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

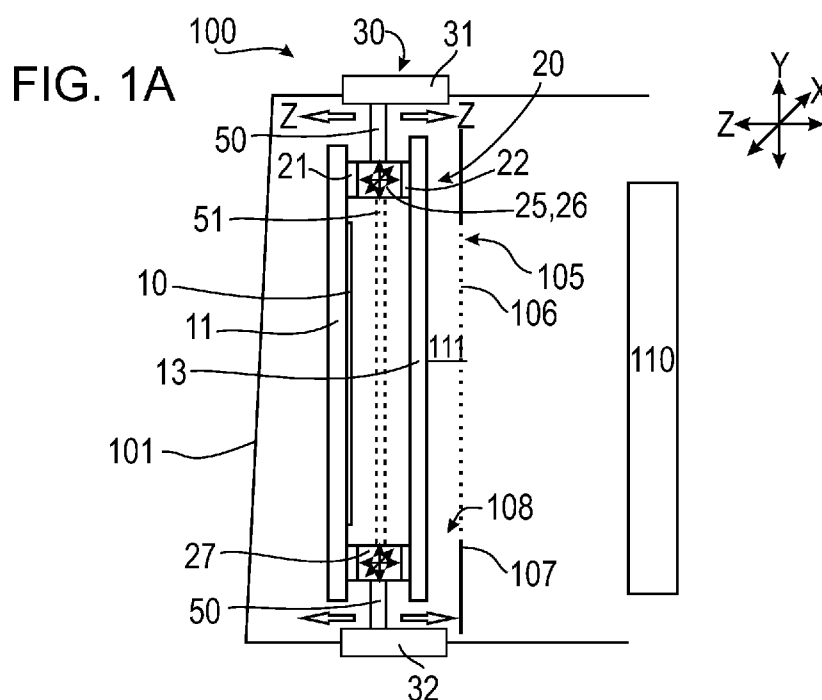
(72) Inventor; and

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

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

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(54) Title: APPARATUS AND SYSTEM FOR PROCESSING A SUBSTRATE IN A VACUUM CHAMBER, AND METHOD OF
ALIGNING A SUBSTRATE CARRIER RELATIVE TO A MASK CARRIER



(57) Abstract: An apparatus (100) for processing a substrate (10) in a vacuum chamber (101) is described. The apparatus includes an alignment system (20) and a shielding device (105). The alignment system (20) includes a first mount (21) for mounting a substrate carrier (11) to the alignment system, a second mount (22) for mounting a mask carrier (13) to the alignment system, and an alignment unit (25) for moving the first mount (21) and the second mount (22) of the alignment system (20) relative to each other. Further, the alignment system (20) and the shielding device (105) are movable relative to each other in a first direction (Z). Further, a system for processing a substrate as well as a method of aligning a substrate carrier with respect to a mask carrier are provided.

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**APPARATUS AND SYSTEM FOR PROCESSING A SUBSTRATE IN A VACUUM
CHAMBER, AND METHOD OF ALIGNING A SUBSTRATE CARRIER
RELATIVE TO A MASK CARRIER**

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FIELD

[0001] Embodiments of the present disclosure relate to an apparatus and a system for
10 processing a substrate in a vacuum chamber, and to a method of aligning a substrate carrier
with respect to a mask 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
masked deposition of a coating material on a substrate, wherein the substrate is aligned
15 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.

BACKGROUND

[0002] Techniques for layer deposition on a substrate include, for example, thermal
20 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
25 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. Accordingly, a material pattern, e.g. a plurality of pixels corresponding to an
30 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 positioning and aligning substrates and masks relative to each other in a vacuum chamber. Further, an efficient use of a vacuum deposition system with short idle times would be beneficial.

SUMMARY

[0006] In light of the above, an apparatus for processing a substrate, a system for processing a substrate, and a method of aligning a substrate carrier relative to a mask 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 an alignment system including a first mount for mounting a substrate carrier to the alignment system, a second mount for mounting a mask carrier to the alignment system, and an alignment unit for moving the first mount and the second mount relative to each other. The apparatus further includes a shielding device, wherein the alignment system and the shielding device are movable relative to each other in a first direction.

[0008] In particular, the alignment system may be movable toward the shielding device, or the shielding device may be movable toward the alignment system, in order to decrease

a gap between the shielding device and a mask carrier that is mounted to the alignment system.

[0009] According to another aspect of the present disclosure, an apparatus for processing a substrate in a vacuum chamber is provided. The apparatus includes an alignment system comprising a first mount, a second mount, and an alignment unit connected to the first mount and to the second mount; and a drive device connected to the alignment system and to the vacuum chamber.

[0010] In some embodiments, the drive device may be configured to move the alignment system relative to the vacuum chamber, particularly toward a shield mount provided in the vacuum chamber.

[0011] 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 according to any of the embodiments described herein. The apparatus includes an alignment system with a first mount, a second mount, and an alignment unit. Further, a substrate carrier is mounted to the first mount of the alignment system, and a mask carrier is mounted to the second mount of the alignment system.

[0012] According to a further aspect of the present disclosure, a method of aligning a substrate carrier relative to a mask carrier is provided. The method includes mounting the mask carrier to a second mount of an alignment system, mounting the substrate carrier to a first mount of the alignment system, moving the first mount and the second mount relative to each other with an alignment unit of the alignment system for aligning the substrate carrier with respect to the mask carrier, and moving the alignment system and a shielding device provided in the vacuum chamber relative to each other.

[0013] Embodiments are also directed at apparatuses for carrying out the disclosed methods and include apparatus parts for performing each described method aspect. These method aspects may be performed by way of hardware components, a computer programmed by appropriate software, by any combination of the two or in any other manner. Furthermore, embodiments according to the disclosure are also directed at

methods for operating the described apparatus. The methods for operating the described apparatus include method aspects for carrying out every function of the apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] 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. 1A shows a schematic sectional view of an apparatus for processing a substrate according to embodiments described herein in a first position;

FIG. 1B shows a schematic sectional view of the apparatus of FIG. 1A 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 shows a schematic sectional view of the apparatus of FIG. 2A in a second position;

FIGS. 3A-3E show several subsequent stages of a method of aligning a substrate carrier relative to a mask carrier according to methods described herein;

FIG. 4 is a flow diagram for illustrating a method of aligning a substrate carrier relative to a mask carrier according to embodiments described herein; and

FIG. 5 is a flow diagram for illustrating a method of aligning a substrate carrier relative to a mask carrier according to embodiments described herein.

DETAILED DESCRIPTION OF EMBODIMENTS

[0015] Reference will now be made in detail to the various embodiments of the disclosure, one or more examples of which are illustrated in the figures. Within the following description of the drawings, the same reference numbers refer to same components. Generally, only the differences with respect to individual embodiments are described. Each example is provided by way of explanation of the disclosure and is not meant as a limitation of the disclosure.

[0016] 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.

[0017] FIG. 1A shows a schematic sectional view of an apparatus 100 for processing a substrate 10 according to embodiments described herein in a first position. FIG. 1B shows the apparatus 100 of FIG. 1A in a second position.

[0018] As is schematically depicted in FIG. 1A, the apparatus 100 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 align a substrate 10 with respect to a mask. In some embodiments, a deposition source 110 is provided in the vacuum chamber 101. A material can be deposited on the substrate 10 through the mask by the deposition source 110.

[0019] The alignment system 20 includes a first mount 21 for mounting a substrate carrier 11 to the alignment system 20 and a second mount 22 for mounting a mask carrier 13 to the alignment system 20. Further, the alignment system 20 includes an alignment unit 25 for moving the first mount 21 and the second mount 22 relative to each other for aligning the substrate carrier 11 and the mask carrier 13 relative to each other. Accordingly, a substrate 10 that is carried by the substrate carrier 11 can be aligned with respect to a mask that is carried by the mask carrier 13 via the alignment unit 25 of the alignment system 20.

[0020] The term “substrate carrier” as used herein may particularly relate to a carrier device configured to carry a substrate 10 along a substrate transportation path in a vacuum

system. The substrate carrier may hold the substrate during the deposition of a coating material on the substrate. In some embodiments, the substrate 10 may be held at the substrate carrier 11 in a non-horizontal orientation, particularly in an essentially vertical orientation, during transport and/or deposition.

5 [0021] For example, the substrate 10 may be held at a holding surface of the substrate carrier 11 during transport through the vacuum chamber, during positioning of the substrate in the vacuum chamber, e.g. with respect to a mask, and/or during deposition of a material on the substrate. In particular, the substrate 10 may be held at the substrate carrier 11 by a chucking device, e.g. by an electrostatic chuck and/or by a magnetic chuck. The
10 chucking device may be integrated in the substrate carrier 11.

[0022] A substrate carrier 11 may include a carrier body with a holding surface configured to hold the substrate 10, particularly in a non-horizontal orientation. In some embodiments, the carrier body may be moved along a substrate transport path by a substrate transportation system, e.g. including a linear motor. In some embodiments, the
15 substrate carrier may be contactlessly held at a guiding structure during the transport, e.g., by a magnetic levitation system.

[0023] Similarly, a “mask carrier” as used herein may relate 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
20 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 13 by a chucking device, e.g. a mechanic chuck such as a clamp, an electrostatic chuck and/or a magnetic chuck. Other types of chucking devices may be used
25 which may be connected to or integrated in the mask carrier.

[0024] 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.

