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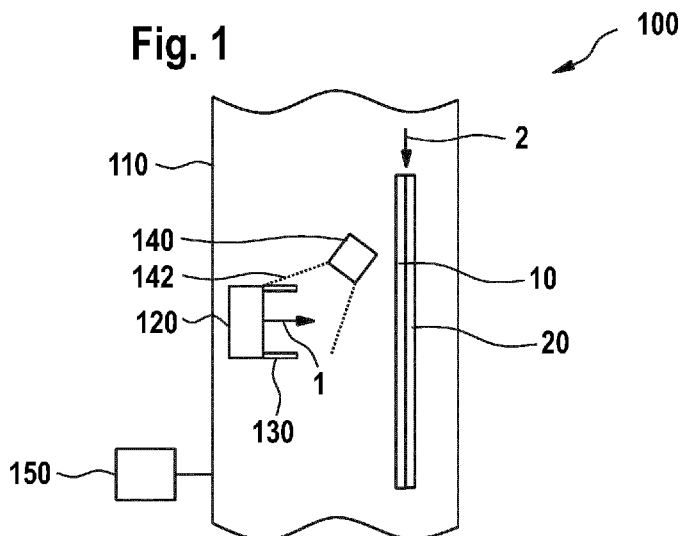
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(57) Abstract: The present disclosure provides an apparatus (100) for deposition of a material on a substrate (10). The apparatus (100) includes a vacuum chamber (110), at least one deposition source (120) in the vacuum chamber (110), a shaper device (130) at the at least one deposition source (120), wherein the shaper device (130) is configured to block at least a portion of the material emitted from the at least one deposition source (120), and a camera device (140) in the vacuum chamber (110), wherein the camera device (140) is configured to monitor a material accumulation on the shaper device (130).



**APPARATUS FOR DEPOSITION OF A MATERIAL ON A SUBSTRATE,
SYSTEM FOR DEPOSITING ONE OR MORE LAYERS ON A SUBSTRATE, AND
METHOD FOR MONITORING A VACUUM DEPOSITION SYSTEM**

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FIELD

10 [0001] Embodiments of the present disclosure relate to an apparatus for deposition of a material on a substrate, a system for depositing one or more layers on a substrate, and a method for monitoring a vacuum deposition system. Embodiments of the present disclosure particularly relate to a deposition of organic materials in the manufacture of organic light-emitting diode (OLED) devices.

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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
20 instance, coated substrates may be used in the field of organic light emitting diode (OLED) devices. OLEDs can be used in 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.

25 [0003] An evaporation source can be used to deposit layers, such as the one or more layers of the organic material, on the substrate. Evaporated material can also be deposited on various components of the vacuum deposition system. The deposited material should be removed from at least some of the components e.g. in predetermined service intervals in order to ensure an operability of the vacuum deposition system.

30 [0004] In view of the above, new apparatuses for deposition of a material on a substrate, systems for depositing one or more layers on a substrate, and methods for monitoring a

vacuum deposition system that overcome at least some of the problems in the art are beneficial. The present disclosure particularly aims at providing an apparatus, system and method that can provide an efficient cleaning process to reduce a downtime of a vacuum deposition system.

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SUMMARY

[0005] In light of the above, an apparatus for deposition of a material on a substrate, a system for depositing one or more layers on a substrate, and a method for monitoring a vacuum deposition system are provided. Further aspects, benefits, and features of the present disclosure are apparent from the claims, the description, and the accompanying drawings.

[0006] According to an aspect of the present disclosure, an apparatus for deposition of a material on a substrate is provided. The apparatus includes a vacuum chamber, at least one deposition source in the vacuum chamber, a shaper device at the at least one deposition source, wherein the shaper device is configured to block at least a portion of the material emitted from the at least one deposition source, and a camera device in the vacuum chamber, wherein the camera device is configured to monitor a material accumulation on the shaper device.

[0007] According to another aspect of the present disclosure, a system for depositing one or more layers on a substrate is provided. The system includes the apparatus for deposition of a material on a substrate according to the embodiments described herein, a load lock chamber connected to the vacuum chamber for loading the substrate into the vacuum chamber, and an unload lock chamber connected to the vacuum chamber for unloading the substrate having the one or more layers deposited thereon from the vacuum chamber.

[0008] According to a further aspect of the present disclosure, a method for monitoring a vacuum deposition system is provided. The method includes evaporating a material for deposition on a substrate using an evaporation source, and monitoring a material accumulation on a shaper device configured to block at least a portion of the material emitted from the evaporation source using a camera device installed in a vacuum chamber.

[0009] 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
5 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

10 [0010] So that the manner in which the above recited features of the present disclosure can be understood in detail, a more particular description of the disclosure, briefly summarized above, may be had by reference to embodiments. The accompanying drawings relate to embodiments of the disclosure and are described in the following:

FIG. 1 shows a schematic view of an apparatus for deposition of a
15 material on a substrate according to embodiments described herein;

FIG. 2 shows a schematic view of an apparatus for deposition of a material on a substrate according to further embodiments described herein;

20 FIG. 3 shows a schematic view of an apparatus for deposition of a material on a substrate according to yet further embodiments described herein;

FIG. 4 shows a schematic view of an evaporation source having a shaper device according to embodiments described herein;

25 FIG. 5 shows a system for depositing one or more layers on a substrate according to embodiments described herein;

- FIGs. 6A to D show schematic views of the system of FIG. 5 with the deposition source in different positions according to embodiments described herein; and
- FIG. 7 shows a flow chart of a method for monitoring a vacuum deposition system according to embodiments described herein.

DETAILED DESCRIPTION OF EMBODIMENTS

[0011] 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. 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.

[0012] Material ejected by a deposition source can be deposited on various components of a vacuum deposition system, such as a shaper device used to shape e.g. a plume of the emitted material. The components can be cleaned from time to time in order to ensure an operability of the vacuum deposition system. The present disclosure uses a camera device located inside the vacuum chamber to monitor a material accumulation on the shaper device. A cleaning process for removing the accumulated material from the shaper device can be performed based on the monitored material accumulation. The cleaning process can be performed in an efficient manner and a downtime of the vacuum deposition system can be minimized.

[0013] FIG. 1 shows a schematic top view of an apparatus 100 for deposition of a material on a substrate 10 according to embodiments described herein.

