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MANN, Annabelle [DE/DE]; Wallstädterstr. 42, 63811
Stockstadt (DE).

(74) Agent: ZIMMERMANN & PARTNER PATENTAN-
WÄLTE MBB; Josephspitalstr. 15, 80331 München (DE).

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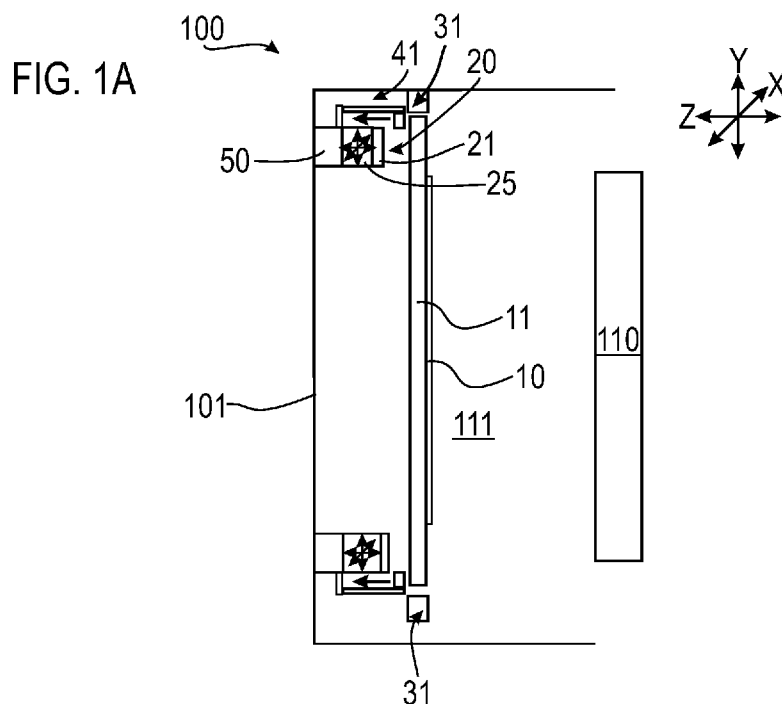
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(71) Applicant: APPLIED MATERIALS, INC. [US/US];
3050 Bowers Avenue, Santa Clara, California 95054 (US).

(72) Inventors; and

(71) Applicants (*for US only*): HEYMANN, Matthias
[DE/DE]; Im Seerich 37, 64839 Münster (DE). HOF-

(54) Title: APPARATUS AND SYSTEM FOR PROCESSING A SUBSTRATE IN A VACUUM CHAMBER, AND METHOD OF
TRANSPORTING A CARRIER IN A VACUUM CHAMBER



(57) Abstract: An apparatus (100) for processing a substrate (10) in a vacuum chamber (101) is described. The apparatus includes a first carrier transport system configured to transport a first carrier (11) along a first transport path in a first direction (X), an alignment system (20, 120) comprising a first mount (21, 121) for mounting the first carrier (11) to the alignment system, a first shifting device (41, 141) configured to move the first carrier from the first transport path to the first mount in a second direction (Z) transverse to the first direction (X), and a common support structure (50, 150) which supports or holds at least a part of the alignment system (20, 120) and at least a part of the first shifting device (41, 141). Further, a system for processing a substrate and a method of transporting a carrier in a vacuum chamber are described.



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APPARATUS AND SYSTEM FOR PROCESSING A SUBSTRATE IN A VACUUM CHAMBER, AND METHOD OF TRANSPORTING A CARRIER IN A VACUUM CHAMBER

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FIELD

[0001] Embodiments of the present disclosure relate to an apparatus and a system for processing a substrate in a vacuum chamber, and to a method of transporting a carrier in a vacuum chamber. More specifically, a method of transporting, positioning, and aligning a substrate carrier and a mask carrier in a vacuum chamber is described. Embodiments of the present disclosure particularly relate to the deposition of a coating material on a substrate, wherein the substrate is aligned with respect to a mask before the deposition. Methods and apparatuses described herein may be used in the manufacture of organic light-emitting diode (OLED) devices.

15

BACKGROUND

[0002] Techniques for layer deposition on a substrate include, for example, thermal evaporation, physical vapor deposition (PVD), and chemical vapor deposition (CVD). Coated substrates may be used in several applications and in several technical fields. For instance, coated substrates may be used in the field of organic light emitting diode (OLED) devices. OLEDs can be used for the manufacture of television screens, computer monitors, mobile phones, other hand-held devices and the like, for displaying information. An OLED device, such as an OLED display, may include one or more layers of an organic material situated between two electrodes that are all deposited on a substrate.

[0003] During the deposition of a coating material on a substrate, the substrate may be held by a substrate carrier, and a mask may be held by a mask carrier in front of the substrate. A material pattern, e.g. a plurality of pixels corresponding to an opening pattern of the mask, can be deposited on the substrate.

[0004] The functionality of an OLED device typically depends on a coating thickness of the organic material, which has to be within a predetermined range. For obtaining high-resolution OLED devices, technical challenges with respect to the deposition of evaporated materials need to be mastered. In particular, an accurate and smooth transportation of the

substrate carriers and the mask carriers through a vacuum system is challenging. Further, a precise alignment of the substrate with respect to the mask is crucial for achieving high quality deposition results, e.g. for producing high-resolution OLED devices. Yet further, an efficient utilization of the coating material is beneficial, and idle times of the system are to be kept as short as possible.

[0005] In view of the above, it would be beneficial to provide apparatuses and systems for accurately and reliably transporting, positioning and/or aligning substrates and masks in a vacuum chamber.

SUMMARY

[0006] In light of the above, an apparatus for processing a substrate in a vacuum chamber, a system for processing a substrate in a vacuum chamber, and a method of transporting a carrier in a vacuum chamber are provided. Further aspects, benefits, and features of the present disclosure are apparent from the claims, the description, and the accompanying drawings.

[0007] According to an aspect of the present disclosure, an apparatus for processing a substrate in a vacuum chamber is provided. The apparatus includes a first carrier transport system configured to transport a first carrier along a first transport path in a first direction, an alignment system including a first mount for mounting the first carrier to the alignment system, a first shifting device configured to move the first carrier from the first transport path to the first mount in a second direction transverse to the first direction, and a common support structure which supports or holds at least a part of the alignment system and at least a part of the first shifting device.

[0008] In embodiments, the first carrier is a substrate carrier configured to hold a substrate. Alternatively, the first carrier may be a mask carrier configured to hold a mask.

[0009] In some embodiments, the common support structure holds or supports the first mount and an alignment unit of the alignment system that is configured to align the first carrier in the vacuum chamber. In some embodiments, the common support structure holds or supports an actuator and/or a bearing of the first shifting device.

[0010] According to another aspect of the present disclosure, an apparatus for processing a substrate in a vacuum chamber is provided. The apparatus includes a first carrier transport system configured to transport a first carrier along a first transport path in a first direction, an alignment system including a first mount for mounting the first carrier to the alignment system, and a first shifting device configured to move the first carrier from the first transport path to the first mount in a second direction transverse to the first direction. The first shifting device is arranged in the vacuum chamber, particularly held by a common support structure which also holds the alignment system.

[0011] According to another aspect of the present disclosure, an apparatus for processing a substrate in a vacuum chamber is provided. The apparatus includes a first carrier transport system extending in a first direction, an alignment system including a first mount, a first shifting device extending in a second direction transverse to the first direction, and a common support structure which supports or holds at least a part of the alignment system and at least a part of the first shifting device.

[0012] According to another aspect of the present disclosure, a system for processing a substrate in a vacuum chamber is provided. The system includes an apparatus for processing a substrate in a vacuum chamber according to any of the embodiments described herein, a first carrier configured as a substrate carrier mounted to the first mount, and a second carrier configured as a mask carrier mounted to a second mount of the alignment system.

[0013] According to a further aspect of the present disclosure, a method of transporting a carrier in a vacuum chamber is provided. The method includes transporting a first carrier along a first transport path in a first direction, moving the first carrier from the first transport path to a first mount of an alignment system in a second direction transverse to the first direction with a first shifting device, wherein at least a part of the first shifting device and at least a part of the alignment system are supported or held by a common support structure, mounting the first carrier to the first mount of the alignment system, and aligning the first carrier with the alignment system.

[0014] In some embodiments, the first carrier is a substrate carrier which holds a substrate, and aligning the first carrier includes aligning the substrate carrier with respect to a mask carrier which holds a mask in front of the substrate.

[0015] Embodiments are also directed at apparatuses for carrying out the disclosed
5 methods and include apparatus parts for performing each described method aspect. These method aspects may be performed by way of hardware components, a computer programmed by appropriate software, by any combination of the two or in any other manner. Furthermore, embodiments according to the disclosure are also directed at methods for operating the described apparatus. The methods for operating the described
10 apparatus include method aspects for carrying out every function of the apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] 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
15 relate to embodiments of the disclosure and are described in the following:

FIG. 1A shows a schematic sectional view of an apparatus for processing a substrate according to embodiments described herein in a first position;

FIG. 1B is a schematic sectional view of the apparatus of FIG. 1A
20 in a second position;

FIG. 2A shows a schematic sectional view of an apparatus for processing a substrate according to embodiments described herein in a first position;

FIG. 2B is a schematic sectional view of the apparatus of FIG. 2A
25 in a second position;

FIG. 3 shows a schematic sectional view of an apparatus according to embodiments described herein;

FIG. 4 shows a schematic front view of an apparatus according to embodiments described herein;

FIG. 5A-D show various stages of a method of transporting a carrier in a vacuum chamber according to embodiments described herein; and

FIG. 6 is a flow diagram illustrating a method of transporting a carrier in a vacuum chamber according to embodiments described herein.

DETAILED DESCRIPTION OF EMBODIMENTS

[0017] 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, same reference numbers refer to same components. Generally, only the differences with respect to individual embodiments are described. Each example is provided by way of explanation of the disclosure and is not meant as a limitation of the disclosure.

[0018] 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.

[0019] FIG. 1A is a schematic sectional view of an apparatus 100 for processing a substrate 10 according to embodiments described herein, wherein a first carrier 11 is in a first position. FIG. 1B shows the apparatus 100 of FIG. 1A, wherein the first carrier 11 has moved to a second position.

[0020] In the following description, the term “first carrier” is used to designate a substrate carrier which is configured to hold a substrate 10, as is schematically depicted in FIG. 1A. The term “second carrier” is used to designate a mask carrier which is configured to hold a mask (see FIG. 2A). However, it is to be understood that, alternatively, the first carrier 11 may be a carrier configured to hold a different object, e.g. a mask or a shield.

[0021] A “substrate carrier” relates to a carrier device configured to carry a substrate 10 along a substrate transportation path in a vacuum chamber. The substrate carrier may hold the substrate 10 during the deposition of a coating material on the substrate. In some embodiments, the substrate 10 may be held at the substrate carrier in a non-horizontal orientation, particularly in an essentially vertical orientation, e.g. during transport and/or deposition.

[0022] For example, the substrate 10 may be held at a holding surface of the first carrier 11 during the transport through a vacuum chamber 101, during positioning of the substrate 10 in the vacuum chamber 101, e.g. with respect to a mask, and/or during the deposition of a coating material on the substrate. In particular, the substrate 10 may be held at the first carrier 11 by a chucking device, e.g. by an electrostatic chuck or by a magnetic chuck. The chucking device may be integrated in the first carrier 11.