[0025] “Transporting”, “moving”, “routing”, “rotating”, “positioning” or “aligning” a substrate or a mask as used herein may refer to a respective movement of a substrate carrier or a mask carrier which holds the substrate or the mask.

[0026] 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.

[0027] The alignment system 20 includes a first mount 21 for mounting the substrate carrier to the alignment system 20. The first mount 21 may hold the substrate carrier 11 at the alignment system by magnetic and/or mechanical forces. In particular, the first mount 21 may be a magnetic mount. For example, the first mount 21 may include a magnetic chuck for magnetically chucking the substrate carrier 11 to the first mount 21.

[0028] In some embodiments, the alignment system 20 includes a plurality of first mounts for holding the substrate carrier 11 at the alignment system. For example, at least four first mounts may be provided for holding the substrate carrier at the four corners thereof.

[0029] The alignment system 20 includes a second mount 22 for mounting the mask carrier 13 to the alignment system. The second mount 22 may hold the mask carrier 13 at the alignment system by magnetic and/or mechanic forces, particularly in an essentially vertical orientation. In particular, the second mount 22 may be a magnetic mount. For example, the second mount 22 may include a magnetic chuck for magnetically chucking the mask carrier 13 to the second mount 22.

[0030] The first mount 21 and/or the second mount 22 may be at least partially arranged between the mask carrier 13 and the substrate carrier 11. In particular, at least a part of the alignment system 20 may be arranged between the mask carrier and the substrate carrier. For example, the substrate carrier may be mounted to a first side of the alignment system, and the mask carrier may be mounted to a second side of the alignment system opposite the first side.

[0031] In some embodiments, the alignment system 20 includes a plurality of second mounts for holding the mask carrier 13. For example, at least four second mounts may be provided for holding the mask carrier at the four corners thereof.

[0032] In some implementations, at least one of the first mount 21 and the second mount 22 may include a magnetic fixing device, particularly an electromagnetic fixing device or an electropermanent magnet assembly (EPM).

[0033] Further, the alignment system 20 includes an alignment unit 25, particularly a plurality of alignment units. The alignment unit 25 is configured to move the first mount 21 and the second mount 22 relative to each other for aligning the substrate carrier 11 with respect to the mask carrier 13. The first mount 21 and the second mount 22 may be connected by a mechanical connection, wherein the alignment unit 25 may form at least part of said mechanical connection. Thus, the second mount 22 can be moved relative to the first mount 21 with the alignment unit 25.

[0034] In some embodiments, the alignment unit 25 includes at least one piezo actuator configured to move the first mount 21 relative to the second mount 22 in at least one direction.

[0035] The alignment unit 25 may be configured to align the substrate carrier 11 with respect to the mask carrier 13. A deposition source 110 may be provided in the vacuum chamber 101 for depositing a coating material on the substrate 10 held by the substrate carrier 11 through the mask held by the mask carrier 13. When the mask carrier 13 and the substrate carrier 11 are accurately aligned with respect to each other, e.g. with a deviation from a target position of less than 10 μm , less than 5 μm , or even less than 2 μm , a material pattern can be accurately deposited on the substrate through the mask. For example, the material pattern may include a plurality of electronic or optoelectronic devices, e.g. pixels.

[0036] According to embodiments described herein, a shielding device 105 is provided in the vacuum chamber, particularly between the deposition source 110 and the alignment system 20. When the mask carrier 13 is mounted to the second mount 22 of the alignment system 20, the shielding device 105 is located between the deposition source 110 and the mask carrier 13. Accordingly, the shielding device 105 at least partially shields the mask carrier 13, in order to reduce a contamination of the mask carrier 13 or of the vacuum chamber 101 itself with coating material. For example, the shielding device 105 may be shaped such that an outer portion of the mask carrier 13 is protected by a shielding plate of the shielding device 105. The shielding device 105 at least partially blocks coating material that is directed toward the outer portion of the mask carrier 13. The coating material that is directed toward the substrate 10 may propagate through the shielding device 105 in an unhindered way.

[0037] For example, the shielding device 105 may include a shielding frame 107 configured to at least partially cover and shield the mask carrier 13, and an opening 106 (indicated as a dashed line in FIG. 1A) provided in the shielding frame 107 configured to allow the coating material 112 to pass through the shielding device 105 toward the substrate 10. The opening 106 of the shielding device 105 may have a size of 0.5 m^2 or more, particularly 1 m^2 or more. The size of the opening 106 may be larger than the area of the substrate that is to be coated.

[0038] In some embodiments, which may be combined with other embodiments described herein, the shielding device 105 includes an opening 106 for the coating material 112 and a shielding frame 107, which surrounds the opening 106. The opening 106 may be

centered in front of the substrate that is held by the substrate carrier 11 such that the coating material can propagate through the opening 106 toward the substrate 10. The surface of the shielding frame 107 may be essentially parallel to the surface of the mask carrier 13, i.e. essentially perpendicular to the first direction Z. For example, the shielding frame 107 may be provided with a rectangle-shaped opening, wherein the shape of the opening 106 may be adapted to the shape of the substrate, and the shape of the shielding frame 107 may be adapted to the portion of the mask carrier 13 that is to be shielded and protected from contamination.

[0039] In some embodiments, the shielding device 105 includes a plurality of frame parts which are connected to each other. Disassembly of the shielding device and cleaning may be facilitated. In other embodiments, the shielding device may include a one-piece plate component comprising the opening 106, particularly an essentially rectangular opening.

[0040] It may be possible that coating material enters a gap 108 between the shielding device 105 and the mask carrier 13 and contaminates the mask carrier 13. For example, in the first position that is depicted in FIG. 1A, the gap 108 has a considerable width in the first direction Z. Accordingly, coating material from the deposition source 110 may impinge on the mask carrier 13 such that the mask carrier 13 may get contaminated by the coating material entering said gap 108. Further, coating material entering said gap 108 may contaminate an inner wall of the vacuum chamber 101 and/or other devices or objects in the vacuum chamber. The deposition result may be negatively affected by coating material, which does not impinge on the substrate through the coating window that is defined by the mask. Further, contaminated surfaces of the vacuum chamber and of the mask carrier may have to be frequently cleaned which may lead to additional costs and frequent downtimes of the deposition system.

[0041] According to embodiments described herein, the alignment system 20 and the shielding device 105 are movable relative to each other in a first direction Z. The first direction Z is a direction extending essentially perpendicular to the substrate 10. In particular, the first direction Z may extend essentially perpendicular to the mask carrier 13 and/or to the shielding device 105. Accordingly, the alignment system 20 can be moved in the first direction Z toward the shielding device 105 in order to decrease the width of the gap 108 between the shielding device 105 and the mask carrier 13.

[0042] In some embodiments, the alignment system 20 can also be oppositely moved in the first direction Z away from the shielding device 105 after the deposition. In particular, the alignment system 20 may be movable toward the deposition source 110 and away from the deposition source 110 in the first direction Z.

5 [0043] For example, the alignment system 20 can be moved toward the shielding device 105 in order to decrease a width of the gap 108 in the first direction Z to a value of 3 mm or less, particularly 1 mm or less. In some embodiments, the mask carrier 13 may be moved toward the shielding device 105 until the mask carrier 13 contacts the shielding device. Accordingly, a propagation of coating material 112 through a gap 108 between the
10 shielding device 105 and the mask carrier 13 can be prevented.

[0044] FIG. 1B shows the apparatus 100 in a second position in which the alignment system 20 has moved toward the shielding device 105 to reduce a width of the gap 108 between the shielding device 105 and the mask carrier 13 to a value of 1 mm or less. A contamination of the mask carrier with coating material 112 can be reduced or prevented.

15 [0045] The shielding device 105 can be easily cleaned, e.g. by temporarily removing the shielding device 105 from the vacuum chamber. It may be sufficient to clean the shielding device 105 at long time intervals. For example, the shielding device 105 may be unloaded from the vacuum chamber 101 after a deposition time of several days for cleaning. Downtimes of the deposition system can be reduced and cleaning can be facilitated. In
20 particular, as is schematically depicted in FIG. 1B, essentially no coating material can contaminate an inner wall of the vacuum chamber, because there is essentially no gap between the shielding device 105 and the mask carrier 13 during deposition.

[0046] As is schematically depicted in FIG. 1A and FIG. 1B, the apparatus may further include a deposition source 110 configured to direct the coating material 112 toward a
25 deposition area 111 in which the alignment system 20 is arranged.

[0047] 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 a second direction X essentially

perpendicular to the first direction Z. The second direction X as used herein may correspond to a width direction of the substrate 10, i.e. perpendicular to the paper plane of FIG. 1A. 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.

[0048] The deposition source 110 may be provided as a line source extending in an essentially vertical direction. The vertical direction may also be referred to herein as a third direction Y, i.e. a direction essentially perpendicular to the first direction Z and the second direction X. The height of the deposition source 110 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 second direction X.

[0049] 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 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.

[0050] In some embodiments, which may be combined with other embodiment described herein, the deposition source 110 may be rotatable. For example, the deposition 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 (not depicted in FIG. 1A). The deposition area 111 and the second deposition area may be located on opposite sides of the deposition source, and the deposition source may be rotatable by an angle of about 180° between the deposition area and the second deposition area.

[0051] As is depicted in FIG. 1A, the shielding device 105 may be arranged between the deposition source 110 and the alignment system 20. Accordingly, the coating material 112 emanating from the deposition source 110 propagates through an opening 106 of the shielding device 105 and enters the deposition area 111. In the deposition area 111, the alignment system 20 is arranged which holds the substrate carrier behind the mask carrier.