[0014] The apparatus 100 includes a vacuum chamber 110, at least one deposition source 120 in the vacuum chamber 110, a shaper device 130 at the at least one deposition source 120 and a camera device 140 in the vacuum chamber 110. The camera device 140 is configured to monitor a material accumulation on the shaper device 130. The shaper device
5 130 is configured to block at least a portion of the material emitted from the at least one deposition source 120. In particular, the shaper device 130 can be configured to define an emission angle of the material emitted from the at least one deposition source 120.

[0015] The material can be emitted from the at least one deposition source 120 in an emission direction 1 towards a deposition area in which the substrate 10 to be coated is
10 located. For instance, the at least one deposition source 120 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 at least one deposition source 120. The material can be ejected through the plurality of openings and/or nozzles. The plurality of openings and/or nozzles can be shaped to define the emission direction 1.

15 [0016] According to some embodiments, which can be combined with other embodiments described herein, the shaper device 130 can be configured to delimit a distribution cone or plume of the material ejected by the at least one deposition source 120. As an example, the at least one deposition source 120 is an evaporation source e.g. having the plurality of openings and/or nozzles, wherein the shaper device 130 is configured to
20 delimit a distribution cone of the material evaporated by the evaporation source. The shaper device 130 can be used to cut off or block the material which is emitted at angles larger than a predetermined angle, such as large angles, for example, 10° or more, 20° or more, or even 30° or more, with respect to a plane perpendicular to the substrate 10 or a substrate surface on which the material is to be deposited. Further, the shaper device 130
25 may be configured to reduce a heat radiation towards the deposition area. The shaper device 130 is further explained with respect to FIG. 4.

[0017] In some implementations, at least a part of the shaper device 130 is arranged within a field of view 142 of the camera device 140 to monitor the material accumulation on the shaper device 130. In particular, at least a part of the shaper device 130 may be
30 positioned in a direct line of sight to the camera device 140. As an example, the camera device 140 can be arranged at a position above and/or behind the substrate 10 such that the

camera device 140 does not interfere with the deposition process. In some embodiments, the camera device 140 can be provided, for example mounted, on top of the at least one deposition source 120 with at least a part of the shaper device 130 being arranged within the field of view 142 of the camera device 140.

5 [0018] According to some embodiments, which can be combined with other embodiments described herein, the camera device 140 includes one or more cameras, such as image cameras, video cameras, high-resolution cameras, infrared cameras, and any combination thereof. In some implementations, the camera device 140 can be configured to provide images in predetermined time intervals such as once per second, once per minute,
10 once per hour, or even once per day. In other implementations, the camera device 140 can be configured to continuously monitor the shaper device 130 and/or the material accumulation. As an example, the camera device 140 can provide a real-time monitoring of the material accumulation.

[0019] According to some embodiments, which can be combined with other
15 embodiments described herein, the apparatus 100 further includes a monitoring device 150 configured to determine the material accumulation on the shaper device 130. The monitoring device 150 can be connected to the camera device 140 by a wireless link and/or by cable. As an example, a USB connection can be provided for connecting the camera device 140 and the monitoring device 150 for data transmission.

20 [0020] In some implementations, the monitoring device 150 can be configured to determine one or more characteristics, such as physical characteristics, of the material accumulated on the shaper device 130. The one or more characteristics can be selected from the group consisting of a layer thickness, a color, a color spectrum, and any combination thereof. As an example, the monitoring device 150 uses a software to
25 determine the one or more characteristics of the material accumulation on the shaper device 130. The software can include an algorithm configured for evaluation of data, such as image data, provided by the camera device 140. The software, and particularly the algorithm, can be configured to derive the one or more characteristics from the data provided by the camera device 140. The monitoring device 150 can include a user
30 interface, such as a display, configured to display information about the one or more characteristics. According to some embodiments, which can be combined with other

embodiments described herein, the monitoring device 150 can be configured to determine a shape or contour of the shaper device 130. The material accumulation can be determined based on a change of the shape or contour, e.g., an enlargement of the shape caused by the material accumulation. As an example, a reference shape can be compared with an actual
5 or determined shape, and the material accumulation can be determined based on the comparison.

[0021] The monitoring device 150 can be configured to determine the layer thickness of the material accumulated on the shaper device 130 using a focus of the camera device 140. As an example, the focus of the camera device 140 can have a fixed setting. The layer
10 thickness can be derived from an amount of a de-focusing caused by the accumulation of the material on the shaper device 130. In another example, the focus of the camera device 140 can be changed while material accumulates, e.g., using an auto focus, such that the monitored portion of the shaper device 130, and particularly the accumulated material, is reproduced clearly. In other words, the image provided by the camera device 140 is a sharp
15 or focused image. The layer thickness can be derived from an amount of the change of the focus caused by the accumulation of the material on the shaper device 130.

[0022] Additionally or alternatively, the monitoring device 150 can be configured to determine an amount of the accumulated material based on a color or a color spectrum of the accumulated material. In particular, the color or color spectrum may change with the
20 accumulation of the material. The layer thickness may be derived from the color or color spectrum.

[0023] According to some embodiments, which can be combined with other embodiments described herein, the apparatus 100 further includes a heating device configured to heat the shaper device 130 for removing the material accumulated on the
25 shaper device 130. In particular, the collected material can be re-evaporated to clean the shaper device 130. Cleaning the shaper device 130 can prevent that e.g. nozzles of the at least one deposition source 120 are blocked by the condensed material. The heating device can be an electrical heater or an induction heater.

[0024] In some implementations, the apparatus 100 is configured to adjust one or more
30 process parameters for heating the shaper device 130 based on the monitored material

accumulation. As an example, the one or more process parameters are selected from the group consisting of a heating start time, a maximal heating temperature, a temperature ramp rate, a heating duration, and any combination thereof. The optimal process parameters can be selected for removing the condensed material because detailed
5 information about the material accumulation is available. In particular, it can be determined optimally when to heat up the shaper device 130, up to which temperature, for how long, and so on.

[0025] In some implementations, the apparatus 100 can be configured to determine the one or more process parameters for heating the shaper device 130 automatically. The
10 monitoring device 150 can include a user interface, such as a display, configured to display the one or more characteristics determined by the monitoring device 150 and/or the determined one or more process parameters. According to some embodiments, the heating of the shaper device 130 can be performed automatically e.g. during a service procedure.

[0026] In other implementations, the one or more process parameters can be determined
15 manually, for example, by an operator. As an example, the monitoring device 150 can include the user interface configured to display the one or more characteristics such as the layer thickness of the accumulated material. The operator can select the one or more process parameters based on the one or more characteristics.