[0023] The first carrier 11 may include a carrier body with a holding surface configured to hold the substrate 10, particularly in a non-horizontal orientation. The carrier body may be movable along a first transport path by a first carrier transport system. In some embodiments, the first carrier 11 may be contactlessly held at a guiding structure during the transport, e.g., by a magnetic levitation system.

[0024] A “mask carrier” as used herein relates to a carrier device configured to carry a mask for the transport of the mask along a mask transport path in the vacuum chamber. The mask carrier may carry the mask during transport, during alignment with respect to a substrate and/or during deposition on the substrate. In some embodiments, the mask may be held at the mask carrier in a non-horizontal orientation, particularly in an essentially vertical orientation during transport and/or deposition. The mask may be held at the mask carrier by a chucking device, e.g. a mechanic chuck such as a clamp, an electrostatic chuck or a magnetic chuck. Other types of chucking devices may be used which may be connected to or integrated in the mask carrier.

[0025] For instance, the mask may be an edge exclusion mask or a shadow mask. An edge exclusion mask is a mask which is configured for masking one or more edge regions of the substrate, such that no material is deposited on the one or more edge regions during the coating of the substrate. A shadow mask is a mask configured for masking a plurality

of features which are to be deposited on the substrate. For instance, the shadow mask can include a plurality of small openings, e.g. a grid of small openings.

[0026] “Transporting”, “moving”, “routing”, “rotating”, “positioning” or “aligning” a substrate or a mask as used herein may refer to a respective movement of a carrier which carries the substrate or the mask.

[0027] An “essentially vertical orientation” as used herein may be understood as an orientation with a deviation of 10° or less, particularly 5° or less from a vertical orientation, i.e. from the gravity vector. For example, an angle between a main surface of a substrate (or mask) and the gravity vector may be between $+10^\circ$ and -10° , particularly between 0° and -5° . In some embodiments, the orientation of the substrate (or mask) may not be exactly vertical during transport and/or during deposition, but slightly inclined with respect to the vertical axis, e.g. by an inclination angle between 0° and -5° , particularly between -1° and -5° . A negative angle refers to an orientation of the substrate (or mask) wherein the substrate (or mask) is inclined downward. A deviation of the substrate orientation from the gravity vector during deposition may be beneficial and might result in a more stable deposition process, or a facing down orientation might be suitable for reducing particles on the substrate during deposition. However, also an exactly vertical orientation ($\pm 1^\circ$) during transport and/or during deposition is possible. In other embodiments, the substrates and masks may be transported in a non-vertical orientation, and/or the substrates may be coated in a non-vertical orientation, e.g. an essentially horizontal orientation.

[0028] The apparatus 100 according to embodiments described herein includes a vacuum chamber 101, wherein an alignment system 20 is provided in the vacuum chamber 101. The alignment system 20 may be configured to accurately position the first carrier 11 in the vacuum chamber. In some embodiments, a deposition source 110 is provided in the vacuum chamber 101. The deposition source 110 is configured for depositing a coating material on the substrate 10 that is held by the first carrier 11.

[0029] The alignment system 20 includes a first mount 21 for mounting the first carrier 11 to the alignment system 20. Further, the alignment system 20 includes an alignment unit 25 for moving the first mount 21 in at least one direction for aligning the first carrier 11 in

the vacuum chamber, e.g. with respect to a mask that is arranged in front of the substrate. Accordingly, a substrate 10 that is carried by the first carrier 11 can be correctly positioned in the vacuum chamber 101 with the alignment unit 25 of the alignment system 20.

[0030] The apparatus further includes a first carrier transport system 31 configured to transport the first carrier 11 along a first transport path in a first direction X. The first carrier transport system 31 may be configured to transport the first carrier 11 into a deposition area 111 in the vacuum chamber 101 in which the substrate 10 faces the deposition source 110, such that a coating material can be deposited on the substrate 10. The first direction X is essentially perpendicular to the paper plane of FIG. 1A.

[0031] After the deposition of the coating material on the substrate 10, the first carrier transport system 31 may transport the first carrier 11 out of the deposition area 111, e.g. for unloading the coated substrate from the vacuum chamber or for depositing a further coating material on the substrate in a further deposition area.

[0032] The first carrier transport system 31 may be configured for a contactless transport of the first carrier 11 in the vacuum chamber 101. For example, the first carrier transport system 31 may hold and transport the first carrier 11 by magnetic forces. In particular, the first carrier transport system 31 may include a magnetic levitation system.

[0033] In the exemplary embodiment of FIG. 1A, the first carrier transport system 31 includes a holding device arranged at least partially above the first carrier 11 and configured to carry at least a part of the weight of the first carrier 11. The holding device may include an active magnetic unit, e.g. an active magnetic bearing configured to contactlessly hold the first carrier 11 at the holding device. The first carrier transport system 31 may further include a drive device configured to contactlessly move the first carrier 11 in the first direction X. In some embodiments, the drive device may be arranged at least partially below the first carrier 11. The drive device may include a drive such as a linear motor configured to move the first carrier by applying a magnetic force on the first carrier.

[0034] The apparatus 100 further includes a first shifting device 41, also referred to herein as a “cross drive device”, that is configured to move the first carrier 11 from the first

transport path to the first mount 21 of the alignment system 20 in a second direction Z transverse to the first direction X, particularly essentially perpendicular to the first direction X. In the embodiment of FIG. 1A, the first direction X is a horizontal direction, and the second direction Z is a horizontal direction essentially perpendicular to the first direction X. In particular, the first carrier transport system 31 may be configured to transport the first carrier into the deposition area 111 at a predetermined distance from the deposition source 110, and the first shifting device 41 may be configured to move the first carrier toward the deposition source 110 or away from the deposition source 110 in the second direction Z.

[0035] In some implementations, the first shifting device 41 may be configured to shift the first carrier 11 in the second direction Z toward the first mount 21 of the alignment system 20, until the first carrier 11 is brought in contact with the first mount 21. The first mount 21 may include a magnetic chuck configured to mechanically or magnetically grab and hold the first carrier 11 at the alignment system 20 while the first carrier 11 contacts the first mount 21.

[0036] The first carrier transport system 31 may be configured to transport the first carrier 11 along the first carrier transport path to a first position that is depicted in FIG. 1A, in which the first carrier 11 is located at a distance from the first mount 21 of the alignment system 20. When the first carrier 11 is in said first position, it may not yet be possible for the first mount 21 to grab the first carrier 11. The first shifting device 41 may be configured to shift the first carrier 11 toward the first mount 21 in the second direction Z (“Z-move”) by a distance of 1 mm or more and/or 50 mm or less, particularly by a distance of 3 mm or more and/or 10 mm or less, until the first carrier 11 contacts the first mount 21 (see FIG. 1B). Thereupon, the first carrier 11 can be mounted to the first mount 21, e.g. by activating a magnetic chuck of the first mount 21. The second position in which the first carrier 11 contacts the first mount 21 and is held by the first mount 21 is schematically depicted in FIG. 1B.

[0037] According to embodiments described herein, a common support structure 50 is provided which supports or holds at least a part of the alignment system 20 and at least a part of the first shifting device 41.

[0038] In particular, the common support structure 50 may support or hold the alignment unit 25 and the first mount 21 of the alignment system 20. For example, the common support structure 50 connects the alignment unit 25 and the first mount 21 of the alignment system 20 to the vacuum chamber 101, such that the alignment unit 25 is held in position in the deposition area 111 of the vacuum chamber.

[0039] Further, the common support structure 50 also supports at least a part of the first shifting device 41, particularly a bearing and/or an actuator of the first shifting device 41. As is exemplarily depicted in FIG. 1B, the first shifting device 41 may include a movable part 42 that is movable in the second direction Z via an actuator 43, wherein the actuator 43 may be supported on the common support structure 50. In some embodiments, the movable part 42 may include a magnetic unit configured to contactlessly move the first carrier 11 toward the first mount 21 by applying a magnetic force on the first carrier 11.

[0040] In some embodiments, which may be combined with other embodiments described herein, the actuator 43 and the movable part 42 may be configured as an integrated drive unit, e.g. including a piezo-actuator integrated with a structure for mechanical amplification of the stroke of the piezo-actuator. The structure for mechanical amplification of the stroke may be a flexible structure. In particular, the shifting device may include an amplified piezoelectric actuator, particularly including a mechanical amplification mechanism utilizing a lever arm and/or a spring leaf. For example, the piezo stroke may be amplified by a factor of 10, 20 or more. The integrated drive device may be entirely provided in the vacuum chamber, e.g. fixed to the common support structure.

[0041] As is schematically depicted in FIG. 1A and FIG. 1B, the common support structure 50 may hold the alignment unit 25 and the first mount 21 of the alignment system 20 and may support the actuator 43 of the first shifting device 41 in the vacuum chamber 101. The first shifting device may be configured to move the first carrier 11 in the second direction Z toward the first mount 21 and/or away from the first mount 21 toward the first transport path.

[0042] In some embodiments, which may be combined with other embodiments described herein, the common support structure 50 connects at least a part of the alignment system 20 to the vacuum chamber 101, particularly the alignment unit 25 and the first

mount 21 of the alignment system. Further, an actuator and/or a bearing of the first shifting device 41 may be attached to the common support structure 50. In particular, both the first shifting device 41 and the alignment system 20 may be connected to the vacuum chamber 101 via the common support structure 50.

5 [0043] According to embodiments described herein, at least a part of the first shifting device 41 and at least a part of the alignment system 20 are held by the same support structure. Accordingly, no additional support structure or mount is needed for connecting the first shifting device 41 to the vacuum chamber 101. Rather, the common support structure 50 may hold both the alignment system and the first shifting device in the
10 vacuum chamber, which is both space saving and may allow for an arrangement of the first shifting device 41 close to the first mount 21 of the alignment system 20. Arranging the first shifting device 41 and the alignment system 20 closely together in the vacuum chamber 101 may reduce the weight and the complexity of the apparatus. Further, when both the first shifting device and the alignment system are fixed to the same common
15 support structure, the tolerance chain can be kept small. In particular, the first shifting device 41 and the alignment unit 25, which are both configured to move and position the first carrier in the vacuum chamber 101, can be connected to the vacuum chamber via a common mechanical connection. Accordingly, the alignment accuracy of the first carrier in the vacuum chamber as well as the deposition result can be improved.

20 [0044] The common support structure 50 may include at least one of a support bar, a support frame, an attachment support, and a housing, e.g. an aligner housing, configured to hold both a part of the alignment system 20 and a part of the first shifting device 41. In one embodiment, the common support structure 50 includes a support frame or a support bar connected to the vacuum chamber 101, wherein at least one alignment unit of the
25 alignment system 20 and at least one actuator and/or bearing of the first shifting device 41 are mounted to the support frame. In some implementations, a plurality of alignment units and a plurality of actuators and/or bearings of the first shifting device may be mounted to the support frame.

[0045] In some embodiments, the common support structure 50 includes an aligner
30 housing which is directly or indirectly fixed to the vacuum chamber 101, wherein the aligner housing houses at least one alignment unit of the alignment system 20, and wherein

at least one actuator and/or bearing of the first shifting device 41 is fixed to the aligner housing.

