 faces the deposition source 30. In particular, the movement is made possible by the actuation of the linear motion mechanism 46 that is coupled to the support body 40 and is located below the rotation mechanism 42.

[0022] The sideways movement of the substrate 20 relative to the deposition source 30 allows for an improved uniformity of the deposited layer. For example, a ripple of a deposition source array may be removed by the movement of the substrate in a direction perpendicular to the axes of the deposition sources, e.g. line sources. This may be confirmed by several measurement techniques, like microwave photoconductivity decay measurements (μ PCD) or X-ray methods. For example, the μ PCD can be an indicator for single layer uniformity tuning.

[0023] The movement of the substrate 20 by an angle 12 into a processing area 72 can be described as a substantially angular displacement. In embodiments, the movement of the substrate 20 by an angle 12 can have a portion of a translation motion. With reference to FIG. 1, the support body 40 can be moved by a translation movement aligned with a horizontal direction and by an angle 12 about an axis of rotation towards the processing area 72. In other words, the support body 40 is configured to move the substrate 20 in a horizontal linear direction perpendicular to the longitudinal axis 31 of the deposition source 30 during the movement from the transfer orientation I to the processing orientation II and vice versa, and providing a linear offset 48 between the edge of the substrate 20 facing to the processing area 72 and the longitudinal axis 31 of the deposition source 30.

[0024] As shown in FIG. 1 and FIG. 2B, the rotation mechanism 42 is located above the linear motion mechanism 46. In particular, the rotation mechanism 42 is supported by the linear motion mechanism 46. This leads to the advantage of positioning the moving parts of the mechanical rotational and translational mechanisms in a more compact and limited area of the swing apparatus 10.

[0025] According to embodiments, which can be combined with any other embodiments described herein, the swing apparatus 10 includes a protection unit 50 for reducing

particles produced by the deposition source 30 within the processing area. The protection unit 50 can be a single element protecting, i.e. screening off, the moving parts of the rotation mechanism 42 and/or of the linear motion mechanism 46 or can be a combination of two or more elements, each protecting a different part of these moving parts. In this way, particle generation in or close to the processing area 72 is reduced or entering of generated particles in the processing area can be reduced.

[0026] For example, the protection unit 50 can include at least a bellows element. The rotation mechanism 42 can include at least a rotating shaft 47 located inside said bellows element. The bellows can have the form of rod tubes or flexible tubes enveloping and covering the rotating shaft 47 of the rotation mechanism 42.

[0027] According to embodiments, which can be combined with any other embodiments described herein, the protection unit 50 can include at least a further or second bellows element and the linear motion mechanism 46 can include linear guides 49 located inside said further or second bellows element. The linear guides 49, schematically shown for example in FIG. 3, serve to provide the translational movements of the substrate 20 sideways in relation to the deposition source 30. In this way, the one or more bellows can have the form of rod tubes or flexible tubes enveloping and covering the linear guides 49 of the linear motion mechanism 46. The bellows can cover and therefore protect other parts of the linear motion mechanism 46, such as linear actuators coupled to the linear guides 49. Due to the fact that the rotation mechanism 42 is supported by the linear motion mechanism 46, a single bellows element can be configured to protect both the rotating shaft 47 and the linear guides 49. Alternatively, two separated bellows can be used to protect the rotating shaft 47 of the rotation mechanism 42 and the linear guides 49 of the linear motion mechanism 46.

[0028] According to embodiments, a support body 40 can be understood as an arrangement configured to hold a substrate 20. For instance, the support body 40 can be a rigid body, such as a frame or a plate. In particular, the support body 40 can be configured to support a surface of a substrate 20, such as the back surface of a substrate 20.

[0029] According to embodiments, which can be combined with any other embodiments described herein, the support body 40 includes a susceptor for heating the substrate 20. In

particular, the support body 40 can include a heated plate in direct contact with the substrate 20, i.e. the back surface of the substrate 20. The heating can occur during the deposition process of the target material in the processing area 72.

[0030] In the present disclosure, clamping elements can be understood as a holding arrangement configured to provide a fixing force for attaching the substrate 20 described therein. In particular, the substrate 20 can be held to the support body 40 through clamps at the edges.

[0031] FIG. 2C describes the swing apparatus 10 showing components in an exploded view. For example, the rotation mechanism 42 includes at least two spline shaft connection elements 421 and at least two rotation motors 422 in order to move the substrate 20 (i.e. the support body 40) by an angle from the horizontal to the vertical orientation. The swing apparatus 10 includes two tubular bellows 52 that symmetrically cover the left and the right part of the rotating shaft 47 of the rotation mechanism 42. Below the rotating shaft 47 is located the linear motion mechanism 46 with linear guides 49, which can additionally be covered by the bellows 52. The swing apparatus can further include a vertical frame 22 located at the processing area 72. When the support body 40 is rotated and is held in the vertical orientation, the substrate 20 is positioned at the processing area 72 and is ready for the deposition process.

[0032] According to embodiments, before the substrate 20 is arranged on the support body 40, the substrate 20 can be aligned with the support body 40. The alignment can be for example carried out by a transport frame, wherein the transport frame transports the substrate 20 being in a horizontal orientation above the support body 40. A pin array can be provided to position the substrate 20 on the support body 40 in an aligned or centered manner. The substrate 20 can also be aligned by simple pushers before the substrate 20 is put on the support body 40 and attached by the clamps.

[0033] After alignment, the substrate 20 can be attached or clamped on the support body 40, for example in a horizontal orientation. The support body 40 can subsequently be positioned in a vertical direction. Due to the gravity forces upon change of orientation, a substrate 20 may undergo sagging. According to some embodiments of the present disclosure, which can be combined with other embodiments described herein, clamps at the

edges may be provided to allow for a combination of reduced sagging and easy release of the substrate 20 from the support body 40 after processing.