[0027] The apparatus 100 can include a transport system configured for transporting the
20 substrate 10 or a carrier 20 having the substrate 10 positioned thereon through the vacuum chamber 110, and in particular through a deposition area, along a transportation path, such as a linear transportation path. The transport system can be configured for transportation of the substrate 10 or the carrier 20 in a transport direction 2, which can be a horizontal direction.

25 [0028] According to some embodiments, which can be combined with other embodiments described herein, the apparatus 100 is configured for deposition of the material on the substrate 10 in a substantially vertical orientation. As used throughout the present disclosure, “substantially vertical” is understood particularly when referring to the substrate orientation, to allow for a deviation from the vertical direction or orientation of
30 $\pm 20^\circ$ or below, e.g. of $\pm 10^\circ$ or below. This deviation can be provided for example because

a substrate support with some deviation from the vertical orientation might result in a more stable substrate position. Further, fewer particles reach the substrate surface when the substrate is tilted forward. Yet, the substrate orientation, e.g., during the vacuum deposition process, is considered substantially vertical, which is considered different from the
5 horizontal substrate orientation, which may be considered as horizontal $\pm 20^\circ$ or below.

[0029] The term “vertical direction” or “vertical orientation” is understood to distinguish over “horizontal direction” or “horizontal orientation”. That is, the “vertical direction” or “vertical orientation” relates to a substantially vertical orientation e.g. of the carrier 20 and the substrate 10, wherein a deviation of a few degrees, e.g. up to 10° or even up to 15° ,
10 from an exact vertical direction or vertical orientation is still considered as a “substantially vertical direction” or a “substantially vertical orientation”. The vertical direction can be substantially parallel to the force of gravity.

[0030] The embodiments described herein can be utilized for evaporation on large area substrates, e.g., for display manufacturing. Specifically, the substrates for which the
15 structures and methods according to embodiments described herein are provided, are large area substrates. For instance, a large area substrate or carrier can be GEN 4.5, which corresponds to a surface area of about 0.67 m^2 ($0.73 \text{ m} \times 0.92 \text{ m}$), GEN 5, which corresponds to a surface area of about 1.4 m^2 ($1.1 \text{ m} \times 1.3 \text{ m}$), GEN 7.5, which corresponds to a surface area of about 4.29 m^2 ($1.95 \text{ m} \times 2.2 \text{ m}$), GEN 8.5, which corresponds to a surface area of
20 about 5.7 m^2 ($2.2 \text{ m} \times 2.5 \text{ m}$), or even GEN 10, which corresponds to a surface area of about 8.7 m^2 ($2.85 \text{ m} \times 3.05 \text{ m}$). 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.

[0031] According to some embodiments, which can be combined with other
25 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
30 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.

[0032] 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.

[0033] According to some embodiments, the substrate 10 is dynamic or static during the deposition of the material. Exemplarily a dynamic substrate and a static substrate are illustrated in FIGs. 1 and 6, respectively. According to some embodiments described herein, a dynamic deposition process can be provided, e.g., for the manufacture of OLED devices.

[0034] FIG. 2 shows a schematic side view of an apparatus 200 for deposition of a material on a substrate 10 according to further embodiments described herein.

[0035] According to some embodiments, the camera device 240 is configured to monitor the material accumulation on the shaper device 130 based on a reflection of the shaper device 130 provided by the substrate 10. In particular, the camera device 240 can be positioned within the vacuum chamber 110 such that at least a part of the substrate 10 is arranged within a field of view 242 of the camera device 240. As an example, the substrate 10 can be provided in front of the at least one deposition source 120, as is illustrated in FIG. 2.

[0036] The substrate 10 can act as a mirror. The camera device 240 can be installed e.g. on the at least one deposition source 120 “looking towards” the substrate 10. As an example, the camera device 240 can look in the shooting direction, i.e., the emission direction 1, of the at least one deposition source 120. Over the reflection on the mirror surface, it is possible to observe the status of the shaper device 130. In particular, the one or more characteristics of the material accumulation and/or the shape of the shaper device

130 can be determined and/or observed. In some implementations, the reflection of the shaper device 130 is provided by an uncoated, i.e., bare substrate, such as a glass substrate. In further implementations, the reflection of the shaper device 130 is provided by a coated substrate, e.g., a metal-coated substrate. The coated substrate can be a substrate having a high reflectivity, such as the metal-coated substrate. The material accumulation can be monitored before a deposition process begins.

[0037] The camera device 240 can be located at a position remote from the deposition area, such as on top of the at least one deposition source 120. The camera device 240 does not interfere with the deposition process, and particularly does not interfere with the deposition material. A material accumulation on the camera device 240 can be prevented.

[0038] According to some embodiments, which can be combined with other embodiments described herein, the camera device 240 is aligned with respect to the emission direction 1, e.g., a main emission direction, of the material emitted from the at least one deposition source 120. The camera device 240, and particularly the field of view 242, can point towards the deposition area, i.e., towards the substrate 10 to be coated such that the reflection of the shaper device 130 on a substrate surface can be captured by the camera device 240.

[0039] The at least one deposition source 120 can be configured and/or arranged such that the emission direction 1 has an angle relative to the surface orthogonal to the substrate surface of about 0° (i.e., the emission direction 1 is orthogonal to the substrate surface), specifically of about 20° or below, for example between 3° and 10° . In some implementations, the at least one deposition source 120, such as an evaporation source, is configured for providing a plume or distribution cone of the material to the substrate 10. The emission direction 1 can be defined as a main direction of propagation of the atoms or molecules forming the plume or distribution cone.

[0040] According to some embodiments, the apparatus 200 includes a transport system 260 configured for contactless levitation, transportation and/or alignment of the carrier 20. The contactless levitation, transportation and/or alignment of the carrier 20 is beneficial in that no particles are generated during transportation, for example due to mechanical contact with guide rails. The transport system 260 provides for an improved purity and

uniformity of the layers deposited on the substrate 10, since particle generation is minimized when using the contactless levitation, transportation and/or alignment.

[0041] FIG. 3 shows a schematic view of an apparatus 300 for deposition of a material on a substrate according to yet further embodiments described herein. The apparatus 300 of
5 FIG. 3 is similar to the apparatus of FIG. 2, and a description of similar or identical aspects is not repeated.