[0046] In some embodiments, the first shifting device 41 is entirely provided in the vacuum chamber 101. For example, as is schematically depicted in FIG. 1A and FIG. 1B, the actuator 43 and the movable part 42 of the first shifting device 41 are provided in the vacuum chamber 101 and are fixed to the common support structure 50. In other embodiments, an actuator of the first shifting device 41 may be arranged outside the vacuum chamber 101, and a bearing of the first shifting device 41 may be provided inside the vacuum chamber 101 and fixed to the common support structure 50. The bearing may support the movable part of the first shifting device. In particular, according to embodiments described herein, at least one of an actuator and a bearing of the first shifting device 41 may be arranged inside the vacuum chamber 101, particularly fixed to the common support structure 50.

[0047] In some embodiments, which may be combined with other embodiments described herein, the first shifting device 41 includes an actuator 43 for moving a movable part 42 of the first shifting device 41, wherein the actuator 43 includes at least one of a piezo actuator, a linear motor, a coil, a servo motor, a walking drive, a piezo stepper motor, a spindle drive, a pneumatic actuator, and a voice coil.

[0048] The movable part 42 of the first shifting device 41 may be configured to contactlessly shift the first carrier 11 in the second direction Z by applying a magnetic force on the first carrier 11. For example, the movable part 42 may include a magnetic side guide for the first carrier 11 which includes a plurality of magnets. When the magnets are moved in the second direction Z by the actuator 43, the first carrier 11 may follow the movement of the magnets, maintaining a constant distance in the second direction Z between the magnets and the first carrier 11.

[0049] In some embodiments, the apparatus 100 described herein may be operated as follows:

[0050] First, a first carrier 11 which holds a substrate 10 is transported into the deposition area 111 along a first transport path in the first direction X with the first carrier

transport system 31. The first carrier 11 may stop at the first position that is depicted in FIG. 1A in which the substrate 10 faces the deposition source 110. In the first position, the first carrier 11 is arranged at a distance from the first mount 21 of the alignment system 20, e.g. at a distance of 1 mm or more and 10 mm or less in the second direction Z.

5 [0051] Then, the first carrier 11 is moved in the second direction Z toward the first mount 21 of the alignment system 20 with the first shifting device 41. FIG. 1B shows a second position of the first carrier 11 in which the first carrier contacts the first mount 21 of the alignment system. The first mount 21 may magnetically mount the first carrier 11 to the alignment system 20.

10 [0052] The first carrier 11 can then be accurately positioned in the deposition area 111 with an alignment unit 25 of the alignment system 20 which is configured to move the first mount 21 in at least one direction. The first carrier 11 may be positioned with respect to a mask that is arranged in front of the substrate 10.

[0053] After the alignment of the first carrier 11, a coating material 112 can be deposited
15 on the substrate 10 with the deposition source 110. In some embodiments, the deposition source 110 is a vapor source configured to direct an evaporated material toward the substrate.

[0054] According to embodiments described herein, at least a part of the alignment
20 system 20 and at least a part of the first shifting device 41 are connected to the vacuum chamber 101 via the common support structure 50. Accordingly, the tolerance chain can be kept small and the complexity of the first shifting device and the alignment system can be reduced.

[0055] FIG. 2A is a schematic view of an apparatus 200 according to embodiments
25 described herein, wherein a first carrier 11 and a second carrier 13 are arranged in a first position. FIG. 2B is a schematic view of the apparatus 200 of FIG. 2A, wherein the first carrier 11 and the second carrier 13 have moved to a second position.

[0056] As is schematically depicted in FIG. 2A, the apparatus 200 includes a vacuum chamber 101, wherein an alignment system 120 is provided in the vacuum chamber 101. The alignment system 120 may be configured to accurately position a first carrier 11

relative to a second carrier 13. The first carrier 11 may be a substrate carrier configured to hold a substrate 10, and the second carrier 13 may be a mask carrier configured to hold a mask. Accordingly, the alignment system 120 is configured to align the substrate 10 held by the first carrier 11 with respect to the mask held by the second carrier 13.

5 [0057] A deposition source 110 may be provided in the vacuum chamber 101. The deposition source 110 may be configured to direct a coating material 112 toward a deposition area 111 in which the alignment system 120 is arranged. The coating material 112 can be deposited on the substrate 10 through the mask. A material pattern corresponding to an opening pattern of the mask can be deposited on the substrate by the
10 deposition source 110, e.g. by evaporation.

[0058] The alignment system 120 includes a first mount 121 for mounting the first carrier 11 to the alignment system 120 and a second mount 122 for mounting the second carrier 13 to the alignment system 20. Further, the alignment system 120 includes an alignment unit 125 for moving the first mount 121 and the second mount 122 relative to
15 each other in at least one direction, particularly in two or more directions. By moving the first mount 121 with respect to the second mount 122, the first carrier 11 can be aligned with respect to the second carrier 13.

[0059] In some embodiments, the alignment unit 125 may be configured to move the first mount 121 relative to the second mount 122 in the first direction X, in the second direction
20 Z, and/or in a third direction Y perpendicular to the first direction X and to the second direction Z.

[0060] In some embodiments, which may be combined with other embodiments described herein, the first mount 121 includes a magnetic chuck configured to magnetically clamp the first carrier 11 to the first mount 121, and/or the second mount 122 includes a
25 magnetic chuck configured to magnetically clamp the second carrier 13 to the second mount 122. In some embodiments, the magnetic chuck may include an electromagnet with a controller configured to activate and/or deactivate a magnetic field of the electromagnet. In some embodiments, the magnetic chuck includes an electropermanent magnet assembly (EPM) with a controller configured to activate a magnetic chucking force of a permanent
30 magnet device by applying an electric pulse.

[0061] The apparatus 200 further includes a first carrier transport system 31 configured to transport the first carrier 11 along a first transport path in the first direction X and a second carrier transport system 32 configured to transport the second carrier 13 along a second transport path in the first direction X. The first carrier 11 and the second carrier 13 may be transported essentially parallel to each other into the deposition area 111, e.g. at a distance of 5 cm or less from each other. For example, a substrate carrier track and a mask carrier track may extend essentially parallel to each other in the deposition area 111. In some embodiments, the substrate carrier track and the mask carrier track may be provided at same heights in a vertical direction. In other embodiments, the substrate carrier track and the mask carrier track may be provided at different heights in the vertical direction, as is schematically depicted in FIG. 2A. In the depicted embodiment, the second carrier 13 has a larger dimension in the vertical direction than the first carrier 11, and the mask carrier track is arranged at a lower height than the substrate carrier track.

[0062] The first carrier transport system 31 and the second carrier transport system 32 may be configured to transport the first carrier 11 and the second carrier 13 into the deposition area 111. In the deposition area 111, the second carrier 13, which holds the mask, may be arranged between the first carrier 11 and the deposition source 110. In particular, the second transport path is located between the first transport path and the deposition source 110 in the second direction Z. A coating material 112 can be deposited on the substrate 10 from the deposition source 110 through the mask that is held by the second carrier 13.

[0063] In some embodiments, the first carrier transport system 31 is configured for a contactless transport of the first carrier 11 along the first transport path, and/or the second carrier transport system 32 is configured for a contactless transport of the second carrier 13 along the second transport path in the first direction X. For example, the first carrier transport system 31 may hold and transport the first carrier 11 by magnetic forces and/or the second carrier transport system 32 may hold and transport the second carrier 13 by magnetic forces. In particular, the first carrier transport system 31 and/or the second carrier transport system 32 may include magnetic levitation devices.

[0064] The apparatus 200 further includes a first shifting device 141 configured to move the first carrier 11 from the first transport path to the first mount 121 of the alignment

system 120 and a second shifting device 142 configured to move the second carrier 13 from the second transport path to the second mount 122 of the alignment system. The second direction Z may be essentially perpendicular to the first direction X, i.e. perpendicular to the transport direction of the carriers. In particular, the first carrier transport system 31 may be configured to transport the first carrier into the deposition area 111 at a predetermined distance from the first mount 121, and the first shifting device 141 may be configured to move the first carrier toward the first mount 121 in the second direction Z (toward the deposition source 110 in the exemplary embodiments of FIG. 2A). The second carrier transport system 32 may be configured to transport the second carrier into the deposition area 111 at a predetermined distance from the second mount 122, and the second shifting device 142 may be configured to move the second carrier toward the second mount 122 in the second direction Z (away from the deposition source 110 in the exemplary embodiment of FIG. 2B). The first shifting device 141 and/or the second shifting device 142 may be configured in accordance with the first shifting device 41 depicted in FIG. 1A and FIG. 1B, such that reference can be made to the above embodiments which are not repeated here.

[0065] The second shifting device 142 may be configured to shift the second carrier 13 toward the second mount 122 in a direction opposite to the direction in which the first shifting device 141 shifts the first carrier 11 toward the first mount 121. Accordingly, the first carrier 11 and the second carrier 13 can be shifted toward opposite sides of the alignment system 120 via the first shifting device 141 and the second shifting device 142 where the first mount 121 and the second mount 122 are respectively arranged.

[0066] In some implementations, at least a part of the first shifting device 141, at least a part of the second shifting device 142 and at least a part of the alignment system 120 are held or supported by a common support structure 150. In particular, the first mount 121, the second mount 122, and the alignment unit 125 of the alignment system 120 may be held by the common support structure 150, such that the alignment system 120 is connected to the vacuum chamber 101 by the common support structure. Further, an actuator and/or a bearing of the first shifting device 141 and an actuator and/or a bearing of the second shifting device 142 may be fixed to the common support structure 150. The common support structure 150 may be configured in accordance with the common support

structure 50 depicted in FIG. 1A, such that reference can be made to the above explanations which are not repeated here.

[0067] When at least a part of the first shifting device 141 and at least a part of the second shifting device 142 are attached to the common support structure 150 which also holds the alignment system 120, the tolerance chain can be reduced. The manufacture and the installation of the apparatus 200 can be facilitated, and the alignment accuracy of the carriers with respect to each other can be improved.

[0068] In some embodiments, the first shifting device 141 and/or the second shifting device 142 may include a movable part and an actuator configured to move the movable part in the second direction Z, respectively. The movable part may be configured to contactlessly shift a carrier in the second direction Z by applying a magnetic force on the carrier.

[0069] In particular, the first shifting device 141 and the second shifting device 142 may include a magnetic unit configured to contactlessly shift a carrier in the second direction Z. For example, the movable part may include a magnetic side guide configured to stabilize a carrier at a constant distance from the side guide in the second direction Z. The actuators and/or the magnetic side guides of the shifting devices may be arranged in the vacuum chamber, particularly supported by the common support structure 150.

[0070] In some implementations, the actuators of the first and second shifting devices include piezo actuators, linear motors or coils that are arranged in the vacuum chamber 101, respectively, particularly fixed to the common support structure 150.

[0071] In some embodiments, which may be combined with other embodiments described herein, the common support structure 150 includes an aligner housing which houses an alignment unit 125 of the alignment system 120, wherein actuators and/or bearings of the first and second shifting devices are attached to the aligner housing. The aligner housing may be fixed directly or indirectly to an inner wall of the vacuum chamber 101.