[0052] In some embodiments, the apparatus further includes a drive device 30 configured to move the alignment system 20 toward the shielding device 105 in the first direction Z. Accordingly, a width of a gap 108 between the shielding device 105 and the mask carrier 13 mounted to the alignment system 20 can be reduced.

5 [0053] The drive device 30 may be configured to move the alignment system 20 together with a mask carrier 13 mounted to the second mount 22 and a substrate carrier 11 mounted to the first mount 21. Accordingly, the whole unit including the alignment unit 25, the first and second mounts, as well as the substrate and mask carriers mounted thereto may be shifted by the drive device 30 toward the shielding device 105 or away from the shielding
10 device 105 in the first direction Z.

[0054] In some embodiments, which may be combined with other embodiments described herein, the alignment system 20 is movable relative to the shielding device 105 by a distance of 1 mm or more and/or 100 mm or less, particularly by a distance of 5 mm or more and/or 30 mm or less in the first direction Z. For example, the drive device 30 may
15 be configured to move the alignment system 20 from the first position depicted in FIG. 1A toward the shielding device 105 to the second position depicted in FIG. 1B by a distance of 5 mm or more and 15 mm or less.

[0055] The drive device 30 may include one or more actuators for moving the alignment system 20 and the shielding device 105 relative to each other in the first direction Z. The
20 one or more actuators may include at least one of a piezo actuator, a linear motor, a servomotor, a spindle drive, a pneumatic actuator, and a voice coil. In some embodiments, the drive device 30 may be at least partially arranged outside the vacuum chamber 101. In other embodiments, the drive device 30 may be arranged inside the vacuum chamber 101.

[0056] For example, the drive device 30 may include an actuator provided outside the
25 vacuum chamber, e.g. at atmospheric pressure, wherein a feed-through may be provided for transmitting a movement of the actuator into the vacuum chamber in order to shift the alignment system 20 in the vacuum chamber. The feed-through may include a flexible element such as a bellows element, wherein a dimension of the flexible element may follow a movement of the actuator. A force transmission element may connect the actuator outside
30 the vacuum chamber with the alignment system 20 inside the vacuum chamber.

[0057] In some embodiments, the drive device 30 may be arranged inside the vacuum chamber. For example, the drive device 30 may include a piezo actuator provided inside the vacuum chamber, e.g. connected to a wall of the vacuum chamber, and configured to move the alignment system 20 with respect to the vacuum chamber 101 in the first direction Z.

[0058] In some embodiments, which may be combined with other embodiments described herein, the alignment system 20 includes a support structure 50. The support structure 50 may support one, two or more alignment units 25 of the alignment system 20 and/or may movably connect the alignment system 20 to the vacuum chamber 101.

[0059] In some implementations, the support structure 50 includes a support frame 51, wherein the alignment unit 25 and optional further alignment units may be attached to the support frame. Thus, the support frame 51 may form a common support for several alignment units of the alignment system 20. In FIG. 1A, the support frame 51 is indicated as a dashed vertical connection bar between two alignment units which may be arranged in a different sectional plane.

[0060] In some embodiments, an upper portion of the support frame 51 is movably connected to the vacuum chamber 101 via at least one first actuator 31, and a lower portion of the support frame 51 is movably connected to the vacuum chamber 101 via at least one second actuator 32. By movably connecting the support frame 51 of the alignment system 20 to the vacuum chamber 101 at several attachment points, the alignment system 20 can be stably held in the vacuum chamber. Further, an accurate movement of the alignment system 20 in the first direction Z can be guaranteed by providing two or more actuators, e.g. at least one first actuator 31 and at least one second actuator 32, which can be operated synchronously for moving the alignment system 20 toward the shielding device 105 and/or away from the shielding device 105.

[0061] In some embodiments, which may be combined with other embodiments described herein, the alignment system 20 includes a plurality of alignment units 25 for aligning the substrate carrier 11 with respect to the mask carrier 13. An upper alignment unit 26 and a lower alignment unit 27 are exemplarily depicted in FIG. 1A and FIG. 1B. Yet further alignment units may be provided. For example, at least four alignment units

may be provided at spaced-apart positions of the alignment system 20 for aligning the substrate carrier 11 with respect to the mask carrier 13, e.g. at the four corners of the substrate carrier 11.

[0062] Further, the alignment system 20 may include a plurality of first mounts for mounting the substrate carrier 11 to the alignment system and a plurality of second mounts for mounting the mask carrier 13 to the alignment system 20. Each alignment unit of a plurality of alignment units may be configured to move a respective first mount relative to a respective second mount for aligning the substrate carrier 11 with respect to the mask carrier 13. In an exemplary embodiment, a plurality of second mounts is fixed to the support frame 51 of the alignment system, and a plurality of first mounts is movably connected to the plurality of second mounts via a plurality of alignment units.

[0063] The plurality of alignment units 25 may be attached to a common support structure of the alignment system 20, e.g. to a support frame 51 of the support structure 50. The support frame 51 may stabilize the alignment system 20 such that an accurate alignment over the whole surface of the substrate can be provided and maintained. In order to move the alignment system 20 toward the shielding device 105, the support frame 51 of the alignment system 20 may be shifted in the first direction Z. The alignment units as well as the first and second mounts may be connected to the support frame 51 directly or indirectly.

[0064] In some embodiments, the alignment unit 25 may be configured to move the first mount 21 relative to the second mount 22 in the first direction Z. Thus, the distance between the mask carrier 13 and the substrate carrier 11 may be adjusted as appropriate by the alignment unit 25. Alternatively or additionally, the alignment unit 25 may be configured to move the first mount 21 relative to the second mount 22 in a second direction X perpendicular to the first direction. The second direction X may be a horizontal direction perpendicular to the first direction Z. In particular, the second direction X may correspond to a width direction of the substrate. 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 25. Alternatively or additionally, the alignment unit 25 may be configured to move the first mount 21 relative to the second mount 22 in a third direction Y perpendicular to the first direction Z and the second direction X. The third direction Y may

be an essentially vertical direction. In particular, the third direction Y may essentially correspond to a height direction of the substrate. 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 25.

- 5 [0065] At least one alignment unit 25 may be configured to move the first mount 21 relative to the second mount 22 in both the second direction X and third direction Y. Thus, the mask may be correctly aligned relative to the substrate in the extension plane of the substrate.

- [0066] The alignment unit 25 may include one or more piezo actuators for moving the
10 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.

- [0067] After the alignment, the mask may be attracted toward the substrate, e.g. via a magnetic chuck, such that the substrate and the mask contact each other during the
15 deposition of the coating material 112 on the substrate. An accurate pattern with structures having a dimension below 10 μm can be deposited on the substrate, e.g. an array of pixels and/or TFT transistors of a display.

- [0068] In some embodiments, a plurality of alignment units may be provided. At least one alignment unit may be configured to align the first mount relative to the second mount
20 in only one direction or in only two directions, whereas the alignment unit 25 may be floating with respect to the remaining directions. The term “floating with respect to a direction” may be understood as the alignment unit allowing a movement of a carrier in said direction, e.g., driven by another alignment unit. As an example, a first alignment unit is configured to actively move the substrate carrier in the first direction, and is configured
25 to passively allow a movement of the substrate carrier 11 in the second direction and/or in the third direction. In some implementations, the term “floating” may be understood as “freely moveable”

- [0069] In some embodiments, at least a portion of the alignment system 20 is arranged in a region between a first plane defined by the substrate carrier and a second plane defined

by the mask carrier. In particular, at least one of the first mount 21 and the second mount 22 is provided between the first plane and the second plane.

[0070] It is to be noted that the shielding device 105 is not necessarily a part of an apparatus according to the embodiments described herein. In particular, in some
5 embodiments, the apparatus includes an alignment system comprising a first mount, a second mount, and an alignment unit connected to the first mount and to the second mount. Further, the apparatus includes a drive device connected to the alignment system and to the vacuum chamber, wherein the drive device may be configured to move the alignment system relative to the vacuum chamber, particularly toward a shield mount configured to
10 mount a shielding device in the vacuum chamber

[0071] In particular, the apparatus may include the alignment system 20 including the first mount 21 for mounting the substrate carrier 11 to the alignment system, the second mount 22 for mounting the mask carrier 13 to the alignment system, and the alignment unit 25 for moving the first mount 21 and the second mount 22 relative to each other. The
15 apparatus further includes the drive device 30 configured to move the alignment system 20 relative to the vacuum chamber 101 in the first direction Z, particularly toward a deposition source and/or away from a deposition source.

[0072] The drive device 30 may be configured to move the alignment system 20 together with the substrate carrier 11 and the mask carrier 13 mounted to the alignment system 20 in
20 the first direction Z. In particular, the drive device 30 may be configured to move the alignment system 20 relative to a shield mount for mounting a shielding device 105, wherein the shield mount is provided in the vacuum chamber 101. The shield mount may be configured to mount the shielding device 105 in the vacuum chamber 101 between the deposition source and the alignment system 20.

[0073] The shielding device 105 may at least partially block the coating material 112
25 which is not directed toward the substrate. Further, the shielding device 105 may provide an open coating window for the coating material which is directed toward the mask and/or the substrate.

[0074] According to some embodiments described herein, a system for processing a substrate in a vacuum chamber is described. The system includes the apparatus 100 of any of the embodiments described herein, a substrate carrier 11 mounted to the first mount 21 of the alignment system 20, and a mask carrier 13 mounted to the second mount 22 of the alignment system.