[0034] In the present disclosure, as regards the rotation mechanism 42, at least an actuator is provided for moving the support body 40 around an axis 44. The actuator can be understood as a rotation motor or an extendable cylinder, for example, a hydraulic, pneumatic, mechanical or electric driven cylinder configured to move a support body 40 around an axis 44 in front of the processing station. An actuator can also be understood as a linear actuator with a rack and pinion system. An axis, in particular an axis of rotation can be configured as a pivot, a swivel, swing or a rotating joint. The axis may include an actuator, for example having a motor and a gear. The axis can be directly driven. A motor and/or a gear can be provided. An actuator can be self-driven or a rotatable mounted rod. The actuator can be fixed to the support body 40 and/or the axis.

[0035] In the present disclosure, as regards the linear motion mechanism 46, at least an actuator is provided for translating the support body 40, and therefore the substrate 20, sideways in relation to the longitudinal axis 31 of the deposition source 30. For example, the actuator can be understood as a linear actuator with a rack and pinion system. The actuator can be a rod-style actuator that can either be fluid powered, such as hydraulic or pneumatic, or electric powered, by a lead screw or ball screw. Alternatively, the actuator can be a rodless actuator that can either be fluid powered or electric powered via a lead screw, ball screw, belt or linear motor. Both styles of actuators find application in guided systems. The guide elements can be profiled rail, round rail or other rolling or sliding systems.

[0036] FIGS. 3 and 4 describe a swing module 60 for receiving a substrate 20 from a transfer chamber 80 of a vacuum processing system and for positioning said substrate 20 in a processing area 72 of a processing chamber 70 of the vacuum processing system. The swing module 60 includes a vacuum chamber 62 and a support body 40 for holding the substrate 20 located within the vacuum chamber 62. A rotation mechanism 42, coupled to the support body 40, is used for moving the substrate 20 by an angle 12 around a rotational axis 44 from a transfer or horizontal orientation I to a processing or vertical orientation II. FIG. 3 shows the substrate in the transfer orientation I. A linear motion mechanism 46, coupled to the support body 40, is used for translating the substrate 20 sideways relative to

the longitudinal axis 31 of the deposition source 30, when the substrate 20 is in the processing orientation II. In order to carry out the translational movement of the substrate as mentioned above, the linear motion mechanism 46 is provided with a linear actuator coupled to linear guides 49, which are located below the rotation mechanism 42. Furthermore, a protection unit 50 is provided for protecting both the rotation mechanism 42 and the linear motion mechanism 46 from the particles generated by the deposition source 30.

[0037] FIG. 4, shows an exemplary vacuum processing system 90 including at least a processing chamber 70, at least a swing module 60 operatively coupled to the processing chamber 70 for positioning the substrate 20 in a processing area 72 of the processing chamber 70 and at least a transfer chamber 80 operatively coupled to the swing module 60, for moving the substrate 20 to the swing module 60. In particular, the swing module 60 includes a vacuum chamber 62 and a support body 40 for holding the substrate 20 within the vacuum chamber 62. Further, the swing module 60 includes a rotation mechanism 42 coupled to the support body 40 for moving the substrate 20 by an angle 12 around a rotational axis 44 from a transfer or horizontal orientation I to a processing or vertical orientation II. Furthermore, the swing module 60 includes a linear motion mechanism 46 coupled to the support body 40 for translating the substrate 20 sideways in relation to the longitudinal axis 31 of the deposition source 30, when the substrate 20 is in the processing orientation II.

[0038] The vacuum chamber 62 of the swing module 60 as well as the transfer chamber 80 can be provided with stands 64. The swing module 60 can include or can be connected to the processing chamber 70 that can be provided with support pillars 74.

[0039] According to embodiments, which can be combined with other embodiments described herein, as illustrated in FIG. 5, the vacuum processing system 90 can include a vacuum transfer chamber 80 wherein more than one, in particular two or more swing modules 60A, 60B, 60C, and 60D are arranged adjacent to the vacuum transfer chamber 80. A substrate 20 (shown with dashed lines in the figure) is transferred to the vacuum transfer chamber 80 e.g. through a load chamber or load module 92. The vacuum transfer chamber 80 can move the substrate 20 to a vacuum chamber of a first swing module 60A. The vacuum processing system 90 can include a support chamber arranged on the vacuum

transfer chamber 80 to perform specific additional functions like storage of substrates or the like. Further, more than one load lock chamber may be provided. For example, one load lock chamber may be provided for loading of substrates into the transfer chamber and one load lock chamber may be provided for unloading substrates from the transfer chamber.

[0040] The substrate 20 can be arranged or attached on the support body 40 by clamps in the vacuum chamber of the first swing module 60A. The support body 40 moves the substrate 20 by an angle θ from a non-vertical orientation I to a non-horizontal orientation II in a processing area of the processing chamber 70A in front of a mask (not show) as described therein. After the processing of the substrate 20 in the processing area of the processing chamber 70A, the substrate 20 is moved out of the processing area in a non-vertical orientation I into the vacuum chamber of the first swing module 60A. The substrate 20 is moved out of the vacuum chamber of the swing module 60A back to the transfer chamber 80. After obtaining the substrate 20 from the vacuum chamber of the swing module 60A, the transfer chamber 80 can move the substrate 20 to a further swing module 60B or 60C or 60D with further processing chambers 70B, 70C, 70D, respectively.