[0072] In some embodiments, which may be combined with other embodiments described herein, an actuator and/or a bearing of the first shifting device 141 is attached to

a first side of the common support structure 150 and an actuator and/or a bearing of the second shifting device 142 is attached to a second side of the common support structure 150 opposite the first side. For example, as is schematically depicted in FIG. 2A, the first shifting device 141 is attached to a lower side of the common support structure 150, and
5 the second shifting device 142 is attached to an upper side of the common support structure 150. Accordingly, the first carrier 11 and the second carrier 13 can be shifted in the second direction Z toward each other or away from each other without interfering with each other, since the respective shifting devices are arranged on opposite sides of the common support structure.

10 [0073] In FIG. 2B, the first carrier 11 and the second carrier 13 have moved toward each other to a respective second position via the first shifting device 141 and the second shifting device 142, until the first carrier contacts the first mount 121 and the second carrier contacts the second mount 122. In the second position, the first carrier 11 and the second carrier 13 are mounted to two opposite sides of the alignment system 120, such that
15 the alignment system is at least partially arranged between the first carrier 11 and the second carrier 13. In the second position, the first carrier can be aligned with respect to the second carrier by moving the first mount with respect to the second mount with the alignment unit 125 of the alignment system.

[0074] In some embodiments, which may be combined with other embodiments
20 described herein, the alignment system 120 includes a plurality of alignment units for aligning the first carrier 11 with respect to the second carrier 13. An upper alignment unit 126 and a lower alignment unit 127 are exemplarily depicted in FIG. 2A. Yet further alignment units may be provided. For example, at least four alignment units may be provided at spaced-apart positions at the common support structure for aligning the first
25 carrier 11 with respect to the second carrier 13, e.g. at the four corners of the carriers.

[0075] The upper alignment unit 126 and the lower alignment unit 127 may be held by a support frame of the common support structure. Alternatively, the upper alignment unit 126 may be held by an upper support bar 151 or an upper aligner housing of the common support structure 150, and the lower alignment unit 127 may be held by a lower support
30 bar 152 or a lower aligner housing of the common support structure 150.

[0076] The alignment system 120 may include a plurality of first mounts for mounting the first carrier 11 to the alignment system and a plurality of second mounts for mounting the second carrier 13 to the alignment system 120. In the exemplary embodiment of FIG. 2A, the upper alignment unit 126 is connected between an upper first mount and an upper second mount, and the lower alignment unit 127 is connected between a lower first mount and a lower second mount. Further mounts and alignment units may be provided. Each alignment unit of the plurality of alignment units may be configured to move a respective first mount relative to a respective second mount for aligning the first carrier 11 with respect to the second carrier 13.

[0077] In some embodiments, an upper shifting device 143 configured to move (an upper portion of) the first carrier 11 in the second direction Z, and a lower shifting device 144 configured to move (a lower portion of) the first carrier 11 in the second direction Z may be provided. At least a part of the upper shifting device 143 may be supported or held by an upper support bar 151 or an upper aligner housing of the common support structure 150, and at least a part of the lower shifting device 144 may be supported or held by a lower support bar 152 or a lower aligner housing of the common support structure 150. Similarly, at least one upper shifting device configured to move an upper portion of the second carrier 13 in the second direction Z, and at least one lower shifting device configured to move a lower portion of the second carrier 13 in the second direction Z may be provided.

[0078] In some embodiments, the alignment unit 125 may be configured to move the first mount 121 relative to the second mount 122 in the second direction Z. Thus, the distance between the first carrier 11 and the second carrier 13 may be adjusted as appropriate by the alignment unit 125. Alternatively or additionally, the alignment unit 125 may be configured to move the first mount 121 relative to the second mount 122 in the first direction X. Thus, a relative position between the mask and the substrate in a width direction of the substrate can be adjusted as appropriate by the alignment unit 125. Alternatively or additionally, the alignment unit 125 may be configured to move the first mount 121 relative to the second mount 122 in a third direction Y perpendicular to the first direction X and the second direction Z. Thus, a relative position between the mask and the substrate in a height direction of the substrate can be adjusted as appropriate by the alignment unit 125.

[0079] The alignment unit 125 may include one or more piezo actuators for moving the first mount with respect to the second mount in one or more directions. Alternatively, the alignment unit may be selected from the group consisting of a stepper actuator, a brushless actuator, a DC (direct current) actuator, a voice coil actuator, and a pneumatic actuator.

5 [0080] In some embodiments, the deposition source 110 may be a vapor source configured to direct evaporated material toward the substrate 10. The deposition source 110 may be movable along a source transportation track which may be provided in the vacuum chamber 101. In particular, the deposition source 110 may be movable in the first direction X past the substrate. The first direction X may correspond to a width direction of
10 the substrate 10. Accordingly, the deposition source 110 can be moved past the substrate 10 in a width direction of the substrate 10 for depositing the coating material 112 on the substrate 10.

[0081] The deposition source 110 may be provided as a line source extending in the third direction Y, i.e. in an essentially vertical direction. The height of the deposition source 110
15 in the vertical direction may be adapted to a height of the vertically oriented substrate such that the substrate can be coated by moving the deposition source 110 past the substrate in the first direction X.

[0082] The deposition source 110 may include a distribution pipe with a plurality of vapor openings or nozzles for directing the coating material 112 toward the deposition area
20 111. Further, the deposition source 110 may include a crucible configured for heating and evaporating the coating material. The crucible may be connected to the distribution pipe such as to be in fluid communication with the distribution pipe.

[0083] In some embodiments, which may be combined with other embodiments described herein, the deposition source 110 may be rotatable. For example, the deposition
25 source may be rotatable from a first orientation in which the vapor openings of the deposition source are directed toward the deposition area 111 to a second orientation in which the vapor openings are directed toward a second deposition area. The deposition area 111 and the second deposition area may be located on opposite sides of the deposition source 110, and the deposition source may be rotatable by an angle of about 180° between
30 the deposition area and the second deposition area.

[0084] FIG. 2A and FIG. 2B further show a system for processing a substrate in accordance with embodiments described herein. The system includes an apparatus according to any of the embodiments described herein, a first carrier 11 configured as a substrate carrier mounted to the first mount 121 of the alignment system 120, and a second carrier 13 configured as a mask carrier mounted to the second mount 122 of the alignment system.

[0085] FIG. 3 is a schematic sectional view of an apparatus 300 according to embodiments described herein. FIG. 4 is a schematic front view of an apparatus 300 according to embodiments described herein. The apparatus 300 may include some features or all the features of the previously described embodiments, which are not repeated here.

[0086] The apparatus 300 includes a vacuum chamber 101, wherein a part of a wall of the vacuum chamber 101 is depicted in FIG. 3. A common support structure 150 is fixed at the wall of the vacuum chamber.

[0087] An alignment system 120 configured to align a first carrier 11 with respect to a second carrier 13, a bearing 301 of a first shifting device 141, and/or a second bearing 302 of a second shifting device 142 are held by the common support structure 150 in the vacuum chamber 101. In particular, the alignment unit 125, the bearing 301 and the second bearing 302 are connected to the vacuum chamber 101 via the common support structure 150. The common support structure 150 may include a support bar, a support frame, an aligner housing, or different types of supports, which connects the alignment unit 125, the bearing 301, and the second bearing 302 to the vacuum chamber 101.

[0088] One benefit of the common support structure 150 is that the tolerance chain of the shifting devices is based on the same reference as the alignment system. This reduces the tolerance specifications and simplifies the assembly.

[0089] In the embodiment depicted in FIG. 3, the common support structure 150 includes an aligner housing 305 which houses an alignment unit 125 of the alignment system 120. In some embodiments, the common support structure 150 may include a plurality of aligner housings, wherein each aligner housing houses an alignment unit 125 of the alignment system 120. The alignment units are configured to move a respective first mount

with respect to a respective second mount, in order to align a first carrier 11 which is mounted to the first mounts relative to a second carrier which 13 is mounted to the second mounts.

[0090] In some embodiments, which may be combined with other embodiments described herein, the first shifting device 141 may include a movable part 311, an actuator 321 configured to move the movable part 311 in the second direction Z, and a bearing 301 which movably supports the movable part 311 at the common support structure 150. In other words, the movable part 311 may be supported on the common support structure 150 via the bearing 301. The bearing 301 may be attached to the common support structure 150 in the vacuum chamber 101. In the embodiment of FIG. 3, the bearing 301 is attached to an aligner housing 305 in the vacuum chamber 101.

[0091] The movable part 311 may include a magnetic unit that is configured to contactlessly shift the first carrier 11 in the second direction Z by applying a magnetic force on the first carrier 11.

[0092] The actuator 321 may be arranged in the vacuum chamber 101 or outside the vacuum chamber 101. In the embodiment depicted in FIG. 3, the actuator 321 is arranged outside the vacuum chamber, and the movable part 311 extends from the actuator 321 through a wall of the vacuum chamber 101 into an interior of the vacuum chamber 101 where the movable part 311 is supported by the bearing 301. The actuator may, e.g., include a servo motor, a piezo stepper motor, or a walking drive. Providing the actuator 321 outside the vacuum chamber may be beneficial in some applications because the maintenance of the actuator can be facilitated and space requirements may be less strict outside the vacuum chamber. In other applications, providing the actuator 321 inside the vacuum chamber may be beneficial because no feed-through for guiding a movable part 311 through a wall of the vacuum chamber may be needed.

[0093] The movable part 311 may be supported on the common support structure 150 by the bearing 301. The bearing 301 may be configured as a flexible structure, which may guide the movable part 311 essentially without the frictional generation of particles in the second direction Z.

[0094] In some embodiments, the bearing 301 may be a compliant mechanism, i.e. a flexible mechanism that transfers the input force provided by the actuator 321 through the deformation of an elastic body. The actuator may be connected to, or integrally formed with the flexible mechanism, e.g. integrated with the elastic body. The elastic body may include at least one elastically deformable body, e.g. a leaf spring. By attaching the compliant mechanism to the same support structure as the alignment system 20, the tolerance chain of the first shifting device 141 is based on the same reference as the tolerance chain of the alignment unit 125. Accordingly, the installation of the apparatus can be simplified.

[0095] The compliant mechanism of the first shifting device may be configured as a cantilever beam arrangement, e.g. a vertical arrangement, a horizontal arrangement or a combination. The compliant mechanism may be manufactured by wire EDM (electrical discharge machining) cutting of a metal, e.g. a Titanium block. Particle generation due to a relative movement between parts in the vacuum chamber may be reduced or entirely avoided.

[0096] Further, a second shifting device 142 may be provided for moving the second carrier 13 in the second direction Z toward the second mount 122 of the alignment system 120. The second shifting device 142 may be configured in a similar or identical way as the first shifting device 141, such that reference can be made to the above explanations. In particular, the second shifting device 142 may include a second bearing 302 which is attached to the common support structure 150, particularly to the aligner housing 305 which houses the alignment unit 125.

[0097] The second shifting device 142 may include a second actuator 322 configured to move a second movable part 312 in the second direction Z, wherein the second movable part 312 is supported on the common support structure 150 via the second bearing 302. The second bearing 302 may be configured as a flexible structure, which may guide the second movable part 312 essentially without the frictional generation of particles. In some embodiments, the second bearing 302 may be a compliant mechanism. The elastic body may include at least one elastically deformable body, e.g. a leaf spring.