[0075] FIG. 2A shows a schematic sectional view of an apparatus 200 for processing a substrate 10 according to embodiments described herein in a first position. FIG. 2B shows the apparatus 200 of FIG. 2A in a second position. The apparatus 200 essentially corresponds to the apparatus 100 of FIG. 1A and FIG. 1B, such that reference can be made to the above explanations which are not repeated here. In particular, same reference numbers correspond to the respective features described with reference to FIG. 1A and FIG. 1B.

[0076] As is schematically depicted in FIG. 2A, the apparatus includes a vacuum chamber 101, wherein an alignment system 20 is provided in the vacuum chamber 101. The alignment system 20 is configured to align a substrate 10 with respect to a mask. A deposition source 110 may be provided in the vacuum chamber 101. A material can be deposited on the substrate 10 through the mask by the deposition source 110.

[0077] Further, a shielding device 105 is provided in the vacuum chamber 101. The shielding device 105 is movable relative to the alignment system 20 in the first direction Z, i.e. toward the alignment system 20 and/or away from the alignment system.

[0078] As is schematically depicted in FIG. 2A, the apparatus 200 includes a drive device 35 configured to move the shielding device 105 toward the alignment system 20 in the first direction Z. Further, the drive device 35 may be configured to move the shielding device 105 away from the alignment system 20 in the first direction Z. Accordingly, a gap 108 between the shielding device 105 and the mask carrier 13 that is mounted to the alignment system 20 can be reduced or closed during the deposition of the coating material 112 on the substrate 10.

[0079] In FIG. 2A, the shielding device 105 is arranged at a first position spaced-apart from the mask carrier 13. In FIG. 2B, the shielding device 105 has moved toward the mask

carrier 13 using the drive device 35, e.g. by a distance of 5 mm or more, such that there is essentially no gap between the mask carrier 13 and the shielding device 105. Accordingly, the deposition result can be improved and downtimes of the system can be decreased.

[0080] Similar to the embodiment depicted in FIG. 1A, the drive device 35 may include one or more actuators configured as at least one of a piezo actuator, a linear motor, a servomotor, a spindle drive, a pneumatic actuator, and a voice coil. The actuator may be provided outside the vacuum chamber 101 under atmosphere. Maintenance of an actuator arranged under atmospheric conditions may be easier, and space requirements may be less strict outside the vacuum chamber. Alternatively, the actuator may be arranged inside the vacuum chamber. Providing the actuator inside the vacuum chamber may be beneficial, because a less complex arrangement, e.g. without a mechanical feed-through, can be used.

[0081] In some embodiments, which may be combined with other embodiments described herein, the apparatus may further include a substrate transport device 60 configured to transport the substrate carrier 11 along a substrate transport track 61 in the second direction X. The second direction X may be essentially perpendicular to the first direction Z and may correspond to a width direction of the substrate. Alternatively or additionally, a mask transport device 62 configured to transport a mask carrier along a mask transport track 63 in the second direction X may be provided.

[0082] The substrate transport device 60 may be configured for a contactless transport of the substrate carrier 11 along the substrate transport track 61, and/or the mask transport device 62 may be configured for a contactless transport of the mask carrier along the mask transport track 63. For example, a first magnetic levitation system may be configured to contactlessly transport substrate carriers along the substrate transport track 61, and a second magnetic levitation system may be configured to contactlessly transport mask carriers along the mask transport track 63.

[0083] In some embodiments, the apparatus may further include a first drive configured to move the substrate carrier 11 from the substrate transport track 61 to the first mount 21 and/or a second drive configured to move the mask carrier 13 from the mask transport track 63 to second mount 22, particularly in the first direction Z respectively.

[0084] The mask carrier 13 and the substrate carrier 11 may be transported to positions on opposite sides of the alignment system 20 by the substrate transport device and the mask transport device, respectively. The first drive may be configured to move the substrate carrier 11 toward the first mount 21 from a first side, and the second drive may be configured to move the mask carrier toward the second mount 22 from a second side opposite the first side.

[0085] In some implementations, at least a portion of the alignment system 20 is provided between the substrate transport track and the mask transport track. In particular, at least one of the first mount 21 and the second mount 22 may be provided between the substrate transport track and the mask transport track. For example, the first mount 21 may be arranged between a plane that is defined by the mask carrier and a plane that is defined by the substrate carrier.

[0086] FIGS. 3A to 3E show several stages of a method of aligning a substrate carrier 11 relative to a mask carrier 13 according to methods described herein. The method may be carried out in the sequence depicted in FIGS. 3A to 3E. Alternatively, the order of some of the stages may be changed.

[0087] In FIG. 3A, a mask carrier 13 carrying a mask is transported with a mask transport device 62 along a mask transport track 63 in the second direction X into a deposition area 111 in a vacuum chamber (not depicted in FIG. 3A). The mask transport device 62 may be a transport device configured for a contactless transport of the mask carrier, e.g. including a magnetic levitation system.

[0088] The mask carrier 13 stops at a first position depicted in FIG. 3A, in which the mask carrier 13 is arranged on a first side of an alignment system 20, particularly between the alignment system 20 and a shielding device 105.

[0089] In FIG. 3B, the mask carrier 13 is laterally shifted in the first direction Z essentially perpendicular to the second direction X toward the second mount 22 of the alignment system 20 by a second drive 67. The second drive 67 may be configured as a crossdrive, which may include a side guide for contactlessly shifting the mask carrier 13 toward the second mount 22.

[0090] As is depicted in FIG. 3B, the second drive 67 may shift the mask carrier 13 away from the shielding device 105 toward the alignment system 20 in the first direction Z until the mask carrier 13 contacts the second mount 22 of the alignment system 20. For example, the second drive 67 may shift the mask carrier in the first direction Z by a distance of 4 mm or more and 10 mm or less.

[0091] The mask carrier 13 may be mounted to the second mount 22, e.g. by activating a magnet of the second mount 22 such that the mask carrier 13 is magnetically chucked toward the second mount 22 and is held by the second mount at the alignment system 20.

[0092] Further, in FIG. 3B, a substrate carrier 11 carrying a substrate 10 is transported with a substrate transport device 60 along a substrate transport track 61 in the second direction X into the deposition area 111. The substrate transport device 60 may be a transport device configured for a contactless transport of the substrate carrier, e.g. including a magnetic levitation system.

[0093] The substrate carrier 11 stops at a first position depicted in FIG. 3B, in which the substrate carrier 11 is arranged on a second side of the alignment system 20 opposite the first side where the mask carrier 13 is arranged. In particular, the substrate carrier 11 may be arranged between the alignment system 20 and a wall of the vacuum chamber (not depicted in FIG. 3B).

[0094] In FIG. 3C, the substrate carrier 11 is laterally shifted in the first direction Z essentially perpendicular to the second direction X toward the first mount 21 of the alignment system 20 by a first drive 68. The first drive 68 may be configured as a crossdrive, which may include a side guide for contactlessly shifting the substrate carrier 11 toward the first mount 21. For example, the first drive 68 may shift the substrate carrier in the first direction Z by a distance of 4 mm or more and 10 mm or less toward the alignment system.

[0095] As is depicted in FIG. 3B and 3C, the second drive 67 may be configured to shift the mask carrier 13 in a direction opposite to the direction in which the first drive 68 shifts the substrate carrier. Accordingly, the substrate carrier 11 and the mask carrier 13 can be

shifted toward opposite sides of the alignment system 20 via the first drive and the second drive, respectively.

[0096] The substrate carrier 11 may be mounted to the first mount 21, e.g. by activating a magnet of the first mount 21 such that the substrate carrier 11 is magnetically chucked to the first mount 21 and is held by the first mount at the alignment system 20.

[0097] In FIG. 3D, the substrate carrier 11 is aligned with respect to the mask carrier 13 by the alignment unit 25 that is provided in a mechanical connection path between the first mount and the second mount. Accordingly, the mask and the substrate are aligned relative to each other with a high accuracy.

[0098] Further, in FIG. 3D, the alignment system 20 is moved toward the shielding device 105 in order to decrease or close a gap 108 between the shielding device 105 and the mask carrier 13. Alternatively or additionally, the shielding device 105 may be moved toward the alignment system 20.

[0099] In FIG. 3E, a coating material 112 is deposited on the substrate, wherein the coating material propagates through an opening 106 of the shielding device 105 toward the substrate. A part of the coating material may be blocked by a shielding frame 107 of the shielding device such that a contamination of the mask carrier, particularly of an outer region of the mask carrier, can be reduced or avoided.

[00100] FIG. 4 is a flow diagram for illustrating a method of aligning a substrate carrier 11 relative to a mask carrier 13 in a vacuum chamber 101. The substrate carrier 11 may carry a substrate 10, and the mask carrier 13 may carry a mask.

[00101] In box 410, the mask carrier 13 is mounted to a second mount 22 of an alignment system 20. The second mount 22 may be a magnetic mount, and the mask carrier may be magnetically chucked to the second mount 22.

[00102] In box 420, the substrate carrier 11 is mounted to a first mount 21 of the alignment system 20. The first mount 21 may be a magnetic mount, and the substrate carrier may be magnetically chucked to the first mount 21.

[00103] The alignment system 20 may include an alignment unit 25 configured to move the first mount 21 and the second mount 22 relative to each other. For example, the first mount and the second mount may be mechanically connected via the alignment unit.