[0041] According to embodiments, the movement of the substrate 20 from a swing module 60A to a further swing module 60B, 60C, 60D can be understood as a lateral movement of the substrate 20, wherein the substrate 20 is moved while being in a non-vertical orientation I. The transfer chamber 80 can be configured to rotate the substrate 20 e.g. to enable an alignment of the substrate 20 before moving the substrate 20 to a process chamber. The substrate 20 can be moved by the transfer chamber 80 from the vacuum chamber of a first swing module 60A to any other vacuum chamber of the swing module 60B, 60C, 60D arranged on the transfer chamber 80 in an undetermined sequence.

[0042] According to embodiments, the vacuum processing system 90 can include more than one load module 92, transfer chamber 80, swing module 60 or processing chamber 70.

[0043] A load module 92 can be understood as a module capable for an intake or an acceptance of a substrate 20 and/or for outtake or removal of a substrate. The load module 92 or load lock chamber can be a chamber with an opening at one side being configured to receive a substrate 20. The load module 92 can be connected to a transporting device being

configured to transport a substrate 20 to the load module 92. For example, a load module 92 can be understood as an air lock for transferring a substrate 20 to a chamber with low pressure, in particular to a chamber with vacuum pressure. According to embodiments, the load module is connected to a transfer chamber 80.

[0044] A transfer chamber 80 can be understood as a chamber with vacuum pressure connected to other substrate processing modules, chambers or devices (i.e. swing modules 60, load modules 92). The transfer chamber 80 can be configured to move a substrate 20 to other modules or devices connected to the transfer chamber 80 for further substrate processing.

[0045] According to embodiments, more than one swing module 60 is arranged at the transfer chamber 80, in particular at the outer wall of the transfer chamber 80. The transfer chamber 80 can form a transporting path configuration between the swing modules 60.

[0046] The transfer chamber 80 can be understood as a transporting path configuration, wherein several swing modules 60A, 60B, 60C, and 60D and corresponding processing chambers 70A, 70B, 70C, and 70D are arranged at the lateral areas of the transporting path configuration. Each swing module or processing chamber can be connected to the transporting path configuration for example by an opening or by an air-lock.

[0047] According to embodiments, the vacuum processing system 90 can include more than one swing modules 60 and processing chambers 70 arranged next to each other. In a first swing module 60A, an actuator moves a support body 40 around an axis 44 into a processing area 72A of a first processing chamber 70A as described herein. For further processing, the substrate 20 can be moved to further swing modules 60B, 60C, 60D and processing chambers 70B, 70C, 70D, wherein the substrate 20 is moved in a non-vertical orientation I from one swing module 60 to another swing module 60.

[0048] According to embodiments, the transfer chamber 80 can have a polygon-shaped, i.e. can be polygonal, or circular design. A polygon-design can for example include a triangulum-shaped, a square-shaped, a pentagon-shaped or hexagon-shaped design. A swing module 60 can be arranged on one edge or on more edges or on each edge of the polygon-shaped designs of the transfer chamber 80. When more than one swing module 60

is provided, the transfer chamber 80 can be arranged in the middle or in the center of the swing modules. The arrangement of the transfer chamber 80 in the center or in the middle of the swing modules 60 enables a cluster-like design of a vacuum processing system 90. More than one swing modules 60 and corresponding processing chambers 70 can be arranged on the transfer chamber 80, wherein each module/chamber has the same distance from a center point of the transfer chamber 80. It is further possible to arrange storage modules for substrates or any other substrate support modules at one or more edges of the polygon-shaped design transfer chamber 80.

[0049] According to embodiments, it is possible to connect two or more cluster-like vacuum processing systems 90 as described herein and enable substrate transporting and further substrate processing between the two or more vacuum processing systems 90.

[0050] According to embodiments, the transfer chamber 80 is configured to transfer the substrate 20 being attached to the support body 40 to the swing module 60. The substrate 20 being attached can be understood as the substrate is kept attached and/or is held by the clamps on the support body 40 while transported within the swing module 60 in the processing area 72. The movement of the substrate 20 can be understood as a displacement in a horizontal direction. The displacement can be carried out by a guiding system with rollers or the like. Keeping the substrate 20 attached to the support body 40 has the advantage that further attaching and detaching operations of the substrate 20 with the clamps of the support body 40 can be avoided when the substrate 20 enters a swing module 60 and approaches the processing area and/or enters the transfer chamber 80 again after processing. Keeping the substrate 20 attached to the support body 40 can accelerate the substrate processing process.

[0051] According to embodiments, which may be combined with other embodiments described herein, the processing chamber 70 includes one or more deposition source 30 having a longitudinal axis 31. For example, an array of 4 or more linear deposition sources, such as rotational sputter cathodes, may be provided.

[0052] Further a processing chamber may also include an implantation source, such as a vertical linear implantation source. The term "linear", for example, for deposition sources or implantation sources, can be understood in the sense that the source has a major

dimension and a minor dimension defining an emission area of the particles or ions (e.g., a substantially rectangular area), wherein the minor dimension is less than the major dimension. For example, the minor dimension can be less than 10%, specifically less than 5% and more specifically less than 1% of the major dimension. The major dimension can extend substantially vertically. In other words, the at least one linear source can be a vertical linear source. According to some embodiments, a beam width of the particles or ions provided by the at least one linear source, e.g., the emission area, can be in a range of between 1 mm to 300 mm, specifically in a range of between 10 mm to 100 mm, and more specifically less than 50 mm. The beam width can be defined perpendicular to the linear extension of the at least one linear source.

[0053] Generally, in embodiments, the linear source being an ion source may be configured for a pretreatment, a cleaning process for the surface of the substrate 20, an ion implantation into the substrate 20 or into a layer which was previously deposited on the substrate 20, or a deposition of a layer on the substrate 20. In embodiments, the linear source may be configured for a cleaning or a pre-treatment of a substrate 20, which may for example include the removal of TiO₂.