[0042] According to some embodiments, the apparatus 300 includes a reflection device 370 installed in the vacuum chamber 110. At least a part of the reflection device 370 is arranged within a field of view 342 of the camera device 340 to monitor the material
10 accumulation on the shaper device 130 based on a reflection of the shaper device 130 provided by the reflection device 370. The reflection device 370 can be a mirror.

[0043] The monitoring of the shaper device 130 can be performed as described with respect to FIG. 2. The camera device 340 can be mounted on the at least one deposition source 120, e.g., on top of the at least one deposition source 120. The camera device 340
15 can be located at a position remote from the deposition area and does not interfere with the deposition process, and particularly does not interfere with the deposition material. A material accumulation on the camera device 340 can be prevented.

[0044] FIG. 4 shows a schematic view of an evaporation source 400 having a shaper device 420 according to embodiments described herein. In particular, the at least one
20 deposition source can be the evaporation source, wherein the shaper device 420 is configured to delimit a distribution cone of the material evaporated by the evaporation source 400.

[0045] As exemplarily shown in FIG. 4, the evaporation source 400 may include a distribution assembly 430 connected to an evaporation crucible 440. For example, the
25 distribution assembly 430 may include a distribution pipe which can be an elongated tube. For instance, a distribution pipe as described herein 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 distribution pipe. Alternatively, one elongated opening extending along the at least one line can be provided. For example, the elongated opening can be a slit. According to

some embodiments, which can be combined with other embodiments described herein, the line may essentially be vertical.

[0046] In some implementations, the distribution assembly 430 may include a distribution pipe which is provided as a linear distribution showerhead, for example, 5 having a plurality of openings disposed therein. A showerhead as understood herein has an enclosure, hollow space, or pipe, in which the material can be provided or guided, for example from the evaporation crucible 440. The showerhead can have a plurality of openings (or an elongated slit) such that the pressure within the showerhead is higher than outside the showerhead. For example, the pressure within the showerhead can be at least 10 one order of magnitude higher than outside the showerhead.

[0047] According to some embodiments, which can be combined with any other embodiments described herein, the length of the distribution pipe may correspond at least to the height of the substrate to be coated. In particular, the length of the distribution pipe may be longer than the height of the substrate to be coated, at least by 10% or even 20%. 15 For example, the length of the distribution pipe can be 1.3 m or above, for example 2.5 m or above. Accordingly, a uniform deposition at the upper end of the substrate and/or the lower end of the substrate can be provided. According to an alternative configuration, the distribution assembly 430 may include one or more point sources which can be arranged along a vertical axis.

20 [0048] According to some embodiments, which can be combined with other embodiments described herein, the evaporation crucible 440 is in fluid communication with the distribution assembly 430 and provided at the lower end of the distribution assembly 430. In particular, a connector, e.g. a flange unit may be provided, which is configured to provide a connection between the evaporation crucible 440 and the 25 distribution assembly 430. For example, the evaporation crucible 440 and the distribution assembly 430 may be provided as separate units, which can be separated and connected or assembled at the connector, e.g. for operation of the evaporation source 400. The evaporation crucible 440 can be a reservoir for a material, such as an organic material, to be evaporated by heating the evaporation crucible 440. The evaporated material may enter 30 the distribution assembly 430, particularly at the bottom of the distribution pipe, and may

be guided essentially in a sideward direction through the plurality of openings in the distribution pipe, e.g., towards an essentially vertically oriented substrate.

[0049] According to some embodiments, a heating unit 410 may be provided for heating the distribution assembly 430, and particularly the distribution pipe(s). The heating unit
5 410 may be mounted or attached to walls of the distribution assembly 430. The distribution assembly 430 can be heated to a temperature such that the vapor of the material, which is provided by the evaporation crucible 440, does not condense at an inner portion of the wall of the distribution assembly 430. Further, a heat shield may be provided around the distribution pipe to reflect heat energy provided by the heating unit 410 back towards the
10 distribution pipe.

[0050] The evaporation source 400 includes the shaper device 420 (also referred to as “shielding device”, “shaper shielding device” or “hot shaper”) to delimit the distribution cone of evaporated material provided to the substrate. Further, the shaper device 420 may be configured to reduce the heat radiation towards the deposition area. In some
15 implementations, the shaper device 420 may be cooled by a cooling element 422. For example, the cooling element 422 may be mounted to the backside of the shaper device 420 and may include a conduit for cooling fluid.

[0051] By providing the shaper device 420, the direction (i.e., the emission direction) of the vapor exiting the distribution pipe or pipes through the outlets can be controlled, i.e. the
20 angle of the vapor emission can be reduced. In particular, at least a portion of the material evaporated through outlets or nozzles of the evaporation source 400 is blocked by the shaper device 420. A width of the emission angle can be controlled. As an example, the shaper device 420 can be used to cut off or block the material which is emitted at angles larger than a predetermined angle, such as large angles, for example, 10° or more, 20° or
25 more, or even 30° or more, with respect to a plane perpendicular to the substrate 10 or a substrate surface on which the material is to be deposited. The shaper device 420 delimits the distribution cone of the materials distributed towards the substrates, i.e. the shaper device 420 is configured to block at least a portion of the emitted material.

[0052] In some implementations, the evaporation source 400 can be configured for a
30 rotation around an axis, particularly during evaporation. A rotation drive may be provided,

for example, at the connections between a source cart (not shown) and the evaporation source 400. The rotation drive can be configured for turning the evaporation source 400 essentially parallel to the substrate before the coating of the substrate is carried out. Various applications for OLED device manufacturing include processes where two or more organic materials are evaporated simultaneously. In some embodiments, two or more distribution assemblies, particularly distribution pipes and corresponding evaporation crucibles, can be provided next to each other. Such an evaporation source may also be referred to as an evaporation source array, e.g. wherein more than one kind of organic material is evaporated at the same time.

10 [0053] FIG. 5 shows a system 500 for depositing one or more layers e.g. of an organic material on a substrate 10 according to embodiments described herein. The system 500 exemplarily illustrates a stationary substrate and a moving deposition source. However, the present disclosure is not limited thereto and the deposition source can be stationary and the substrate can be moving during the layer deposition process, as exemplarily illustrated with
15 respect to FIGs. 1 to 3.

[0054] The system 500 includes the apparatus for deposition of a material on a substrate according to the embodiments described herein, a load lock chamber 501 connected to the vacuum chamber 540 for loading the substrate 10 into the vacuum chamber 540, and an unload lock chamber 502 connected to the vacuum chamber 540 for unloading the
20 substrate 10 having the one or more layers deposited thereon from the vacuum chamber 540. The system 500 can be configured for deposition of an organic material.