[00104] In box 430, the first mount 21 and the second mount 22 are moved relative to each other with the alignment unit 25 for aligning the substrate carrier 11 with respect to the mask carrier 13.

[00105] In box 440, the alignment system 20 and a shielding device 105 provided in the vacuum chamber 101 are moved relative to each other with a drive device. In particular, the alignment system 20 may be moved toward the shielding device 105 for reducing or closing a gap 108 between the mask carrier 13 and the shielding device 105, and/or the shielding may be moved toward the alignment system 20 for reducing or closing a gap 108 between the mask carrier 13 and the shielding device.

[00106] In optional box 450, a coating material is deposited on the substrate 10 that is held by the substrate carrier 11. The coating material may be directed from a deposition source toward the substrate and may propagate through an opening of the shielding device 105 and through the mask toward the substrate. A portion of the coating material that is not directed toward the substrate may be blocked by a shielding frame of the shielding device 105. Due to the reduced gap between the shielding device and the mask carrier, a contamination of the mask carrier can be reduced or prevented.

[00107] It is to be noted that the sequence of boxes 410-450 may be changed. For example, the substrate carrier may be mounted to the first mount, before the mask carrier is mounted to the second mount. In another example, the width of the gap 108 may be reduced by moving the alignment system relative to the shielding device, before the substrate carrier and the mask carrier are aligned with respect to each other with the alignment unit.

[00108] FIG. 5 is a flow diagram for illustrating a method of aligning a substrate carrier 11 relative to a mask carrier 13 in a vacuum chamber 101 according to embodiments described herein. The substrate carrier 11 may carry a substrate 10, and the mask carrier 13 may carry a mask.

[00109] In box 510, the mask carrier 13 is transported in a second direction X along a mask transport track into a deposition area of a vacuum chamber 101. The second direction X may also be referred to herein as a “transport direction”. For example, the mask carrier may be contactlessly transported by a magnetic levitation system along the mask transport track. The mask carrier 13 may be transported to a position that is exemplarily depicted in FIG. 3A in which the mask carrier 13 is arranged between, and at a distance to, the second mount 22 of the alignment system 20 and the shielding device 105.

[00110] In box 520, the mask carrier 13 may be moved from the mask transport track toward the second mount 22 in the first direction Z transverse to the transport direction.

For example, a crossdrive may be provided for moving the mask carrier 13 toward the second mount 22 in the first direction X. The crossdrive may contactlessly guide the mask carrier 13 in the first direction Z toward the second mount 22, until the second mount 22 magnetically grabs the mask carrier such that the mask carrier is firmly held by the second mount 22. The crossdrive may include a magnetic side guide configured to contactlessly shift the mask carrier in the first direction Z by applying a repulsive magnetic force on the mask carrier.

[00111] In box 530, the mask carrier 13 is mounted to the second mount 22 of the alignment system 20. The second mount 22 may be a magnetic mount, and the mask carrier may be magnetically chucked to the second mount 22. For example, the second mount 22 may include an electromagnet or an electropermanent magnet assembly (EPM assembly).

[00112] In box 540, the substrate carrier 11 is transported in the second direction X, i.e. in the transport direction, along a substrate transport track. The substrate transport track and the mask transport track may extend essentially parallel to each other in the vacuum chamber 101.

[00113] The substrate carrier 11 may be contactlessly transported by a magnetic levitation system along the substrate transport track. The substrate carrier 11 may be transported to a position that is exemplarily depicted in FIG. 3B in which the substrate carrier 11 is arranged at a distance to the first mount 21. In particular, the substrate carrier

11 may be arranged on an opposite side of the alignment system 20 as compared to the mask carrier 13.

[00114] In some embodiments, the substrate transport track and the mask transport track extend at the same height. In other embodiments, the substrate transport track and the mask transport track extend at different heights. For example, when the mask carrier has a larger extension in the vertical direction than the substrate carrier, the mask transport track may extend at a lower height than the substrate transport track.

[00115] In box 550, the substrate carrier 11 is moved from the substrate transport track to the first mount 21 in the first direction Z. As the substrate carrier 11 and the mask carrier 13 are provided on opposite sides of the alignment system 20, the substrate carrier 11 is moved toward the first mount 21 in a direction opposite to the movement direction of the mask carrier toward the second mount 22 in box 520.

[00116] For example, a further crossdrive may be provided for moving the substrate carrier 11 toward the first mount 21. The further crossdrive may contactlessly guide the substrate carrier 11 toward the first mount 21, as is exemplarily depicted in FIG. 3C. The first mount 21 may magnetically grab the substrate carrier such that the substrate carrier is firmly held by the first mount 21. The further crossdrive may include a magnetic side guide configured to contactlessly shift the substrate carrier toward the first mount 21 in the first direction Z by applying a repulsive magnetic force on the substrate carrier.

[00117] In box 560, the substrate carrier 11 is mounted to the first mount 21 of the alignment system 20. The first mount 21 may be a magnetic mount, and the substrate carrier may be magnetically chucked to the first mount 21. For example, the first mount 21 may include an electromagnet or an electropermanent magnet assembly (EPM assembly).

[00118] The alignment system 20 may include an alignment unit 25 configured to move the first mount 21 and the second mount 22 relative to each other. For example, the first mount and the second mount may be mechanically connected via the alignment unit.

[00119] In box 570, the first mount 21 and the second mount 22 are moved relative to each other with the alignment unit 25 for aligning the substrate carrier 11 with respect to the mask carrier 13.

[00120] In some embodiments, a direct mechanical connection path between the mask carrier and the substrate carrier may be provided via the first mount, the alignment unit, and the second mount, when the mask carrier and the substrate carrier are mounted to the alignment system. In other words, a direct mechanical connection path may be provided
5 between the mask carrier and the substrate carrier via the alignment system, wherein said connection path does not extend through other parts of the vacuum chamber. Accordingly, vibrations of the vacuum chamber or of other devices provided in the vacuum chamber may be decoupled from the alignment system 20. The deposition accuracy can be improved.

10 [00121] In box 580, the alignment system 20 and a shielding device 105 provided in the vacuum chamber 101 are moved relative to each other with a drive device. In particular, the alignment system 20 may be moved toward the shielding device 105 for reducing or closing a gap 108 between the mask carrier 13 and the shielding device 105, and/or the shielding may be moved toward the alignment system 20 for reducing or closing the gap
15 108 between the mask carrier 13 and the shielding device.

[00122] In box 590, a coating material may be deposited on the substrate 10. The coating material may be directed from a deposition source toward the substrate and may propagate through an opening of the shielding device 105 and through the mask toward the substrate. A portion of the coating material that is not directed toward the substrate may be blocked
20 by the shielding device 105. Due to the reduced gap 108 between the shielding device and the mask carrier, a contamination of the mask carrier can be reduced or prevented. For example, an evaporated material may be deposited on the substrate by a vapor source.

[00123] It is to be noted that the sequence of boxes 510-590 may be changed.

[00124] According to some embodiments, which can be combined with other
25 embodiments described herein, the substrate carrier can include an electrostatic chuck (E-chuck) providing an electrostatic force for holding the substrate at the substrate carrier. As an example, the substrate carrier includes an electrode arrangement configured to provide an attracting force acting on the substrate.

[00125] According to some embodiments, the substrate carrier includes an electrode arrangement having a plurality of electrodes configured to provide an attracting force for holding the substrate at a holding surface of the substrate carrier. A controller of the substrate carrier can be configured to apply one or more voltages to the electrode arrangement to provide the attracting force (also referred to as “chucking force”).

[00126] The plurality of electrodes of the electrode arrangement can be embedded in the body, or can be provided, e.g., placed, on the body. According to some embodiments, which can be combined with other embodiments described herein, the body is a dielectric body, such as a dielectric plate. The dielectric body can be fabricated from a dielectric material, preferably a high thermal conductivity dielectric material such as pyrolytic boron nitride, aluminum nitride, silicon nitride, alumina or an equivalent material, but may be made of such materials as polyimide. In some embodiments, the plurality of electrodes, such as a grid of fine metal strips, can be placed on the dielectric plate and covered with a thin dielectric layer.

[00127] According to some embodiments, which can be combined with other embodiments described herein, the substrate carrier includes one or more voltage sources configured to apply one or more voltages to the plurality of electrodes. In some implementations, the one or more voltage sources are configured to ground at least some electrodes of the plurality of electrodes. As an example, the one or more voltage sources can be configured to apply a first voltage having a first polarity, a second voltage having a second polarity, and/or ground to the plurality of electrodes.

[00128] According to some embodiments, which can be combined with other embodiments described herein, the apparatus can be configured for a contactless levitation and/or a contactless transportation of the substrate carrier 11 and/or the mask carrier 13. As an example, the apparatus may include a guiding structure configured for a contactless levitation of the substrate carrier 11 and/or the mask carrier 13. Likewise, the apparatus can include a drive structure configured for contactless transportation of the substrate carrier 11 and/or the mask carrier 13. In particular, the carrier can be held in a levitating or floating state using magnetic forces instead of mechanical forces. For example, in some implementations, there can be no mechanical contact between the carrier and the

transportation track, particularly during levitation, movement and positioning of the substrate carrier and/or mask carrier.

[00129] The contactless levitation and/or transportation of the carriers is beneficial in that no particles are generated during transportation, for example due to mechanical contact with guide rails. An improved purity and uniformity of the layers deposited on the substrate can be provided, since particle generation is minimized when using the contactless levitation and/or transportation.