[0098] By attaching the compliant mechanism of the first shifting device 141 and the compliant mechanism of the second shifting device 142 to the same support structure as the alignment system 120, the tolerance chain of the first shifting device 141, of the second shifting device 142 and of the alignment unit 125 are based on the same reference

5 [0099] In some embodiments, the bearing 301 of the first shifting device 141 is attached to a first side of the aligner housing 305, e.g. to an upper side, and the second bearing 302 of the second shifting device 142 is attached to a second side of the aligner housing 305 opposite the first side, e.g. to a lower side.

[00100] As is schematically depicted in FIG. 3, the common support structure 150 may
10 include at least one further aligner housing 306 which holds at least one further alignment unit, wherein bearings of a further shifting device may be supported on the further alignment housing.

[00101] FIG. 4 shows the apparatus 300 of FIG. 3 in a front view. As is schematically depicted in FIG. 4, the common support structure 150 may include a plurality of supports,
15 e.g. three upper supports and three lower supports. Each support may include an aligner housing 305 which houses an alignment unit 125 of the alignment system 120 configured to move a respective first mount 121 relative to a respective second mount 122.

[00102] At least a part of a first shifting device 141 for moving a first carrier 11 in the second direction Z and at least a part of a second shifting device 142 for moving a second
20 carrier 13 in the second direction Z may be attached to each of the supports of the common support structure 150.

[00103] In some implementations, the first shifting device 141 may include a magnetic side guide 313 configured to contactlessly shift the first carrier 11 in the second direction Z, wherein the magnetic side guide 313 may be supported on a plurality of supports,
25 particularly on the aligner housings 305, via a plurality of bearings, particularly via a plurality of compliant mechanisms. The bearings may be attached to the aligner housings 305 of the common support structure 150. The bearings may be configured as compliant mechanisms including flexible elements for transferring the displacement force of one or

more actuators to the magnetic side guide 313. Accordingly, the magnetic side guide 313 can be shifted in the second direction Z.

[00104] Similarly, the second shifting device 142 may include a magnetic side guide configured to contactlessly shift the second carrier 13 in the second direction Z, wherein
5 also the magnetic side guide of the second shifting device 142 may be supported on the plurality of supports, via a plurality of bearings, particularly via a plurality of compliant mechanisms.

[00105] In another embodiment, the common support structure includes a support frame, wherein each alignment unit of a plurality of alignment units is attached to the support
10 frame. Further, bearings and/or actuators of the first shifting device and bearings and/or actuators of the second shifting device may be attached to the support frame. The support frame may be connected to the vacuum chamber via a mechanical isolation element, e.g. a vibration damper, in order to decouple vibrations of the vacuum chamber from the support frame which holds the alignment system as well as the shifting devices.

[00106] FIGS. 5A to 5D show several stages of a method of transporting carriers in a vacuum chamber according to methods described herein. In FIGS. 5A to 5D, a substrate carrier (the first carrier 11) is transported and aligned relative to a mask carrier (the second carrier 13). The method may be carried out in the sequence depicted in FIGS. 5A to 5D. Alternatively, the order of some of the stages may be changed.

[00107] In FIG. 5A, a second carrier 13 carrying a mask is transported with a second carrier transport system 32 along a second transport path in the first direction X into a deposition area 111 in a vacuum chamber. The second carrier transport system 32 may be a transport system configured for a contactless transport of the second carrier, e.g. including a magnetic levitation system.

[00108] The second carrier 13 stops at a first position depicted in FIG. 5A, in which the second carrier 13 is arranged on a first side of an alignment system 120 at a distance from a second mount 122.

[00109] In FIG. 5B, the second carrier 13 is laterally shifted in the second direction Z essentially perpendicular to the first direction X toward the second mount 122 of the

alignment system 120 by a second shifting device 142. The second shifting device 142 may be configured as a cross drive device which may include a movable part for shifting the second carrier 13 toward the second mount 122.

[00110] As is depicted in FIG. 5B, the second shifting device 142 may shift the second carrier 13 from the second transport path toward the alignment system 120 in the second direction Z until the second carrier 13 contacts the second mount 122 of the alignment system 120. For example, the second shifting device may shift the second carrier in the second direction Z by a distance of 4 mm or more and 10 mm or less.

[00111] The second carrier 13 may be mounted to the second mount 122, e.g. by activating a magnet of the second mount 122 such that the second carrier 13 is magnetically chucked to the second mount 122 and is held by the second mount at the alignment system 120.

[00112] Further, in FIG. 5B, a first carrier 11 carrying a substrate 10 is transported with a first carrier transport system 31 along a first transport path in the first direction X into the deposition area 111. The first carrier transport system 31 may be a transport system configured for a contactless transport of the first carrier, e.g. including a magnetic levitation system.

[00113] The first carrier 11 stops at a first position depicted in FIG. 5B, in which the first carrier 11 is arranged on a second side of the alignment system 120 opposite the first side where the second carrier 13 is arranged. In particular, the first carrier 11 may be arranged between the alignment system 120 and a wall of the vacuum chamber (not depicted in FIG. 5B).

[00114] In FIG. 5C, the first carrier 11 is laterally shifted in the second direction Z essentially perpendicular to the first direction X toward the first mount 121 of the alignment system 120 by a first shifting device 141. The first shifting device 141 may be configured as a cross drive device which may include a movable part for contactlessly shifting the first carrier 11 toward the first mount 121. For example, the first shifting device 141 may shift the substrate carrier in the second direction Z by a distance of 4 mm or more and 10 mm or less toward the alignment system.

[00115] As is depicted in FIG. 5B and 5C, the second shifting device 142 may be configured to shift the second carrier 13 in a direction opposite to the direction in which the first shifting device shifts the first carrier 11. Accordingly, the first carrier 11 and the second carrier 13 can be shifted toward opposite sides of the alignment system 120 via the first shifting device and the second shifting device, respectively.

[00116] The first carrier 11 may be mounted to the first mount 121, e.g. by activating a magnet of the first mount 121 such that the first carrier 11 is magnetically chucked to the first mount 121 and is held by the first mount at the alignment system 120.

[00117] In FIG. 5D, the first carrier 11 is aligned with respect to the second carrier 13 by the alignment unit 125 that is provided in a mechanical connection path between the first mount 121 and the second mount 122. Accordingly, the mask and the substrate are aligned relative to each other with a high accuracy. Then, a coating material 112 may be deposited on the substrate, particularly by evaporation.

[00118] The alignment system 120 as well as actuators and/or bearings of the first shifting device 141 and the second shifting device 142 are supported or held by a common support structure.

[00119] FIG. 6 is a flow diagram which schematically illustrates a method of transporting carriers according to methods described herein.

[00120] In box 710, a first carrier 11 carrying a substrate 10 is transported along a first transport path in a first direction X into a deposition area 111.

[00121] In box 720, the first carrier 11 is moved from the first transport path to a first mount of an alignment system in a second direction Z transverse to the first direction with a first shifting device, wherein at least a part of the first shifting device and at least a part of the alignment system are supported or held by a common support structure.

[00122] In box 730, the first carrier 11 is mounted to the first mount of the alignment system.

[00123] In box 740, the first carrier is aligned with the alignment system.

[00124] In box 750, a coating material is deposited on a substrate.

[00125] The method may optionally include in box 705 which may be carried out before box 710: transporting a second carrier 13 which carries a mask along a second transport path in the first direction X, moving the second carrier 13 from the second transport path to
5 a second mount of the alignment system with a second shifting device, wherein at least a part of the second shifting device is supported or held by the common support structure, and mounting the second carrier to the second mount of the alignment system.

[00126] Aligning in box 740 may include moving the first mount relative to the second mount for aligning the first carrier 11 with respect to the second carrier 13.

10 [00127] The apparatus described herein can be configured for evaporation of e.g. an organic material for the manufacture of OLED devices. As an example, the deposition source can be an evaporation source, particularly an evaporation source for depositing one or more organic materials on a substrate to form a layer of an OLED device.

[00128] The embodiments described herein can be utilized for evaporation on large area
15 substrates, e.g., for OLED display manufacturing. Specifically, the substrates for which the structures and methods according to embodiments described herein are provided, are large area substrates, e.g. having a surface area of 0.5 m² or more, particularly 1 m² or more. For instance, a large area substrate or carrier can be GEN 4.5, which corresponds to a surface area of about 0.67 m² (0.73 x 0.92m), GEN 5, which corresponds to a surface area of about
20 1.4 m² (1.1 m x 1.3 m), GEN 7.5, which corresponds to a surface area of about 4.29 m² (1.95 m x 2.2 m), GEN 8.5, which corresponds to a surface area of about 5.7m² (2.2 m x 2.5 m), or even GEN 10, which corresponds to a surface area of about 8.7 m² (2.85 m x 3.05 m). Even larger generations such as GEN 11 and GEN 12 and corresponding surface areas can similarly be implemented. Half sizes of the GEN generations may also be
25 provided in OLED display manufacturing.

[00129] According to some embodiments, which can be combined with other embodiments described herein, the substrate thickness can be from 0.1 to 1.8 mm. The substrate thickness can be about 0.9 mm or below, such as 0.5 mm. 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 also embrace flexible substrates such as a web or a foil. The term “substantially inflexible” is understood to distinguish over “flexible”. Specifically, a substantially inflexible substrate can have a certain degree of flexibility, e.g. a glass plate having a thickness of 0.9 mm or below, such as 0.5 mm or below, wherein the flexibility of the substantially inflexible substrate is small in comparison to the flexible substrates.

[00130] According to embodiments described herein, the substrate may be made of any material suitable for material deposition. For instance, the substrate may be made of a material selected from the group consisting of glass (for instance soda-lime glass, borosilicate glass, and the like), metal, polymer, ceramic, compound materials, carbon fiber materials or any other material or combination of materials which can be coated by a deposition process.

[00131] A method described herein may include aligning the first carrier and the second carrier relative to each other with an alignment unit of the alignment system. At least one of mechanical noise, vibrations from the system, and vibrations from the building, i.e. dynamic and static deformations, which may be transferred from the vacuum chamber to the alignment system may be compensated or reduced by a mechanical isolation element which may be arranged in a connection line between the alignment system and the vacuum chamber, particularly integrated in the common support structure.

[00132] The combination of a pre-alignment via a contactless transportation system, for example a magnetic levitation system, and a fine alignment with mechanical contact by the alignment system allows for an alignment system with reduced complexity and, thus, reduced cost of ownership.

[00133] According to embodiments described herein, the method for aligning and/or transportation of a substrate carrier and a mask carrier in a vacuum chamber can be conducted using computer programs, software, computer software products and the interrelated controllers, which can have a CPU, a memory, a user interface, and input and output devices being in communication with the corresponding components of the apparatus.

[00134] The present disclosure provides a first carrier transport system for a first carrier and a second carrier transport system for a second carrier that may be equally sized in at least one dimension. In other words, the second carrier may fit into the first carrier transport system and the first carrier may fit into the second carrier transport system. The first carrier transport system and the second carrier transport system can be flexibly used while providing an accurate and smooth transportation of the carriers through the vacuum system. The alignment system allows for a precise alignment of the substrate with respect to the mask, or vice versa. High quality processing results, e.g. for production of high resolution OLED devices, can be achieved.

[00135] In other embodiments, the mask carriers and the substrate carriers may be differently sized. For example, the mask carriers may be larger than the substrate carriers, particularly in a vertical direction.