[0055] The at least one deposition source, particularly an evaporation source 400, is provided in the vacuum chamber 540. The at least one deposition source can be provided on a track or linear guide 522. The linear guide 522 may be configured for a translational movement of the at least one deposition source. Further, a drive for providing a translational movement of at least one deposition source can be provided. The vacuum chamber 540 may be connected to the load lock chamber 501 and the unload lock chamber 502 via respective gate valves. The gate valves can allow for a vacuum seal between adjacent vacuum chambers and can be opened and closed for moving a substrate and/or a
25 mask into or out of the vacuum chamber 540.
30

[0056] In the present disclosure, a “vacuum chamber” is to be understood as a vacuum process chamber or a vacuum deposition chamber. The term “vacuum”, as used herein, can be understood in the sense of a technical vacuum having a vacuum pressure of less than, for example, 10 mbar. The pressure in the vacuum chamber 540 may be between 10^{-5} mbar and about 10^{-8} mbar, specifically between 10^{-5} mbar and 10^{-7} mbar, and more specifically between about 10^{-6} mbar and about 10^{-7} mbar. The system 500 can include one or more vacuum pumps, such as turbo pumps and/or cryo-pumps, connected to the vacuum chamber 540 for generation of the vacuum inside the vacuum chamber 540.

[0057] According to some embodiments, which can be combined with any other embodiment described herein, two substrates, e.g. a first substrate 10A and a second substrate 10B, can be supported on respective transportation tracks within the vacuum chamber 540. Further, two tracks for providing masks thereon can be provided. In particular, coating of the substrates may include masking the substrates by respective masks, e.g. by an edge exclusion mask or by a shadow mask. According to some embodiments, the masks, e.g. a first mask 30A corresponding to the first substrate 10A and a second mask 30B corresponding to a second substrate 10B, are provided in a mask frame 530 to hold the mask in a predetermined position.

[0058] According to some embodiments, which can be combined with other embodiments described herein, the substrates can be supported by a respective carrier, which can be connected to an alignment system 550, e.g. by connecting elements 552. An alignment system 550 can adjust the position of the substrate with respect to the mask. The substrate can be moved relative to the mask in order to provide for a proper alignment between the substrate and the mask during deposition of the material. According to a further embodiment, which can be combined with other embodiments described herein, alternatively or additionally the mask and/or the mask frame 530 holding the mask can be connected to the alignment system 550. Either the mask can be positioned relative to the substrate or the mask and the substrate can both be positioned relative to each other.

[0059] According to some embodiments, a source support 531 configured for the translational movement of the at least one deposition source along the linear guide 522 may be provided. The source support 531 can support the evaporation crucible 440 and the distribution assembly 430 provided over the evaporation crucible 440. Vapor generated in

the evaporation crucible 440 can move upwardly and out of the one or more outlets of the distribution assembly 430. The distribution assembly 430 is configured for providing evaporated material, particularly a plume of evaporated source material, from the distribution assembly 430 to the substrate.

- 5 [0060] The at least one deposition source includes the shaper device 420. Additionally, a material collection unit 560 may be arranged in the vacuum chamber 540 to collect evaporated source material emitted from the at least one deposition source, e.g. the evaporation source 400, when the at least one deposition source is in a rotated position as exemplarily shown in FIG. 6C. The heating device 570 may be provided for cleaning the
- 10 shaper device 420 in a service position of the at least one deposition source. The service position may be a position of the at least one deposition source in which the outlets of the distribution assembly 430 are in a rotated position as compared to a deposition position of the distribution assembly 430 in which the outlets are directed towards a substrate to be coated.
- 15 [0061] FIGs. 6A to D show schematic views of the system of FIG. 5 with the at least one deposition source, which can be the evaporation source 400, in different positions according to embodiments described herein. A plume or distribution cone 518 is emitted by the at least one deposition source.

- [0062] FIGs. 6A to D show the at least one deposition source, particularly the
- 20 evaporation source 400, in various positions in the vacuum chamber 540. The movement between the different positions is indicated by arrows 102B, 102C, and 102D. In FIG. 6A, the at least one deposition source is shown in a first position. As shown in FIG. 6B, the left substrate in the vacuum chamber 540 is coated with a layer of a material by a translational movement of the at least one deposition source as indicated by arrow 102B. While the left
- 25 substrate, e.g. the first substrate, is coated with the layer of the material, the second substrate, e.g. the substrate on the right-hand side in FIGs. 6A to D, can be exchanged, as indicated by the dotted lines. After the first substrate has been coated, the distribution assembly of the at least one deposition source can be rotated as indicated by arrow 102C in FIG. 6C. During deposition of the material on the first substrate, the second substrate has
- 30 been positioned and aligned with respect to the second mask. After the rotation shown in FIG. 6C, the second substrate can be coated with a layer of the material by a translational

movement of the at least one deposition source as indicated by arrow 102D in FIG. 6D. While the second substrate is coated with the organic material, the first substrate can be moved out of the vacuum chamber 540, as indicated by the dotted lines.

[0063] FIG. 7 shows a flow chart of a method 700 for monitoring a vacuum deposition
5 system according to embodiments described herein. The method can utilize the apparatus and the system according to the present disclosure.

[0064] The method 700 includes in block 710 evaporating a material for deposition on a substrate using an evaporation source, and in block 720 monitoring a material accumulation on a shaper device configured to block at least a portion of the material
10 emitted from the evaporation source using a camera device installed in a vacuum chamber.

[0065] In some implementations, the method 700 further includes determining one or more process parameters for a heating device based on the monitored material accumulation, and heating the shaper device by the heating device using the determined one or more process parameters. The optimal process parameters can be selected for
15 removing the condensed material because detailed information about the material accumulation is available. In particular, it can be determined optimally when to heat up the shaper device, up to which temperature, for how long, and so on.

[0066] According to embodiments described herein, the method for monitoring a vacuum deposition system can be conducted by means of computer programs, software, computer
20 software products and the interrelated controllers, which can have a CPU, a memory, a user interface, and input and output means being in communication with the corresponding components of the apparatus for processing a large area substrate.