[00130] One or more deposition sources 110 can be provided in the vacuum chamber 101. The substrate carrier 11 can be configured to hold the substrate 10 during a vacuum deposition process. The vacuum system can be configured for evaporation of e.g. an organic material for the manufacture of OLED devices. As an example, the one or more deposition sources can be evaporation sources, particularly evaporation sources for depositing one or more organic materials on a substrate to form a layer of an OLED device. The substrate carrier for carrying the substrate can be transported into and through the vacuum chamber, and in particular into and/or through a deposition area, along a transportation path, such as a linear transportation path.

[00131] The material can be emitted from the one or more deposition sources in an emission direction towards the deposition area in which the substrate to be coated is located. For instance, the one or more deposition sources may provide a line source with a plurality of openings and/or nozzles which are arranged in at least one line along the length of the one or more deposition sources. The material can be ejected through the plurality of openings and/or nozzles.

[00132] The embodiments described herein can be utilized for evaporation on large area 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 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 provided in OLED display manufacturing.

5 [00133] 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
10 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
15 in comparison to the flexible substrates.

[00134] 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
20 fiber materials or any other material or combination of materials which can be coated by a deposition process.

[00135] The term “masking” may include reducing and/or hindering a deposition of material on one or more regions of the substrate 10. The masking may be useful, for instance, in order to define the area to be coated. In some applications, only parts of the
25 substrate are coated and the parts not to be coated are covered by the mask.

[00136] A method may include aligning a substrate carrier and the mask 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.

[00137] 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. This may, for example, be provided by the pre-alignment with the levitation system.

[00138] 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.

[00139] The present disclosure provides a first transport device for a substrate carrier and a second transport device for a mask carrier that may be equally sized in at least one dimension. In other words, the mask carrier may fit into the first transport device and the substrate carrier may fit into the second transport device. The first transport device and the second transport device 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.

[00140] 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.

[00141] 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) for processing a substrate (10) in a vacuum chamber (101), comprising:

an alignment system (20) comprising a first mount (21) for mounting a substrate carrier (11) to the alignment system, a second mount (22) for mounting a mask carrier (13) to the alignment system, and an alignment unit (25) for moving the first mount (21) and the second mount (22) relative to each other; and

a shielding device (105),

the alignment system (20) and the shielding device (105) being movable relative to each other in a first direction (Z).

2. The apparatus of claim 1, further comprising a drive device (30, 35) configured to move the alignment system (20) toward the shielding device (105) and/or to move the shielding device (105) toward the alignment system (20).

3. The apparatus according to claim 1 or 2, further comprising a deposition source (110) configured to direct a coating material (112) toward a deposition area (111) in which the alignment system (20) is arranged.

4. The apparatus according to any of claims 1 to 3, wherein the shielding device (105) comprises an opening (106) for a coating material (112) and a shielding frame (107) which surrounds the opening (106).

5. The apparatus according to any of claims 1 to 4, wherein the alignment system (20) is movable relative to the shielding device (105) by a distance of 1 mm or more and/or 100 mm or less in the first direction (Z).

6. The apparatus according to any of claims 1 to 5, comprising one or more actuators for moving the alignment system (20) and shielding device (105) relative to each other in the first direction (Z), wherein the one or more actuators comprise at least one of a piezo actuator, a linear motor, a servomotor, a spindle drive, a pneumatic actuator, and a voice coil.

7. The apparatus according to any of claims 1 to 6, wherein the alignment system (20) comprises a support frame (51), wherein an upper portion of the support frame is movably connected to the vacuum chamber (101) via at least one first actuator (31), and a lower portion of the support frame is movably connected to the vacuum chamber (101) via at least one second actuator (32).

8. The apparatus according to any of claims 1 to 7, wherein the alignment unit (25) is configured to move the first mount (21) relative to the second mount (22) in the first direction (Z), in a second direction (X) perpendicular to the first direction (Z), and/or in a third direction (Y) perpendicular to the first direction (Z) and to the second direction (X).

9. The apparatus according to any of claims 1 to 8, wherein the alignment system (20) comprises a plurality of first mounts, a plurality of second mounts, and a plurality of alignment units (25) for moving a respective first mount relative to a respective second mount.

10. The apparatus according to any of claims 1 to 9, further comprising at least one of

a substrate transport device configured to transport a substrate carrier along a substrate transport track in a second direction (X) essentially perpendicular to the first direction (Z); and/or

a mask transport device configured to transport a mask carrier along a mask transport track in the second direction (X).

11. The apparatus according to claim 10, further comprising a first drive configured to move a substrate carrier (11) from the substrate transport track to the first mount (21) in the first direction (Z), and/or a second drive configured to move a mask carrier (13) from the mask transport track to the second mount (22) in the first direction (Z).

12. An apparatus (100) for processing a substrate (10) in a vacuum chamber (101), comprising:

an alignment system (20) comprising a first mount (21), a second mount (22), and an alignment unit (25) connected to the first mount (21) and to the second mount (22); and

a drive device (30) connected to the alignment system (20) and to the vacuum chamber (101).

13. A system for processing a substrate, comprising:

the apparatus (100) of any of claims 1 to 12;

5 a substrate carrier (11) mounted to the first mount (21); and

a mask carrier (13) mounted to the second mount (22).

14. A method of aligning a substrate carrier (11) relative to a mask carrier (13) in a vacuum chamber (101), comprising:

mounting the mask carrier (13) to a second mount (22) of an alignment system (20);

10 mounting the substrate carrier (11) to a first mount (21) of the alignment system (20);

moving the first mount (21) and the second mount (22) relative to each other with an alignment unit (25) of the alignment system (20) for aligning the substrate carrier (11) with respect to the mask carrier (13); and

15 moving the alignment system (20) and a shielding device (105) provided in the vacuum chamber (101) relative to each other.

15. The method according to claim 14, wherein the alignment system (20) is moved toward the shielding device (105) or the shielding device (105) is moved toward the alignment system (20) for reducing a gap (108) between the mask carrier (13) and the
20 shielding device (105).