[0054] Generally, a width of the processing chamber 70 in a dimension parallel to the substrate can be significantly greater than the width of the substrate 20 in a horizontal direction perpendicular to the substrate. It is understood that a processing chamber 70 with a deposition source 30 and a large width can be employed in other configurations, as well, for example in an apparatus having two or more such processing chambers with deposition sources 30. An extended width of the processing chamber 70 allows to move the substrate 20 along the deposition source 30 while enabling that any section of the substrate surface is effected by the beam 32 of the deposition source 30 during the process.

[0055] The deposition source 30 can be configured as a sputter source or as a PLD source (pulsed laser deposition). In Pulsed laser deposition (PLD), a high-powered pulsed laser beam is focused inside the vacuum chamber to strike a target of the material that is to be deposited. The material is ablated or vaporized from the target, and the resulting plasma plume deposits as a thin film on the substrate 20. For sputter deposition, typically a magnetron sputtering source may be provided, for example having a cylindrical target with permanent magnets provided within the target cylinder.

[0056] With exemplary reference to FIG. 6, embodiments of the method 100 for processing a substrate 20 are provided. The method 100 includes holding 102 the substrate 20 on a support body 40 of a swing apparatus 10, moving 104 the substrate 20 relative to a deposition source 30 for processing the substrate 20 having a longitudinal axis 31 by an angle 12 around a rotational axis 44 from a transfer or horizontal orientation I to a processing or vertical orientation II by means of a rotation mechanism 42 coupled to the support body 40 and treating or processing 106 the surface of the substrate 20 by a beam from the deposition source 30. In addition, the method 100 includes translating 108 the substrate 20 sideways in relation to the longitudinal axis 31 of the deposition source 30, when the substrate 20 is in the processing orientation II by means of a linear motion mechanism 46 coupled to the support body 40.

[0057] Furthermore, the method includes moving the substrate 20 in a horizontal linear direction perpendicular to the longitudinal axis 31 of the deposition source 30 during the movement from the transfer orientation I to the processing orientation II and vice versa.

[0058] The embodiments according to the present disclosure have several advantages including the possibility to improve the uniformity of the deposited layer. Furthermore, the embodiments according to the present disclosure have the advantage of reducing particle generation in or close to the processing chamber.

[0059] 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 swing apparatus (10) for moving a substrate (20) relative to one or more deposition sources (30) having a longitudinal axis (31), the swing apparatus (10) comprising:

a support body (40) for holding the substrate (20);

a rotation mechanism (42) coupled to the support body (40) for moving the substrate (20) by an angle (12) around a rotational axis (44) to vary the substrate orientation from a transfer or horizontal orientation (I) to a processing or vertical orientation (II) at a processing area (72); and

a linear motion mechanism (46) coupled to the support body (40) for translating the substrate (20) relative to the longitudinal axis (31) of the deposition source (30), when the substrate (20) is in the processing orientation (II).

2. The swing apparatus (10) of claim 1, wherein the support body (40) is configured to move the substrate (20) in a horizontal linear direction perpendicular to the longitudinal axis (31) of the deposition source (30) during the movement from the transfer orientation (I) to the processing orientation (II) and vice versa, and providing a linear offset (48) between an edge of substrate (20) adjacent to the processing area (72) and the longitudinal axis (31) of the deposition source (30).

3. The swing apparatus (10) of any of claims 1 or 2, wherein the rotation mechanism (42) is supported by the linear motion mechanism (46).

4. The swing apparatus (10) of any one of the preceding claims, further comprising:

a protection unit (50) for deposition source reducing particles in the processing area.

5. The swing apparatus (10) of claim 4, wherein the protection unit (50) comprises at least a first bellows element (52) and the rotation mechanism (42) comprises at least a rotating shaft (47) located inside said first bellows element (52).

6. The swing apparatus according to claim 5, wherein the linear motion mechanism is provided inside the first bellows element.

7. The swing apparatus (10) of claim 4 or 5, wherein the protection unit (50) comprises at least a second bellows element and the linear motion mechanism (46) comprises linear guides (49) located inside said second bellows element.

8. The swing apparatus (10) of any one of the preceding claims, wherein the support body (40) comprises a susceptor for heating the substrate (20).

9. The swing apparatus (10) of any one of the preceding claims, wherein the rotation mechanism (42) comprises at least two spline shaft connection elements (421) and at least two rotation motors (422).

10. The swing apparatus (10) of any one of the preceding claims, wherein the substrate (20) is held to the support body (40) by clamps.

11. A method (100) for processing a substrate (20), comprising:

holding (102) the substrate (20) on a support body (40);

moving (104) the substrate (20) relative to a deposition source (30) for processing the substrate (20) having a longitudinal axis (31), the movement of the substrate (20) being carried out by an angle (12) around a rotational axis (44) to vary the substrate orientation from a transfer or horizontal orientation (I) to a processing or vertical orientation (II) by a rotation mechanism (42) coupled to the support body (40);

processing (106) a surface of the substrate (20) with the deposition source (30); and

translating (108) the substrate (20) relative to the longitudinal axis (31) of the deposition source (30), when the substrate (20) is in the processing orientation (II) by a linear motion mechanism (46) coupled to the support body (40).

12. The method (100) of claim 11, further comprising:

moving the substrate (20) in a horizontal linear direction perpendicular to the longitudinal axis (31) of the deposition source (30) during the movement from the transfer orientation (I) to the processing orientation (II) and vice versa.