[0067] Material ejected by a deposition source can be deposited on various components of a vacuum deposition system, such as a shaper device used to shape e.g. a plume of the
25 emitted material. The components can be cleaned from time to time in order to ensure an operability of the vacuum deposition system. The present disclosure uses a camera device located inside the vacuum chamber to monitor a material accumulation on the shaper device. A cleaning process for removing the accumulated material from the shaper device can be performed based on the monitored material accumulation. The cleaning process can

be performed in an efficient manner and a downtime of the vacuum deposition system can be minimized.

[0068] 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
5 scope thereof, and the scope thereof is determined by the claims that follow.

CLAIMS

1. An apparatus for deposition of a material on a substrate, comprising:
a vacuum chamber;
5 at least one deposition source in the vacuum chamber;
a shaper device at the at least one deposition source, wherein the shaper device is configured to block at least a portion of the material emitted from the at least one deposition source; and
a camera device in the vacuum chamber, wherein the camera device is configured
10 to monitor a material accumulation on the shaper device.
2. The apparatus of claim 1, wherein at least a part of the shaper device is arranged within a field of view of the camera device to monitor the material accumulation on the shaper device.
15
3. The apparatus of claim 1, wherein the camera device is configured to monitor the material accumulation on the shaper device based on a reflection of the shaper device provided by the substrate.
- 20 4. The apparatus of claim 3, wherein the camera device is positioned within the vacuum chamber such that at least a part of the substrate is arranged within a field of view of the camera device.
5. The apparatus of claim 1, further including a reflection device installed in the
25 vacuum chamber, wherein at least a part of the reflection device is arranged within a field

of view of the camera device to monitor the material accumulation on the shaper device based on a reflection of the shaper device provided by the reflection device.

6. The apparatus of any one of claims 1 to 5, wherein the camera device is mounted
5 on the at least one deposition source.

7. The apparatus of any one of claims 1 to 6, wherein the camera device is aligned with respect to an emission direction of the material emitted from the at least one deposition source.

10

8. The apparatus of any one of claims 1 to 7, further including a monitoring device connected to the camera device by a wireless link or by cable, wherein the monitoring device is configured to determine the material accumulation on the shaper device.

15 9. The apparatus of any one of claims 1 to 8, further including a heating device configured to heat the shaper device for removing the material accumulated on the shaper device.

10. The apparatus of claim 9, wherein the apparatus is configured to adjust one or more
20 process parameters for heating the shaper device based on the material accumulation.

11. The apparatus of claim 10, wherein the one or more process parameters are selected from the group consisting of a heating start time, a maximal heating temperature, a temperature ramp rate, a heating duration, and any combination thereof.

25

12. The apparatus of any one of claims 1 to 11, wherein the at least one deposition source is an evaporation source, and wherein the shaper device is configured to delimit a distribution cone of the material evaporated by the evaporation source.
- 5 13. A system for depositing one or more layers on a substrate, comprising:
- the apparatus of any one of claims 1 to 12;
- a load lock chamber connected to the vacuum chamber for loading the substrate into the vacuum chamber; and
- an unload lock chamber connected to the vacuum chamber for unloading the
- 10 substrate having the one or more layers deposited thereon from the vacuum chamber.
14. A method for monitoring a vacuum deposition system, comprising:
- evaporating a material for deposition on a substrate using an evaporation source;
- and
- 15 monitoring a material accumulation on a shaper device configured to block at least a portion of the material emitted from the evaporation source using a camera device installed in a vacuum chamber.
15. The method of claim 14, further including:
- 20 determining one or more process parameters for a heating device based on the monitored material accumulation; and
- heating the shaper device by the heating device using the determined one or more process parameters.