FIG. 1A

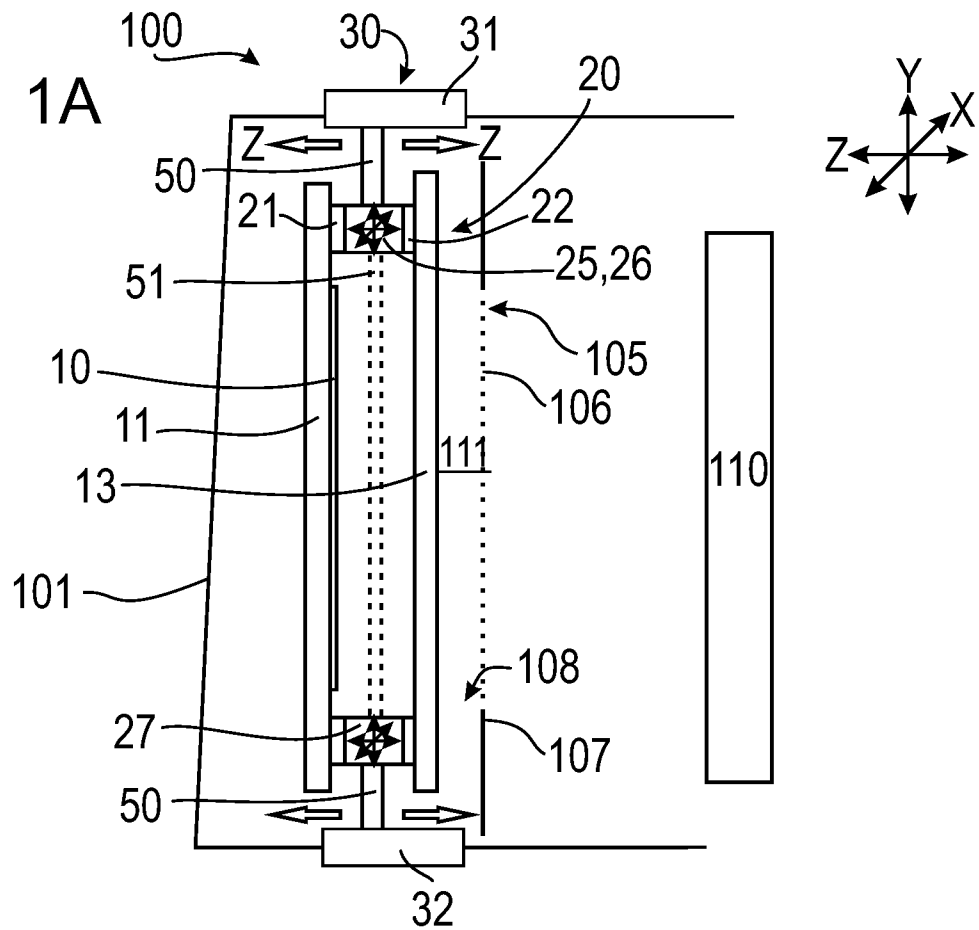


FIG. 1B

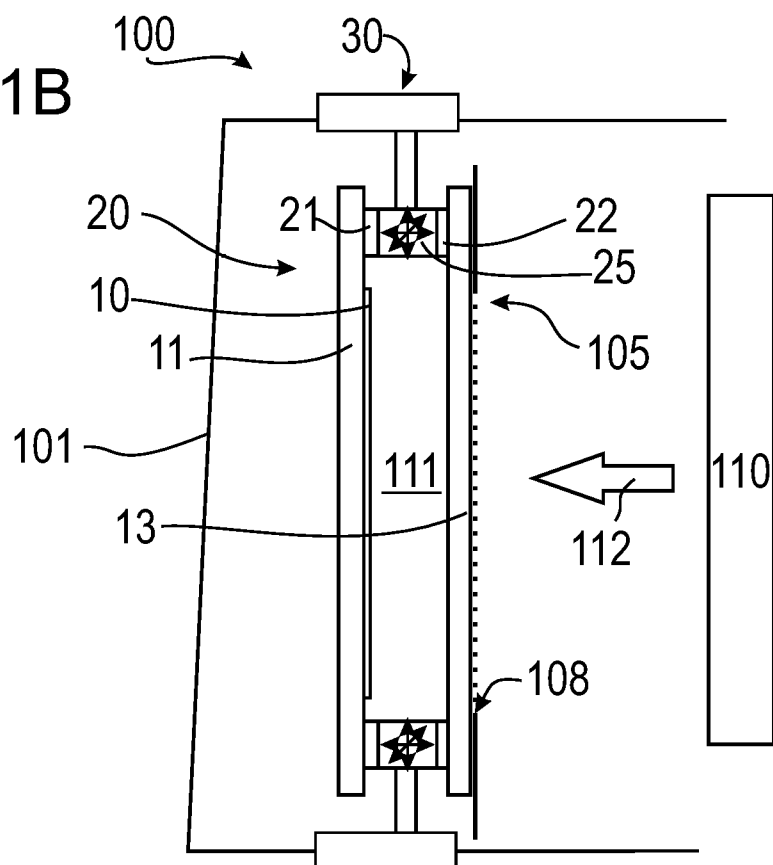


FIG. 2A

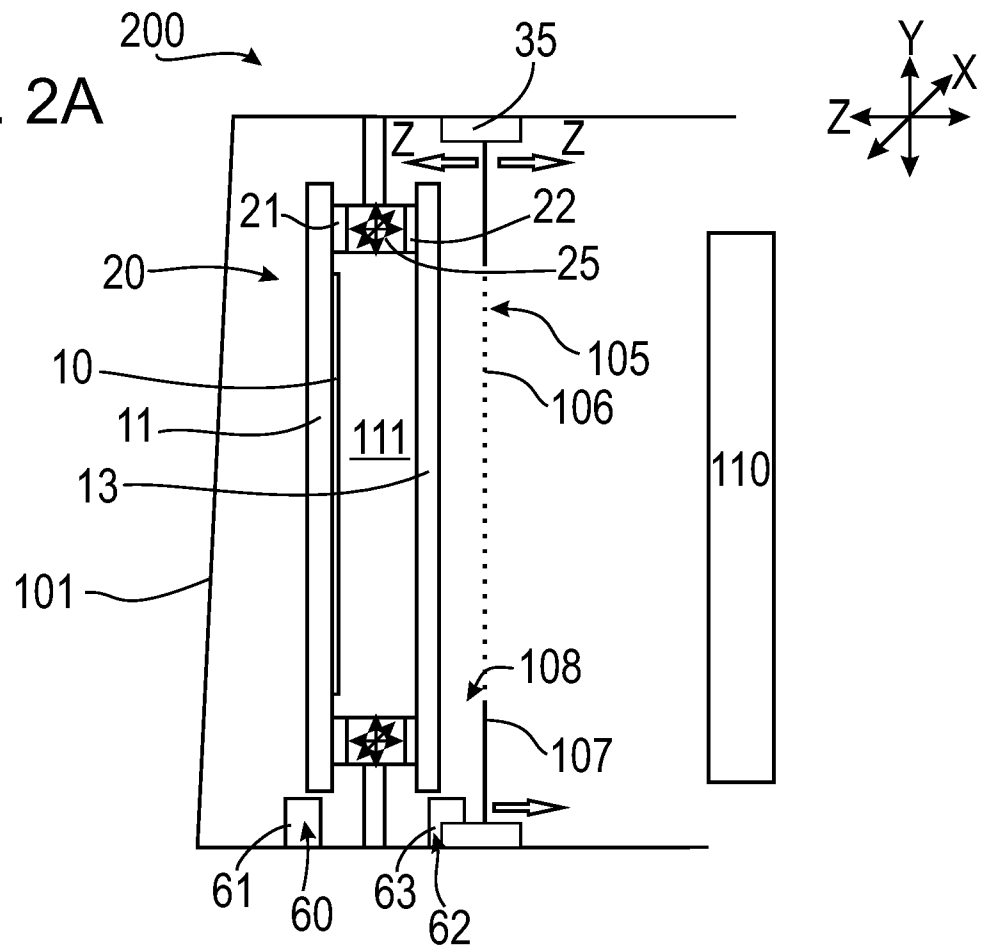
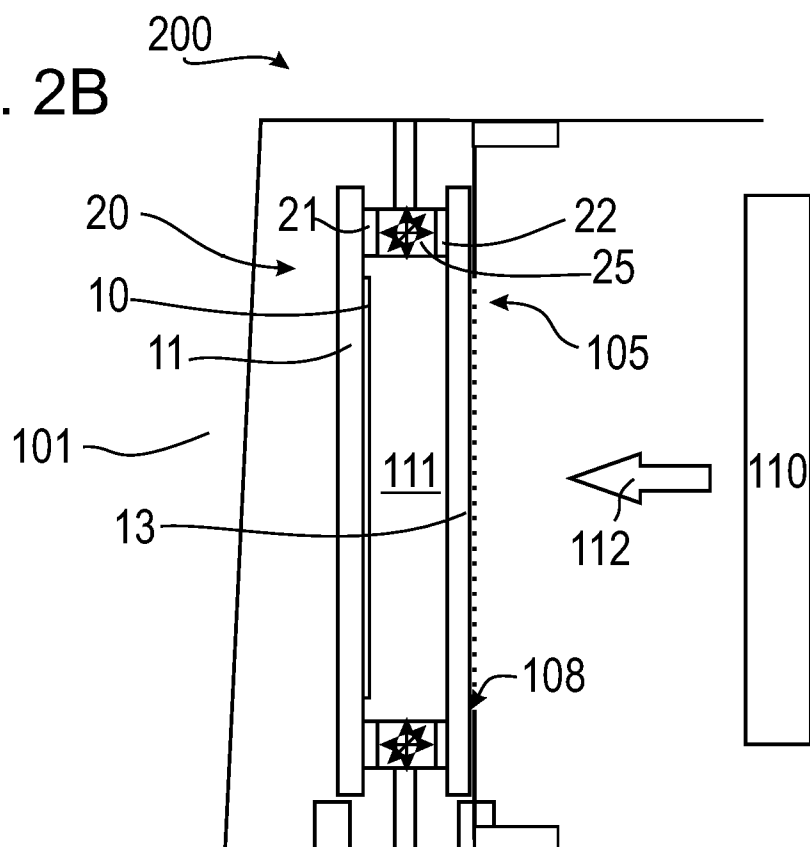