13. A swing module (60) for receiving a substrate (20) from a transfer chamber (80) of a vacuum processing system and for positioning said substrate (20) in a processing area (72) of a processing chamber (70) of the vacuum processing system, the swing module (60) comprising:

a vacuum chamber (62),

a support body (40) for holding the substrate (20) within the vacuum chamber (62);

a rotation mechanism (42) coupled to the support body (40) for moving the substrate (20) by an angle (12) around a rotational axis (44) to vary the substrate

orientation from a transfer or horizontal orientation (I) to a processing or vertical orientation (II); and

a linear motion mechanism (46) coupled to the support body (40) for translating the substrate (20) sideways in relation to the longitudinal axis (31) of the deposition source (30), when the substrate (20) is in the processing orientation (II).

14. A vacuum processing system (90) for processing a substrate (20), the system (90) comprising:

at least a processing chamber (70) including a deposition source (30) with a longitudinal axis (31) for processing the substrate (20);

at least a swing module (60), operatively coupled to the processing chamber (70), for positioning the substrate (20) in a processing area (72) of the processing chamber (70); and

a transfer chamber (80) operatively coupled to the swing module (60), for moving the substrate (20) to the swing module (60),

said swing module (60) comprising:

a vacuum chamber (62);

a support body (40) for holding the substrate (20) within the vacuum chamber (62);

a rotation mechanism (42) coupled to the support body (40) for moving the substrate (20) by an angle (12) around a rotational axis (44) to vary the substrate orientation from a transfer or horizontal orientation (I) to a processing or vertical orientation (II); and

a linear motion mechanism (46) coupled to the support body (40) for translating the substrate (20) sideways in relation to the longitudinal axis (31) of the deposition source (30), when the substrate (20) is in the processing orientation (II).

15. The system (90) of claim 14, further comprising at least a load lock chamber (92) coupled to the transfer chamber (80).

16. The system (90) of any one of claims 14 or 15, wherein the transfer chamber (80) has a polygonal or circular shape and is coupled to two or more swing modules (70).

17. The system (90) of any one of claims 14 to 16, wherein the deposition source (30) is a vertical linear deposition source or wherein the system further comprises a vertical linear implantation source.

Fig. 2A

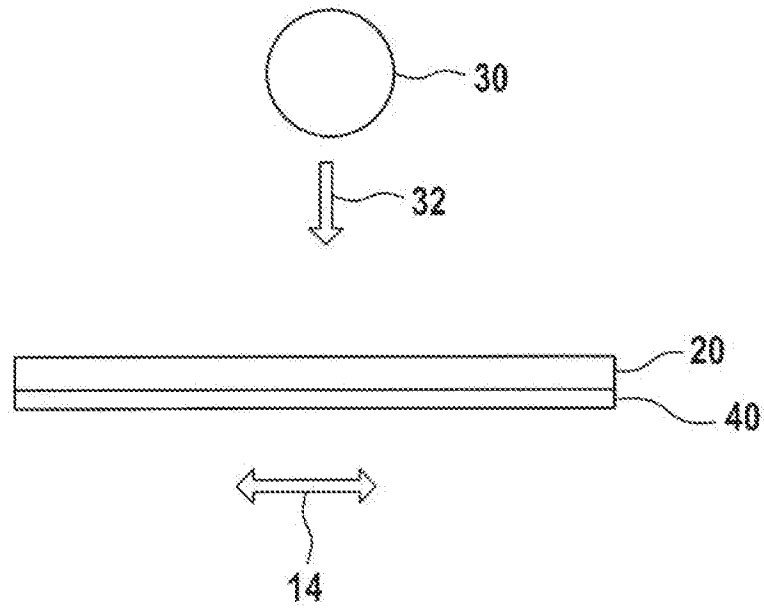
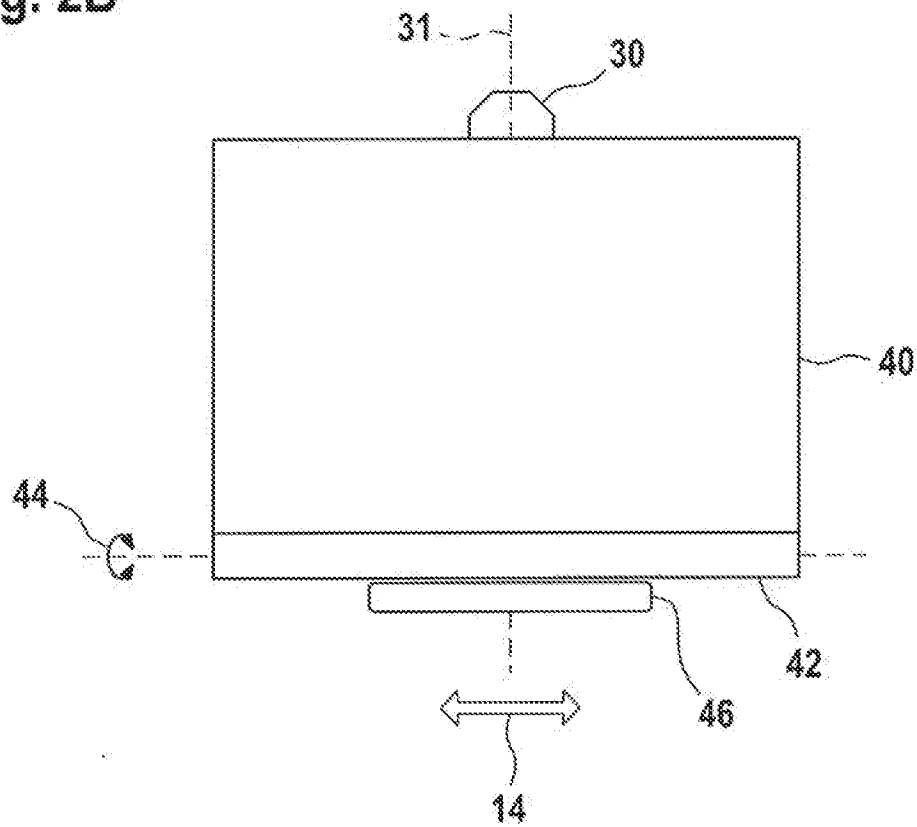