[00136] 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. An apparatus (100, 200, 300) for processing a substrate in a vacuum chamber (101), comprising:

a first carrier transport system (31, 131) configured to transport a first carrier (11)
5 along a first transport path in a first direction (X);

an alignment system (20, 120) comprising a first mount (21, 121) for mounting the first carrier (11) to the alignment system (20, 120);

a first shifting device (41, 141) configured to move the first carrier from the first transport path to the first mount (21, 121) in a second direction (Z) transverse to the first
10 direction (X); and

a common support structure (50, 150) which supports or holds at least a part of the alignment system (20, 120) and at least a part of the first shifting device (41, 141).

2. The apparatus of claim 1, wherein the common support structure (50, 150) connects at least a part of the alignment system (20, 120) to the vacuum chamber (101), and wherein
15 at least one of an actuator and a bearing (301) of the first shifting device (41, 141) is attached to the common support structure.

3. The apparatus of claim 1 or 2, wherein the common support structure (50, 150) comprises an aligner housing (305) which houses an alignment unit (25, 125) of the alignment system (20, 120), wherein at least one of an actuator and a bearing (301) of the
20 first shifting device (41, 141) is attached to the aligner housing (305).

4. The apparatus of any of claims 1 to 3, wherein the first shifting device (41, 141) comprises a movable part (311) that is supported on the common support structure (50, 150) via a bearing (301) comprising a flexible structure, particularly a compliant mechanism.

25 5. The apparatus of any of claims 1 to 4, wherein the first shifting device (41, 141) comprises an actuator, particularly a piezo actuator or a linear motor, arranged in the vacuum chamber (101), particularly fixed to the common support structure (50, 150).

6. The apparatus of any of claims 1 to 5, comprising an upper shifting device (143) configured to move an upper portion of the first carrier in the second direction (Z), and a lower shifting device (144) configured to move a lower portion of the first carrier in the second direction (Z).

5 7. The apparatus of any of claims 1 to 6, wherein the first shifting device (41, 141) comprises a movable part (311) configured to contactlessly shift the first carrier (11) in the second direction (Z) by applying a magnetic force on the first carrier (11).

8. The apparatus of any of claims 1 to 7, wherein the alignment system (120) comprises a second mount (122) for mounting a second carrier (13) to the alignment
10 system (120), and an alignment unit (125) for moving the first mount (121) and the second mount (122) relative to each other.

9. The apparatus of claim 8, wherein the first mount (121) comprises a magnetic chuck configured to magnetically clamp the first carrier (11) to the first mount (121), and/or wherein the second mount (122) comprises a magnetic chuck configured to
15 magnetically clamp the second carrier (13) to the second mount (122).

10. The apparatus of claim 8 or 9, further comprising a second shifting device (142) configured to move the second carrier (13) to the second mount (122) in the second direction (Z), wherein at least a part of the second shifting device (142) is supported on or attached to the common support structure (150).

20 11. The apparatus of claim 10, wherein the common support structure (150) comprises an aligner housing (305) which houses an alignment unit (125) of the alignment system (120), wherein at least one of an actuator (321) and a bearing (301) of the first shifting device (141) is attached to a first side of the aligner housing (305), and at least one of an actuator and a bearing of the second shifting device (142) is attached to a second side of
25 the aligner housing (305) opposite the first side.

12. The apparatus of any of claims 8 to 11, further comprising a second carrier transport system (132) configured to transport the second carrier (13) along a second transport path in the first direction (X), wherein the first carrier transport system (131) is configured for a contactless transport of the first carrier (11) along the first transport path,

and wherein the second carrier transport system (132) is configured for a contactless transport of the second carrier (13) along the second transport path.

13. An apparatus for processing a substrate in a vacuum chamber (101), comprising:

a first carrier transport system extending in a first direction (X);

5 an alignment system comprising a first mount;

a first shifting device extending in a second direction (Z) transverse to the first direction; and

a common support structure (50, 150) which supports or holds at least a part of the alignment system and at least a part of the first shifting device.

10 14. A system for processing a substrate, comprising:

the apparatus (100) of any of claims 8 to 12,

a first carrier (11) configured as a substrate carrier mounted to the first mount; and

a second carrier (13) configured as a mask carrier mounted to the second mount.

15. A method of transporting a carrier in a vacuum chamber, comprising:

15 transporting a first carrier (11) along a first transport path in a first direction (X);

moving the first carrier (11) from the first transport path to a first mount of an alignment system (120) in a second direction (Z) transverse to the first direction with a first shifting device (141), wherein at least a part of the first shifting device and at least a part of the alignment system are supported or held by a common support structure (150);

20 mounting the first carrier (11) to the first mount of the alignment system (120); and

aligning the first carrier (11) with the alignment system (120).

16. The method of claim 15, further comprising:

transporting a second carrier (13) along a second transport path in the first direction (X);

moving the second carrier (13) from the second transport path to a second mount of the alignment system (120) with a second shifting device (142), wherein at least a part of
5 the second shifting device is supported or held by the common support structure (150); and

mounting the second carrier (13) to the second mount of the alignment system (120),

wherein aligning comprises moving the first mount relative to the second mount for aligning the first carrier (11) with respect to the second carrier (13).

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FIG. 1A

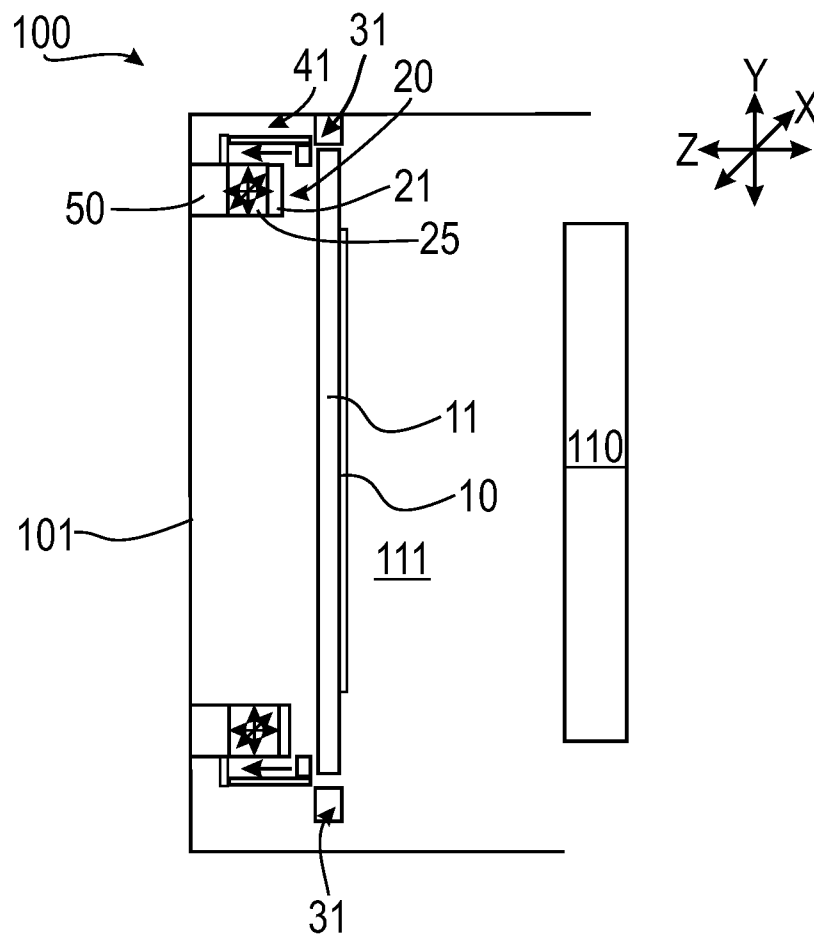
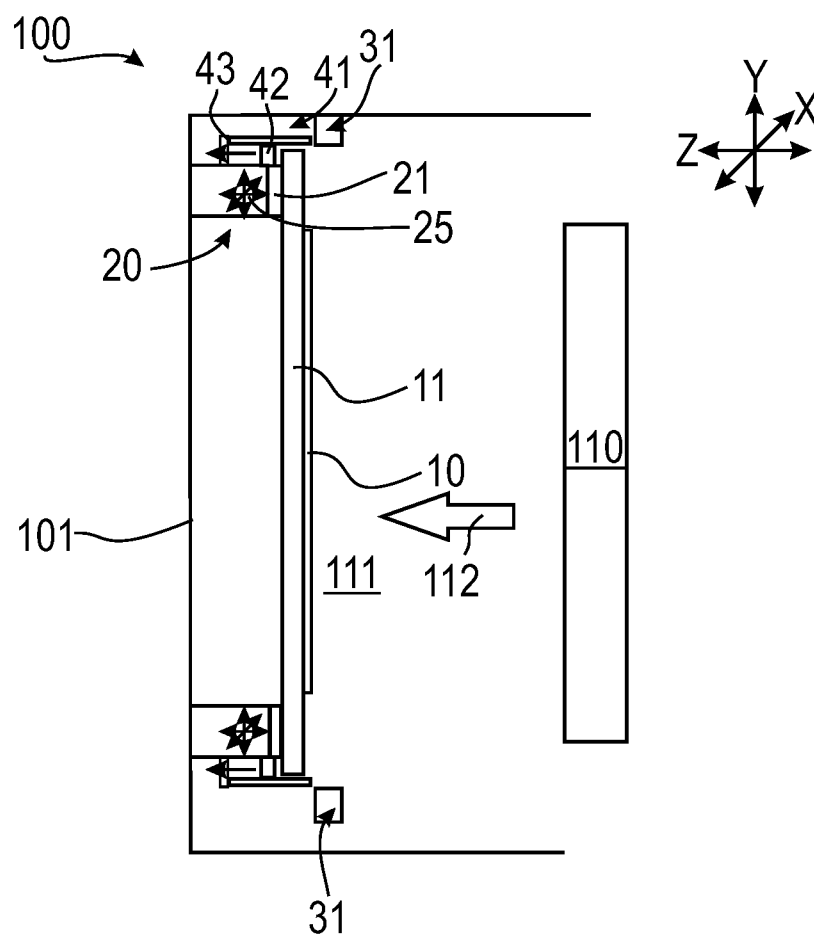