FIG. 2B



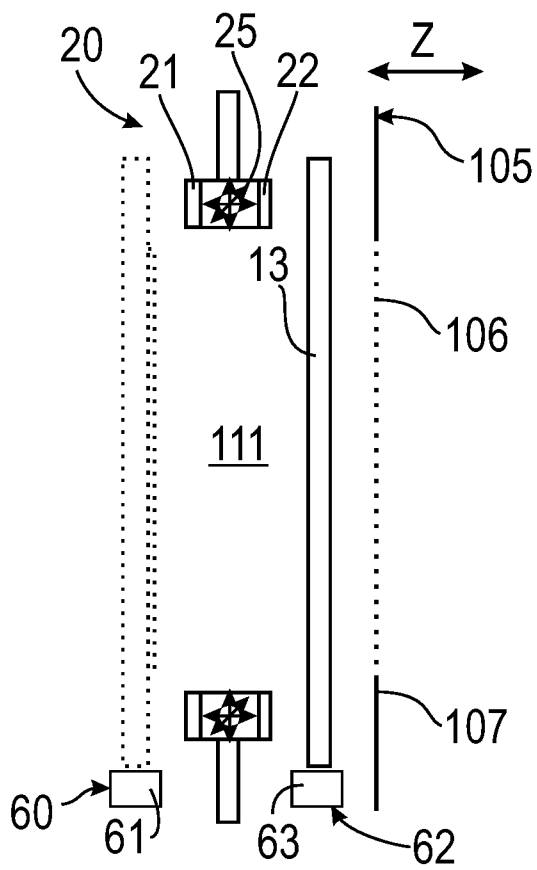


FIG. 3A

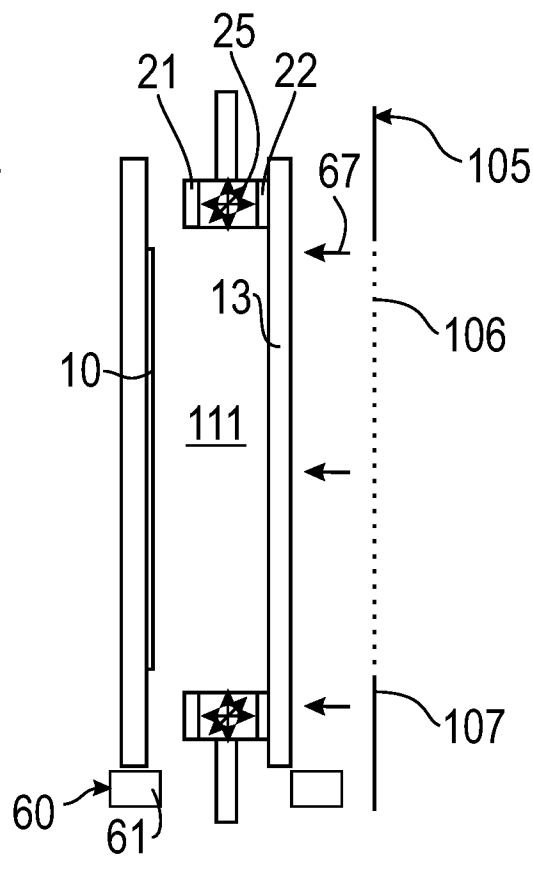


FIG. 3B

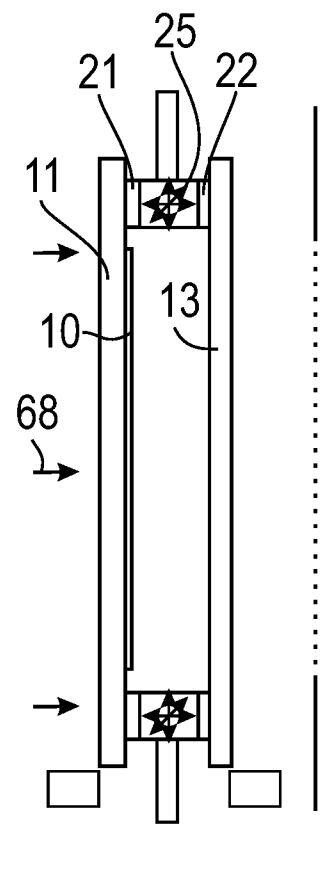


FIG. 3C

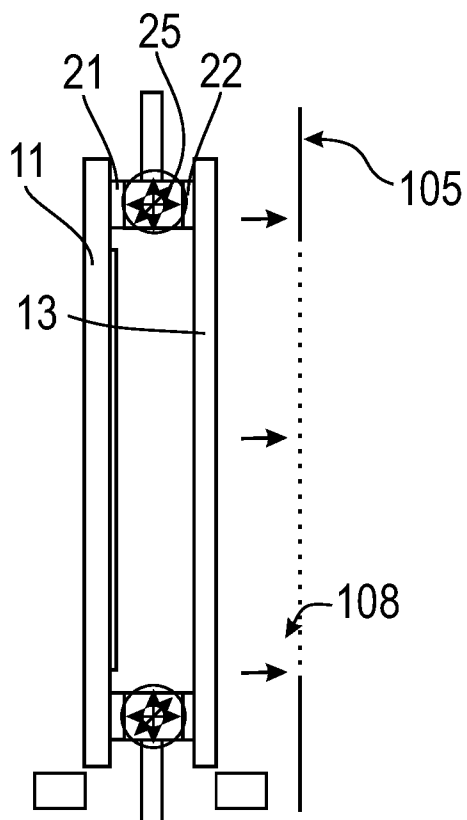


FIG. 3D

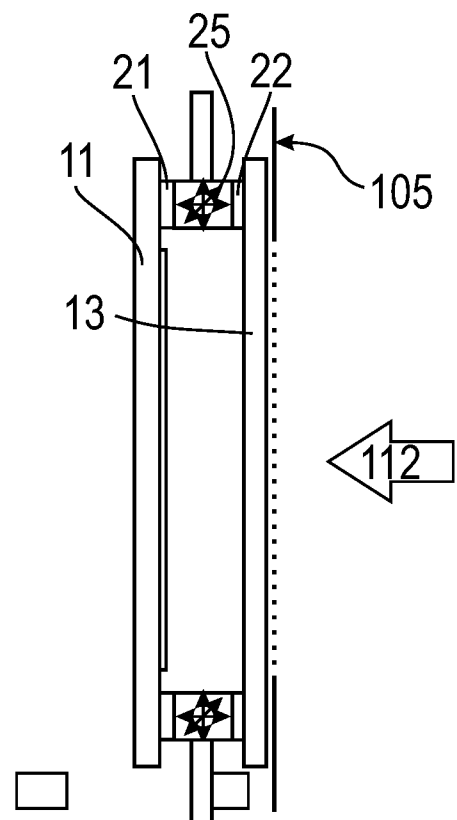


FIG. 3E

FIG. 4

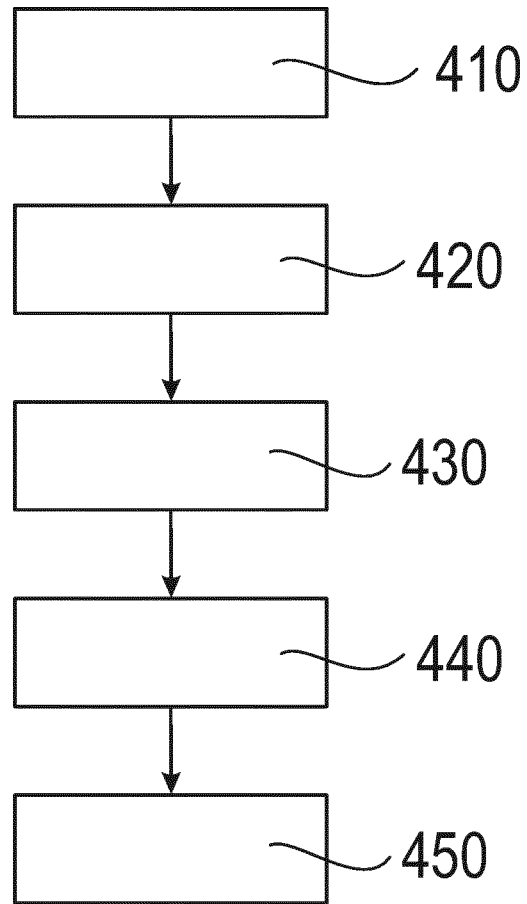
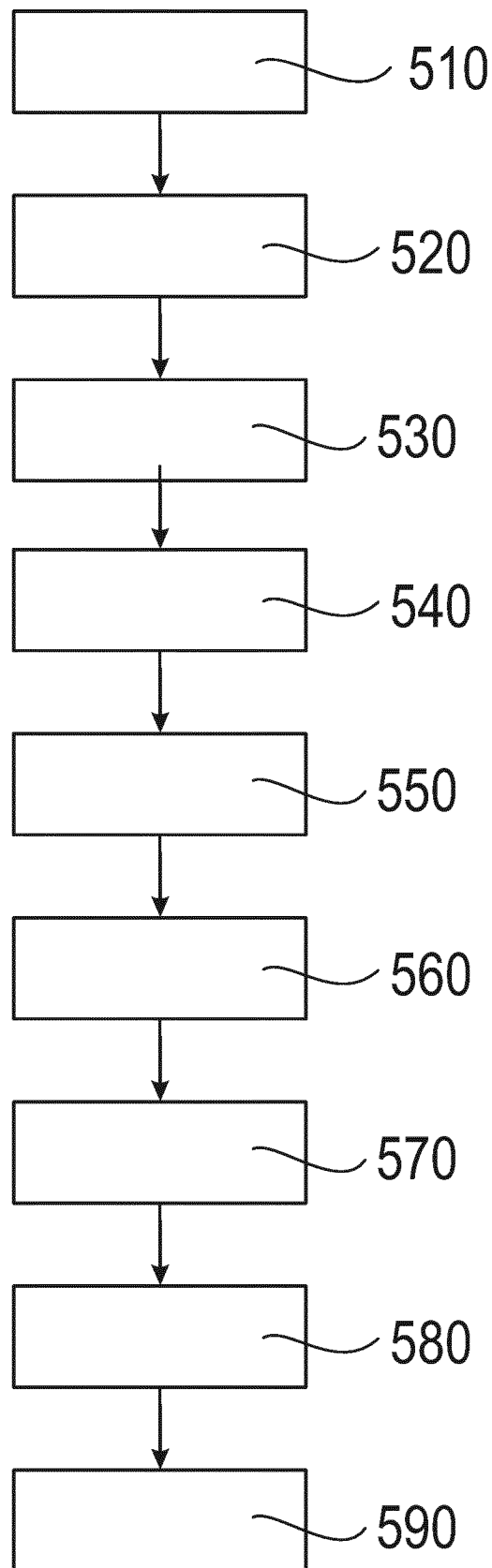


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/068657

A. CLASSIFICATION OF SUBJECT MATTER INV. C23C14/04 C23C14/50 C23C14/56 C23C16/04 C23C16/44 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		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2010/044213 A1 (WOLF HANS [DE] ET AL) 25 February 2010 (2010-02-25) page 1, paragraphs 11,12 - page 2, paragraphs 16,18,19, 25,26,27,28 page 3, paragraph 42 - page 4, lines 53,60,61 -----	1-15
Y	WO 2014/075729 A1 (APPLIED MATERIALS INC [US]; LINDENBERG RALPH [DE]; KOPARAL ERKAN [DE]) 22 May 2014 (2014-05-22) page 2, paragraphs 5,8 - page 6, paragraph 18 page 7, paragraphs 22,23 - page 8, paragraph 28 page 9, paragraph 31 - page 10, paragraph 33 page 15, paragraph 50 ----- -/--	1-15
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 20 March 2018		Date of mailing of the international search report 27/03/2018
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
PCT/EP2017/068657

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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