Fig. 2B



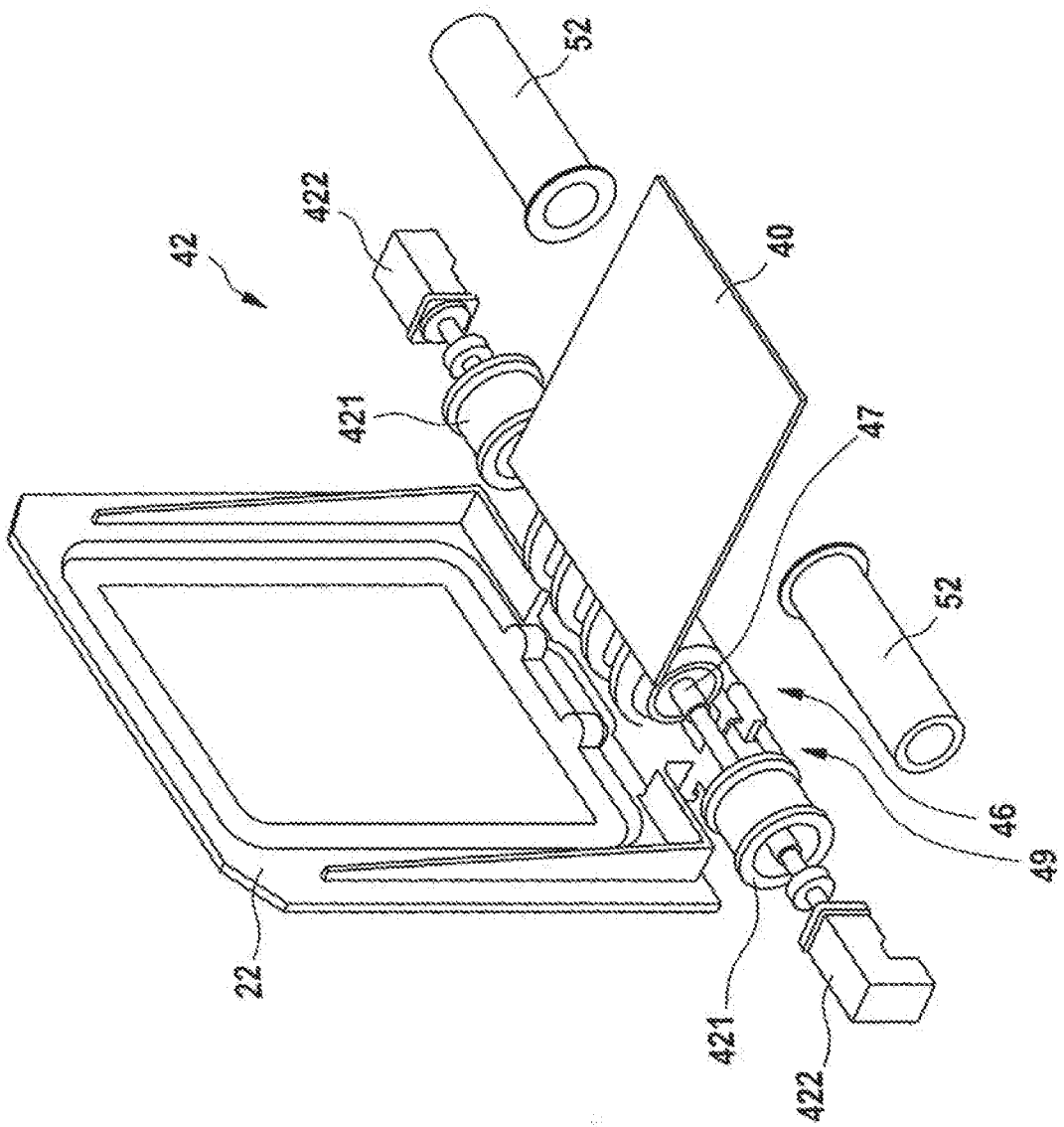


Fig. 2C

Fig. 3

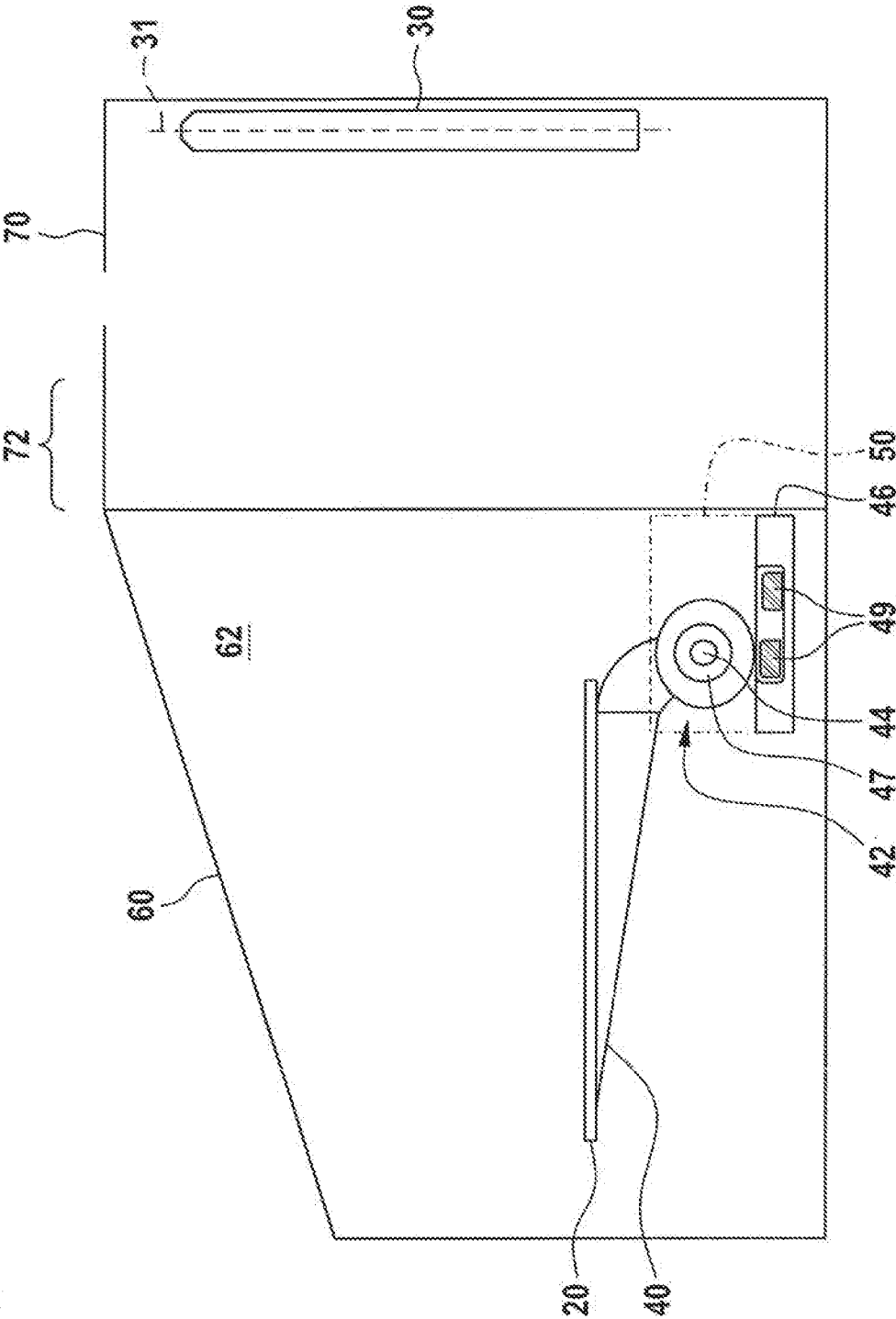


Fig. 4

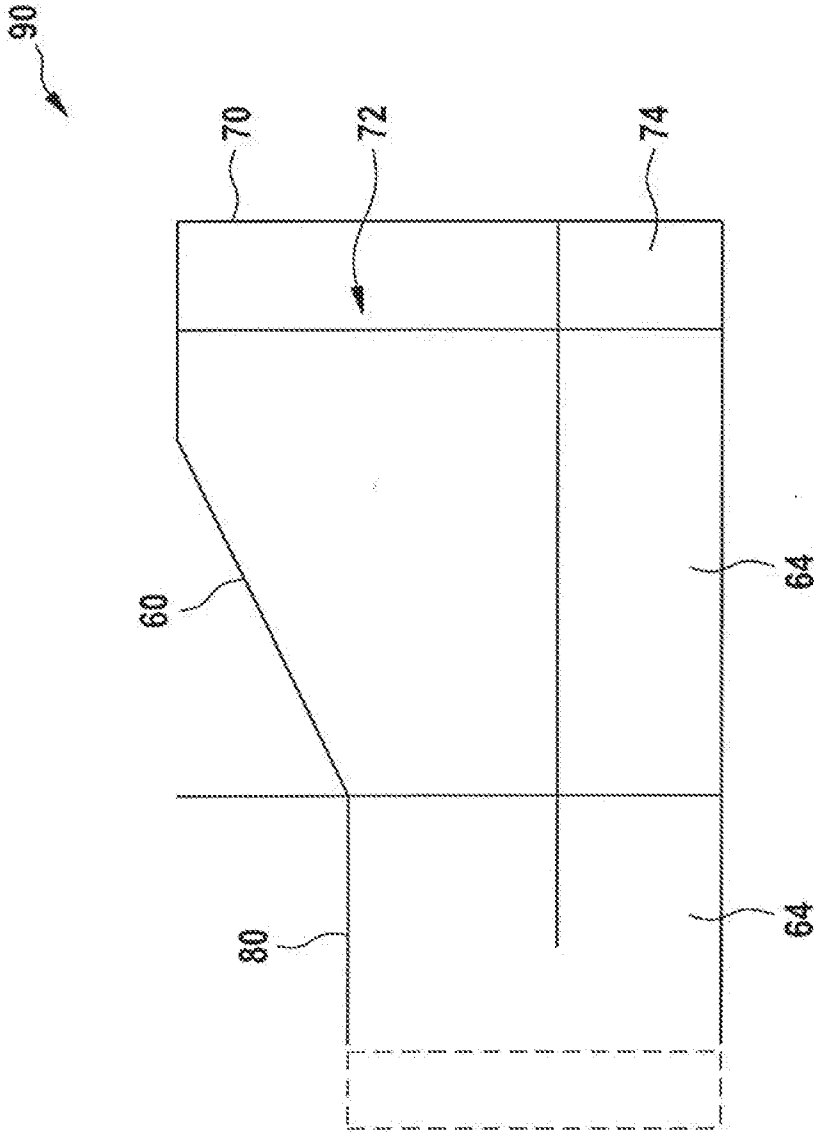


Fig. 5

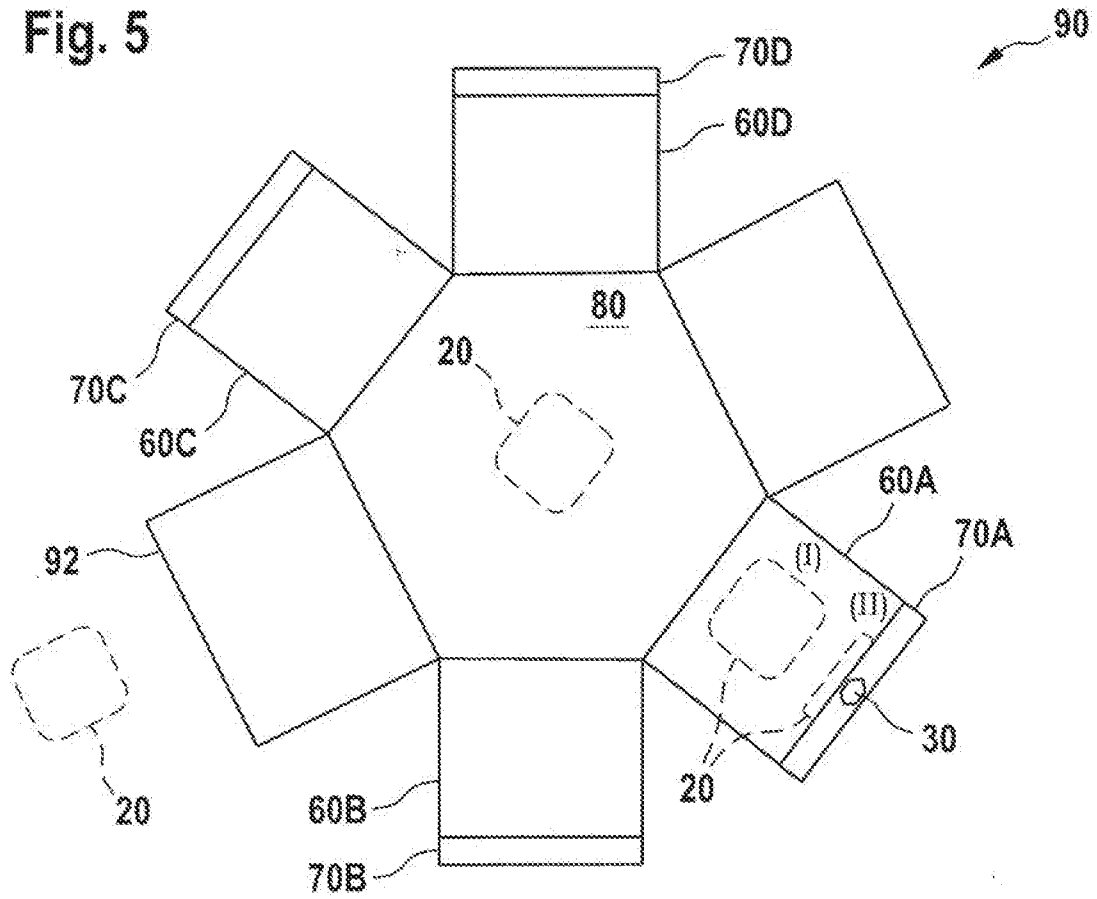
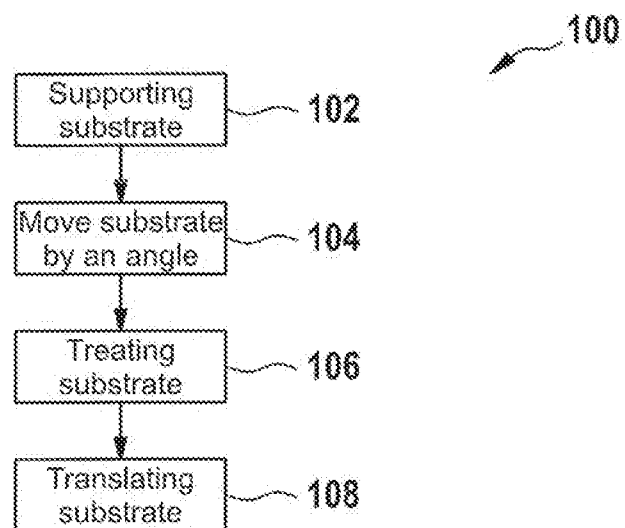


Fig. 6



A. CLASSIFICATION OF SUBJECT MATTER**H01L 21/67(2006.01)i**

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 21/67; C23C 14/04; C23C 14/12; C23C 14/24; C23C 14/50; H01L 51/56; H05B 33/10

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & keywords: swing apparatus, transfer chamber, vertical, horizontal, orientation, rotation, linear motion

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 10-2013-0023313 A (HITACHI HIGH-TECHNOLOGIES CORPORATION) 07 March 2013 See paragraphs [0060]-[0063], [0095]-[0105] and figures 1-3, 8.	1-17
A	US 2017-0244070 A1 (APPLIED MATERIALS, INC.) 24 August 2017 See paragraphs [0032]-[0033], [0140]-[0143] and figures 1A-12B.	1-17
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A	JP 2004-031181 A (SONY CORP.) 29 January 2004 See paragraphs [0012]-[0030] and figures 1-2.	1-17
A	JP 2006-169625 A (SAMSUNG SDI CO., LTD.) 29 June 2006 See paragraphs [0055]-[0063] and figures 2, 11.	1-17



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"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

25 March 2019 (25.03.2019)

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Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2018/040004

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