FIG. 1B



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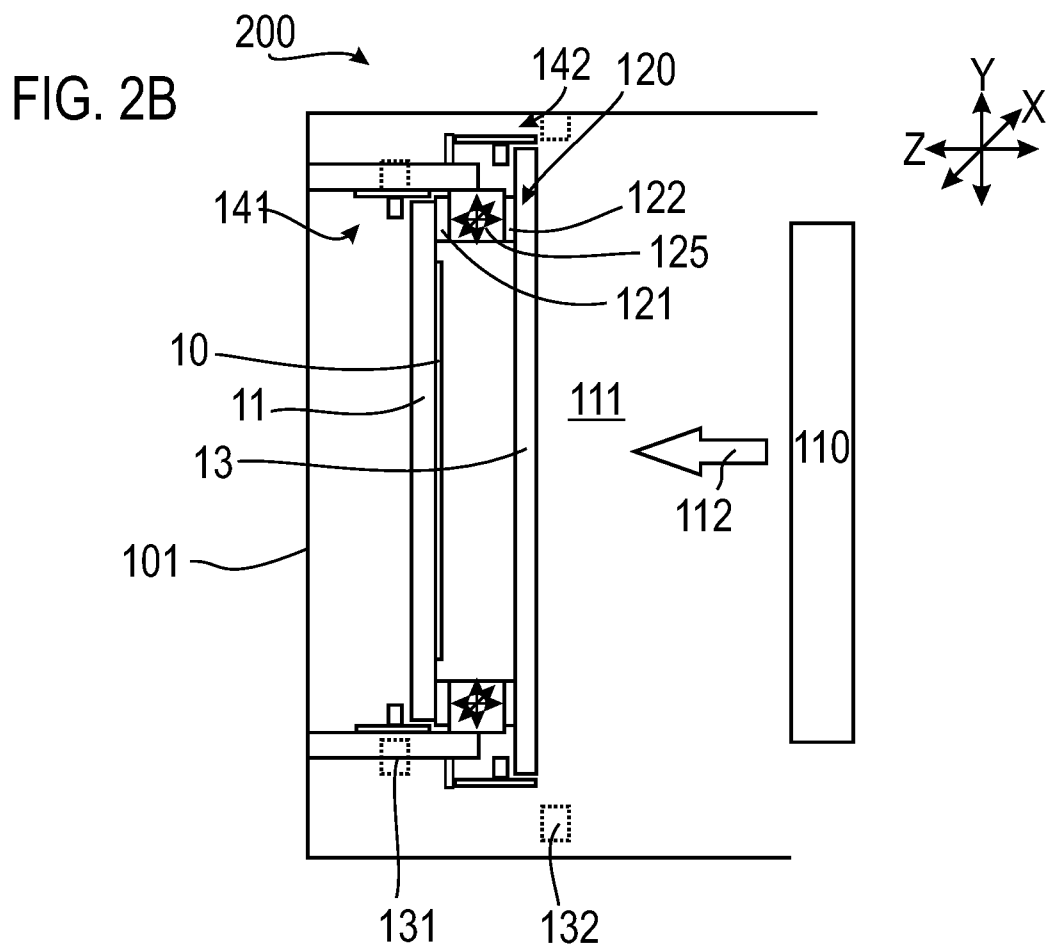
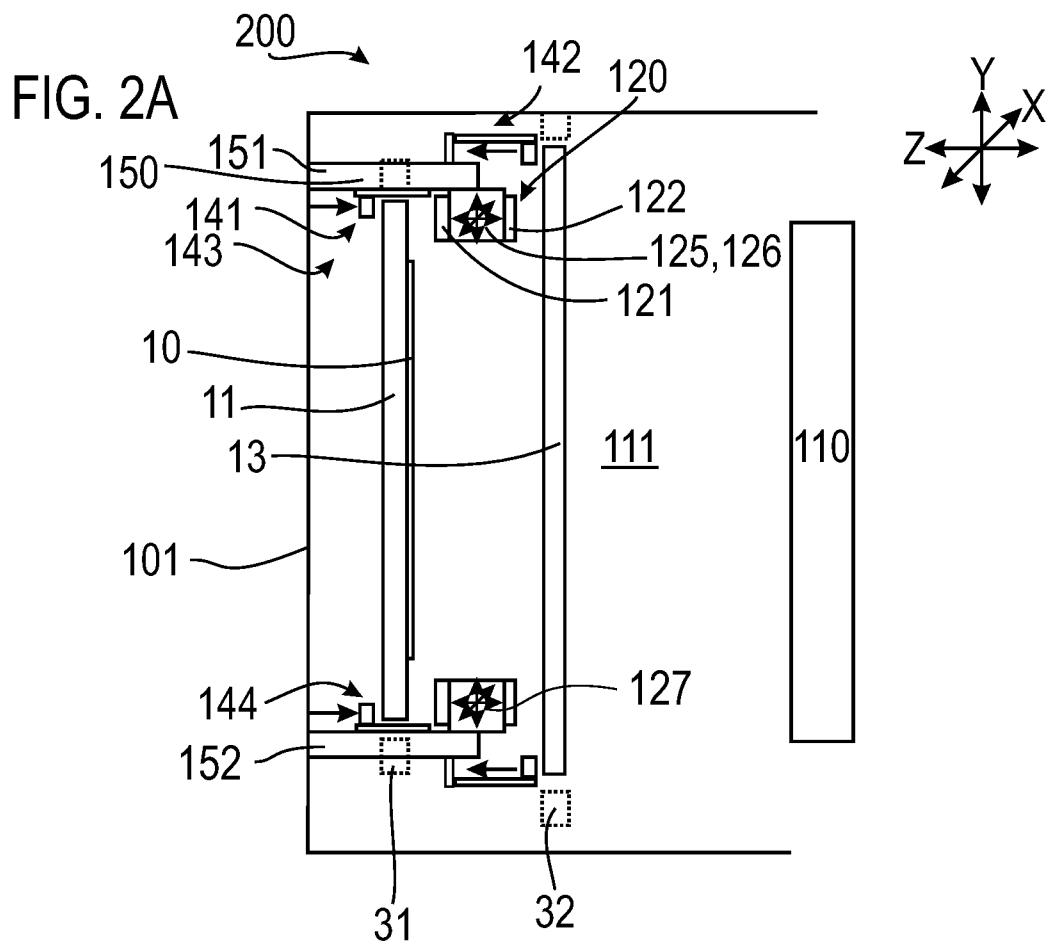


FIG. 3

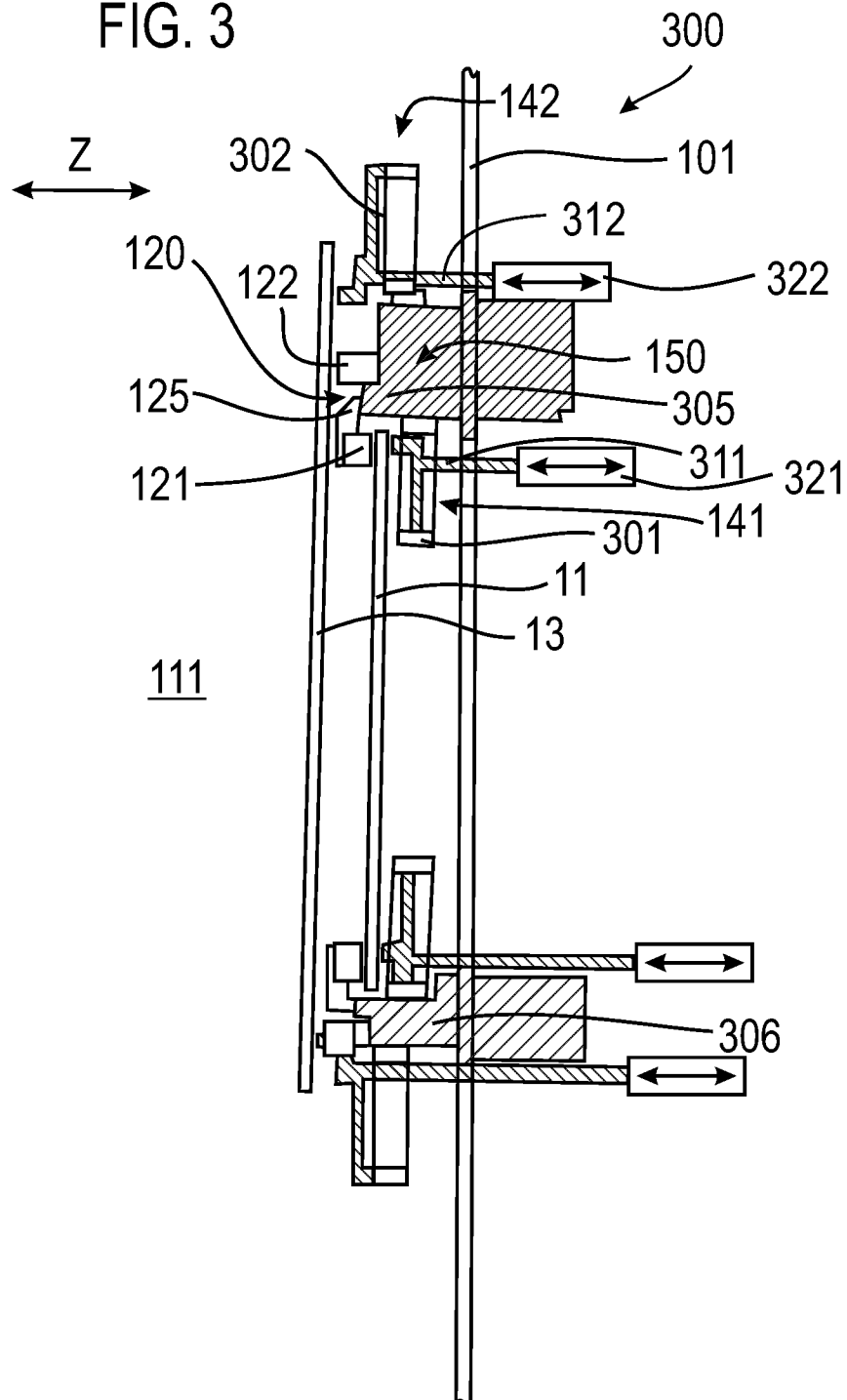
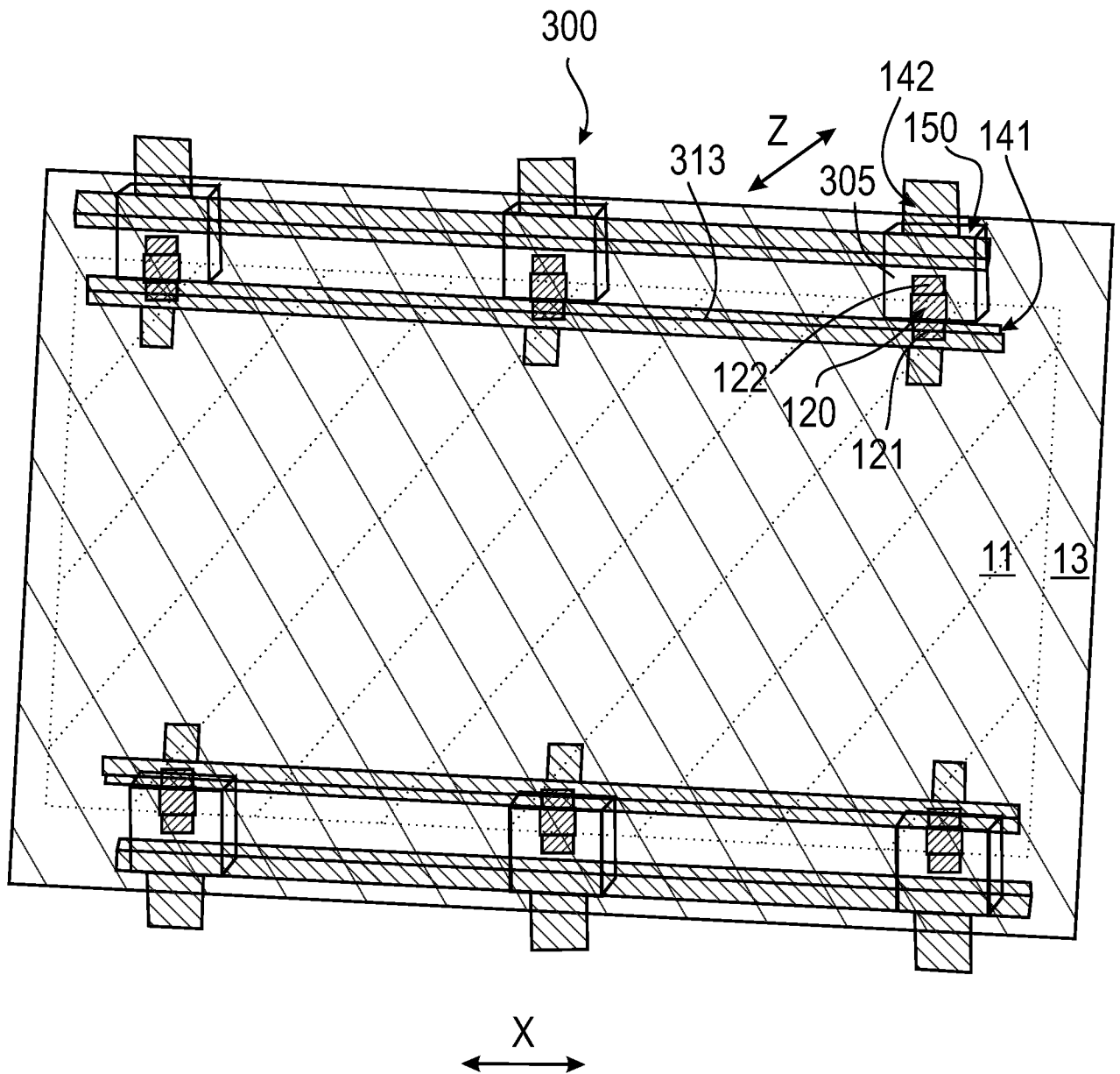