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Fig. 1

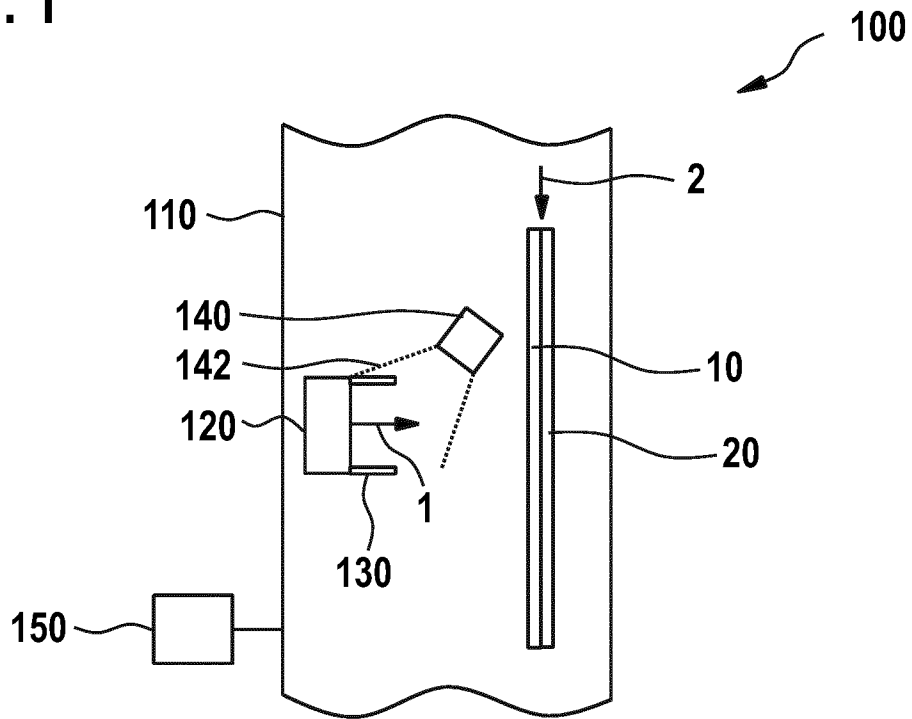
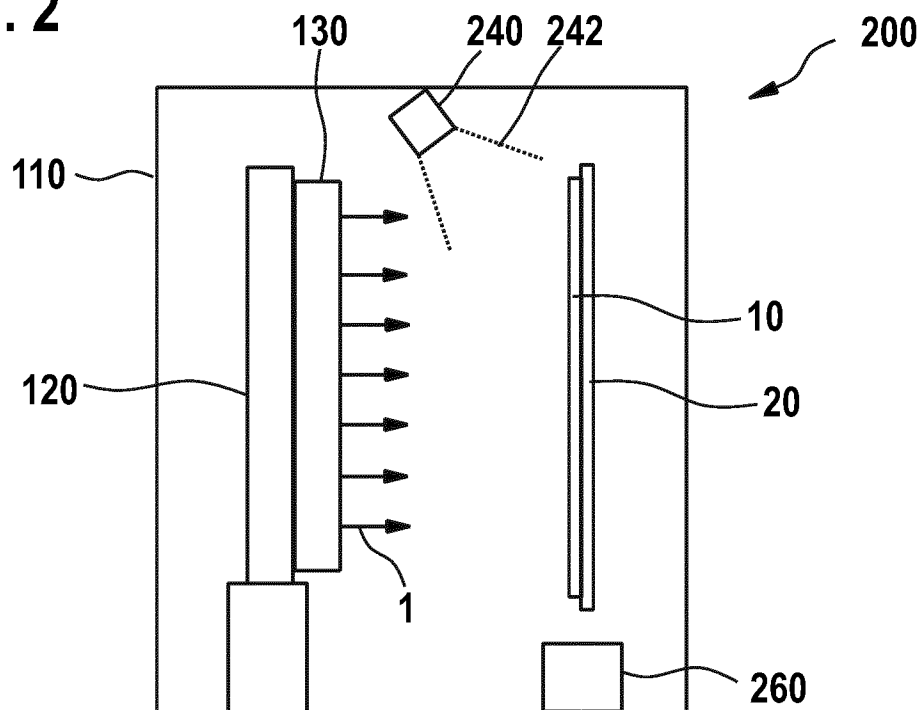
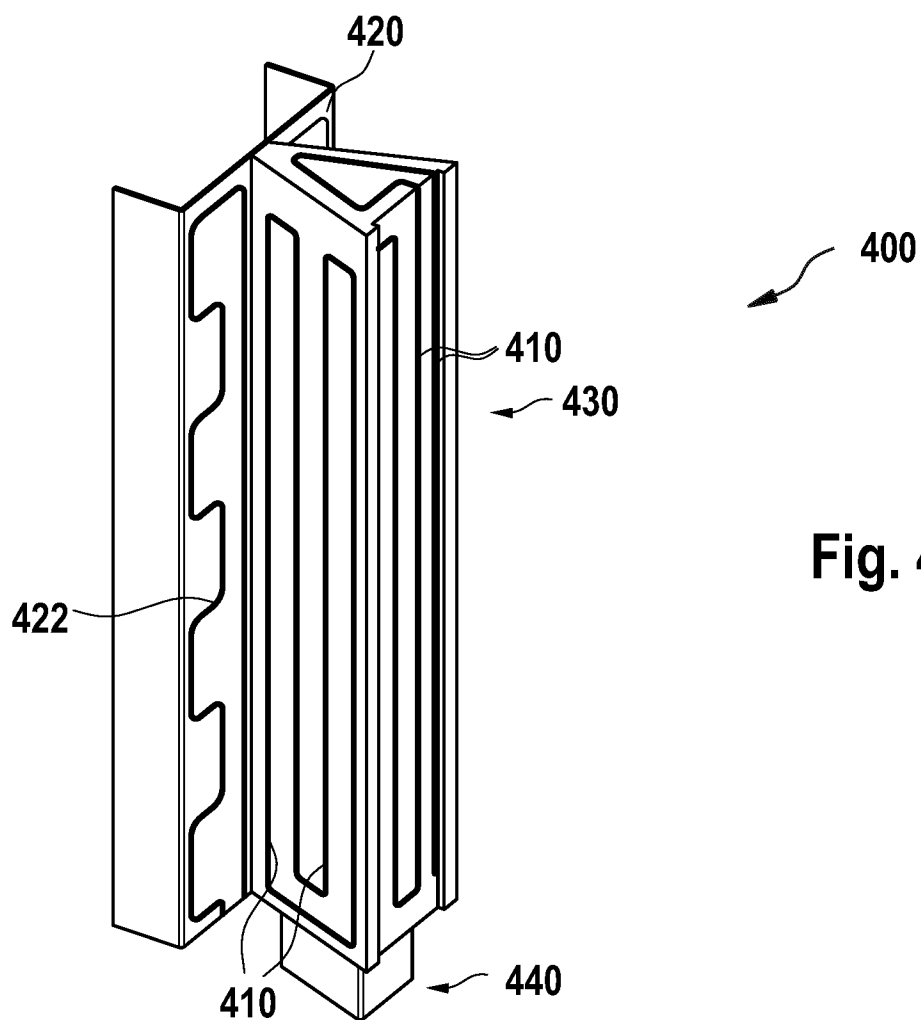
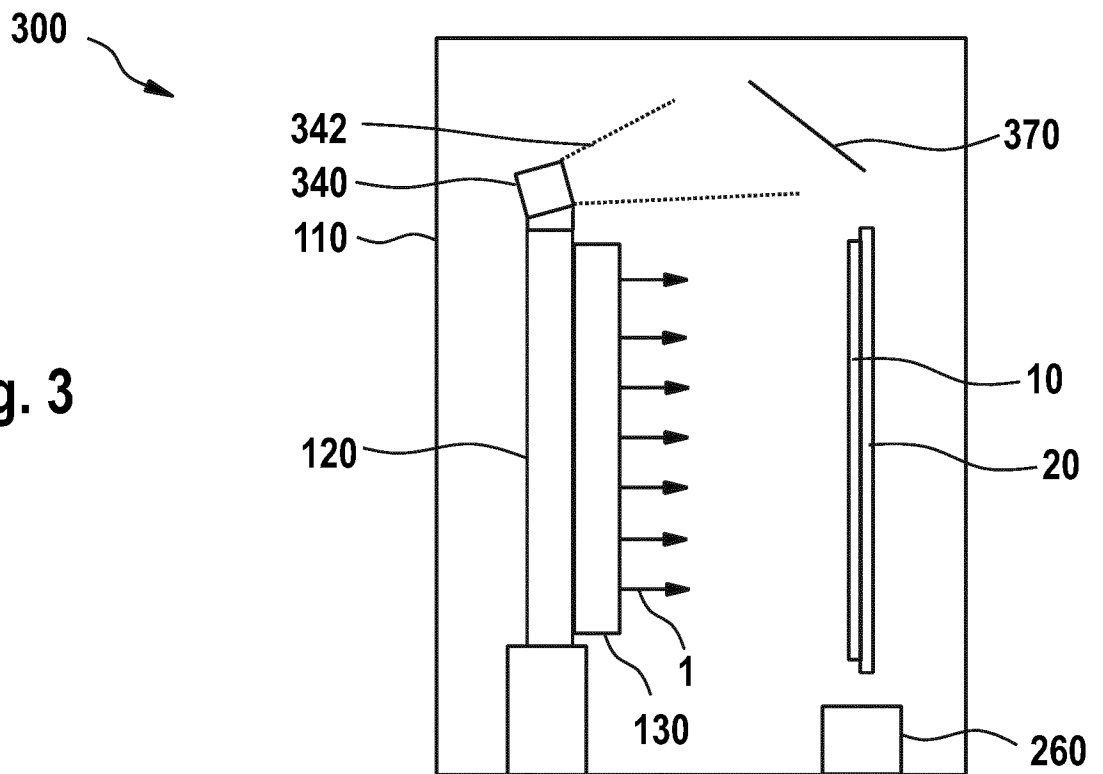