FIG. 4



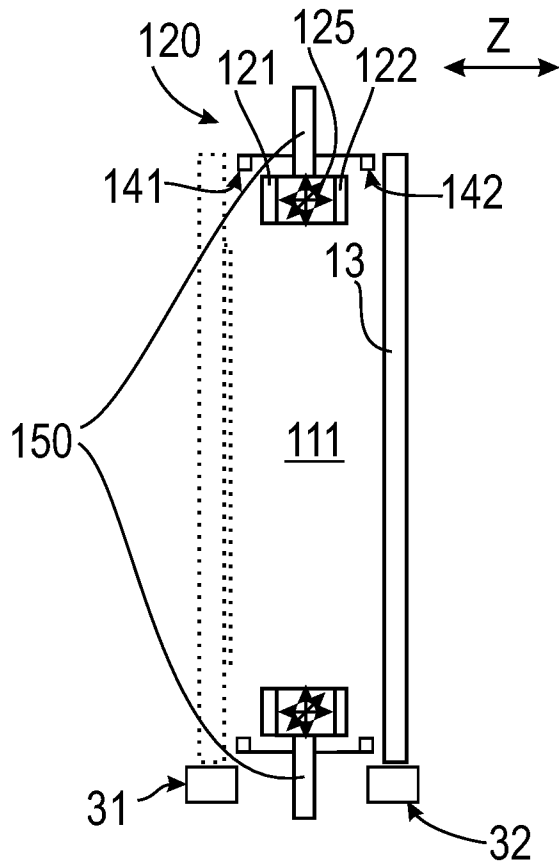


FIG. 5A

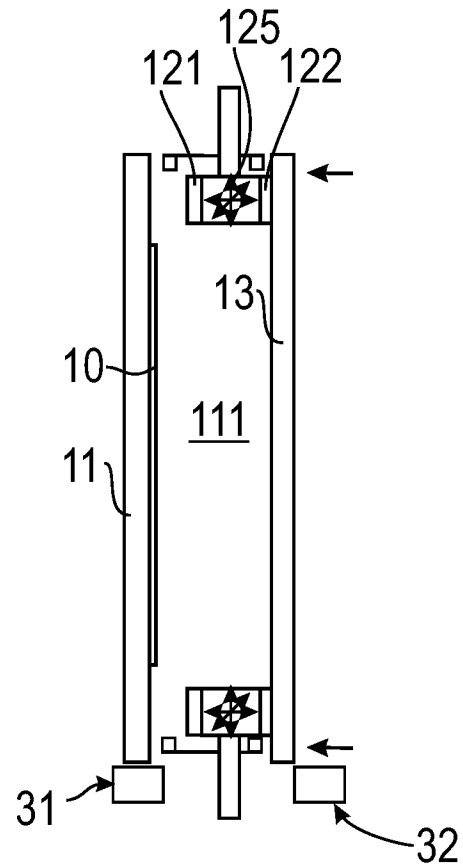


FIG. 5B

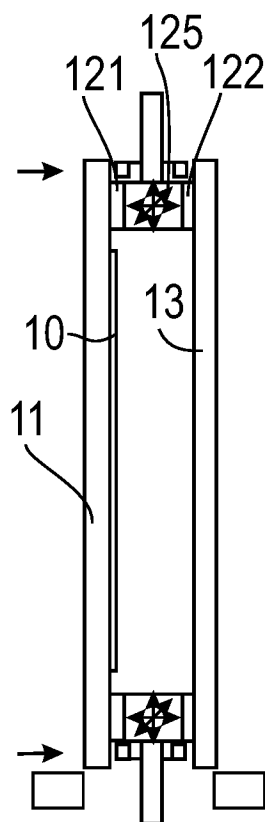


FIG. 5C

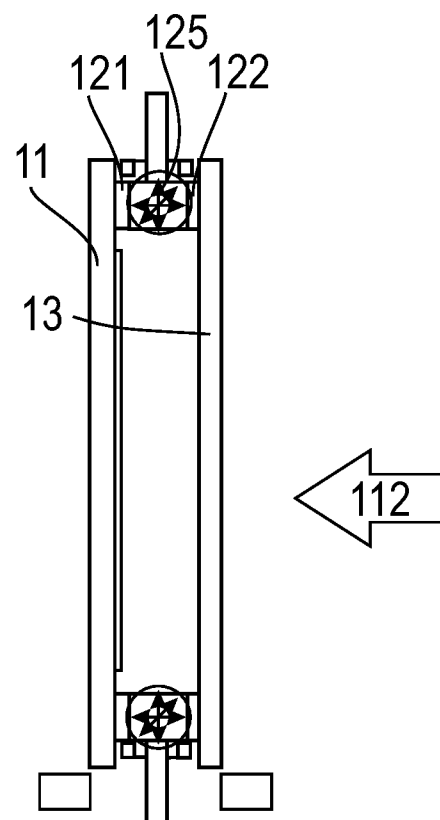


FIG. 5D

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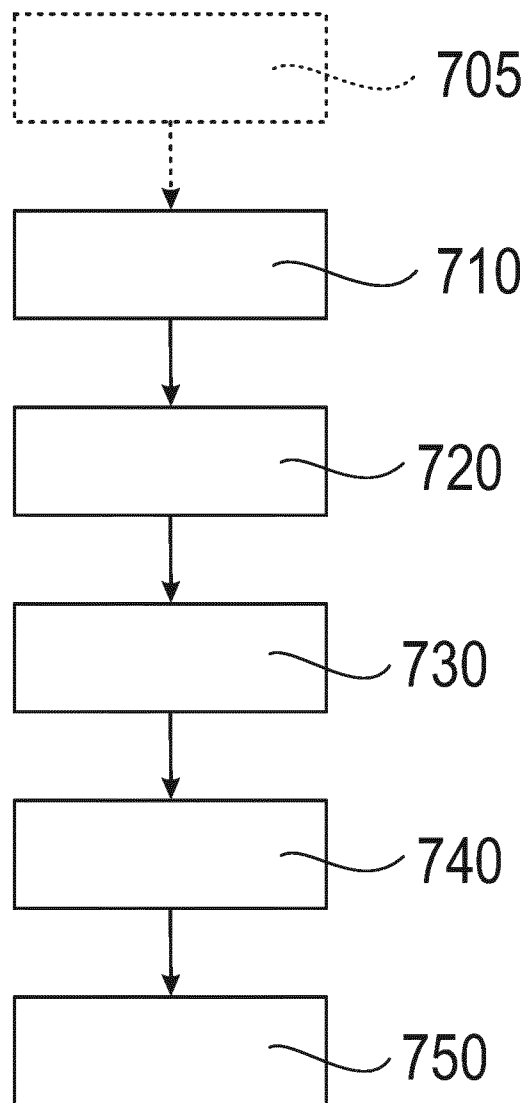


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/068660

A. CLASSIFICATION OF SUBJECT MATTER INV. C23C14/04 C23C14/50 C23C16/04 C23C16/458 H01L21/68 H01L51/00 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) C23C H01L Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data											
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;">Category*</th> <th style="width: 70%;">Citation of document, with indication, where appropriate, of the relevant passages</th> <th style="width: 20%;">Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td style="text-align: center; vertical-align: top;">Y</td> <td style="vertical-align: top;"> WO 2016/112951 A1 (APPLIED MATERIALS INC [US]; VERCESI TOMMASO [IT]; HAAS DIETER [US]; BA) 21 July 2016 (2016-07-21) page 3, paragraphs 7,8 - page 4, paragraph 10; figures 3-5 page 7, paragraph 19 - page 8, paragraph 23 page 10, paragraphs 32,33,34 - page 16, paragraph 56 page 18, paragraph 65 ----- </td> <td style="text-align: center; vertical-align: top;">1-16</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">Y</td> <td style="vertical-align: top;"> EP 3 187 618 A1 (APPLIED MATERIALS INC [US]) 5 July 2017 (2017-07-05) column 7, paragraphs 18,21,22 - column 8, paragraphs 22,23; figures 2,4A,4B column 12, paragraph 36 - column 16, paragraph 51 ----- -/- </td> <td style="text-align: center; vertical-align: top;">1-16</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	Y	WO 2016/112951 A1 (APPLIED MATERIALS INC [US]; VERCESI TOMMASO [IT]; HAAS DIETER [US]; BA) 21 July 2016 (2016-07-21) page 3, paragraphs 7,8 - page 4, paragraph 10; figures 3-5 page 7, paragraph 19 - page 8, paragraph 23 page 10, paragraphs 32,33,34 - page 16, paragraph 56 page 18, paragraph 65 -----	1-16	Y	EP 3 187 618 A1 (APPLIED MATERIALS INC [US]) 5 July 2017 (2017-07-05) column 7, paragraphs 18,21,22 - column 8, paragraphs 22,23; figures 2,4A,4B column 12, paragraph 36 - column 16, paragraph 51 ----- -/-	1-16
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.									
Y	WO 2016/112951 A1 (APPLIED MATERIALS INC [US]; VERCESI TOMMASO [IT]; HAAS DIETER [US]; BA) 21 July 2016 (2016-07-21) page 3, paragraphs 7,8 - page 4, paragraph 10; figures 3-5 page 7, paragraph 19 - page 8, paragraph 23 page 10, paragraphs 32,33,34 - page 16, paragraph 56 page 18, paragraph 65 -----	1-16									
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Date of the actual completion of the international search 5 April 2018		Date of mailing of the international search report 16/04/2018									
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Boussard, Nadège									

INTERNATIONAL SEARCH REPORT

International application No

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