Fig. 2



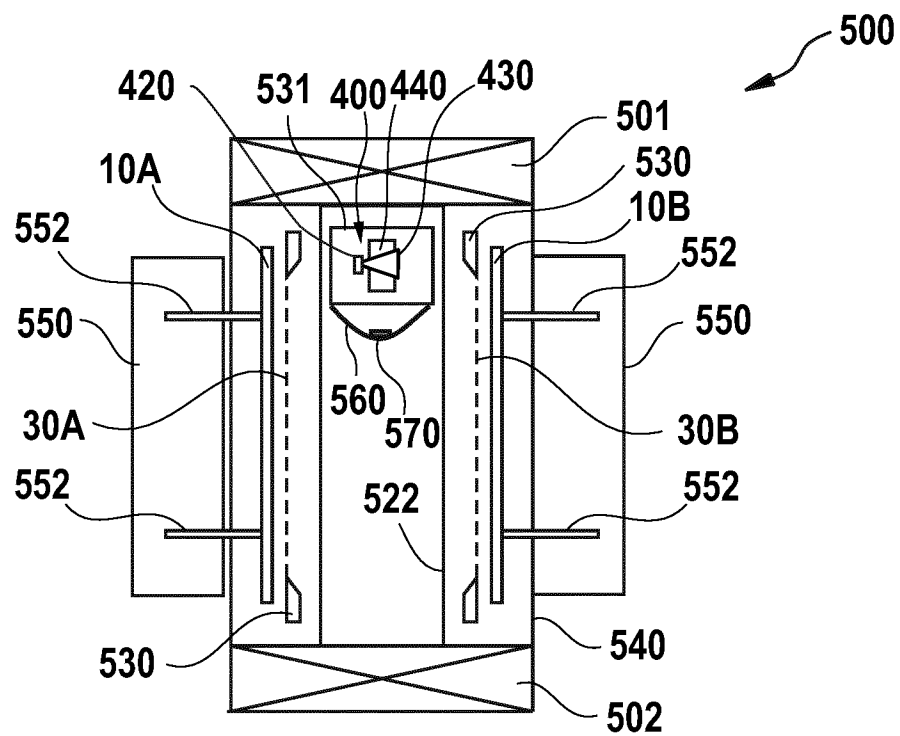
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Fig. 3



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Fig. 5



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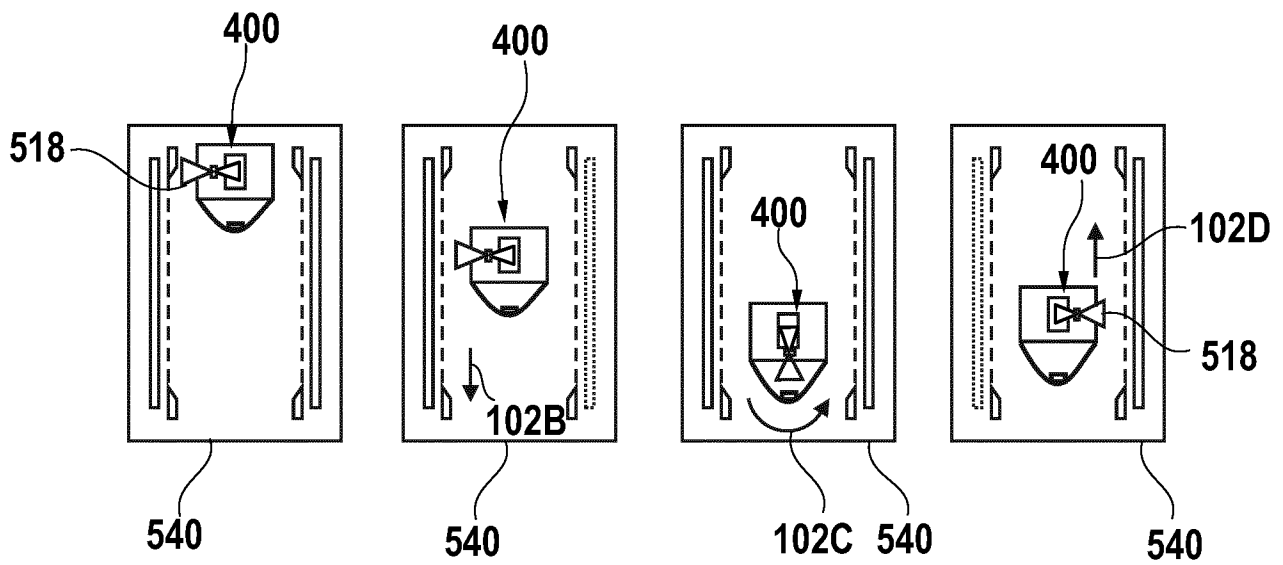
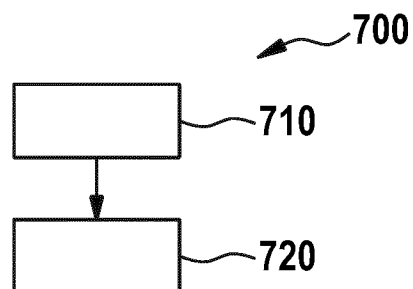


Fig. 7



INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2016/080666

A. CLASSIFICATION OF SUBJECT MATTER

INV. C23C14/54 G01B11/06
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 G01B

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

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A	WO 2015/139777 A1 (APPLIED MATERIALS INC [US]; DIEGUEZ-CAMPO JOSE MANUEL [DE]; BANGERT ST) 24 September 2015 (2015-09-24) page 22, paragraphs 58, 59; figure 8 figure 10 -----	1,13
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Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

4 August 2017

Date of mailing of the international search report

17/08/2017

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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