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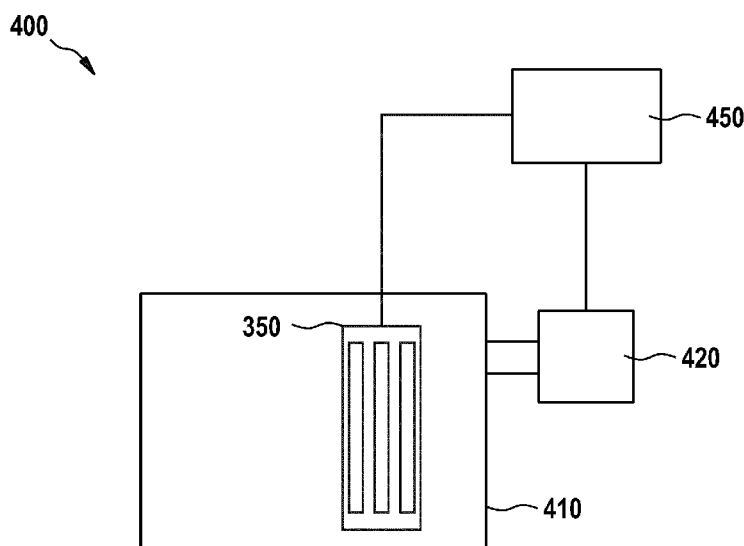
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AND APPARATUS FOR VACUUM PROCESSING A SUBSTRATE

Fig. 4



(57) Abstract: A method for cleaning a vacuum chamber, particularly a vacuum chamber used in the manufacture of OLED devices, is described. The method includes igniting a UV source within the vacuum chamber; and adjusting a pressure in the vacuum chamber to a vacuum condition providing a mixture of ozone and active radicals from a process gas in the vacuum chamber.

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**METHOD FOR CLEANING A VACUUM SYSTEM, METHOD FOR VACUUM
PROCESSING OF A SUBSTRATE, AND APPARATUS FOR VACUUM
PROCESSING A SUBSTRATE**

FIELD

[0001] Embodiments of the present disclosure relate to a method for cleaning a vacuum system, a method for vacuum processing a substrate, and an apparatus for vacuum processing of a substrate. Embodiments of the present disclosure particularly relate to methods and apparatuses used in the manufacture of organic light-emitting diode (OLED) devices.

BACKGROUND

[0002] Techniques for layer deposition on a substrate include, for example, thermal evaporation, physical vapor deposition (PVD), and chemical vapor deposition (CVD). Coated substrates may be used in several applications and in several technical fields. For instance, coated substrates may be used in the field of organic light emitting diode (OLED) devices. OLEDs can be used 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 deposited on a substrate.

[0003] OLED devices can include a stack of several organic materials, which are for example evaporated in a vacuum chamber of a processing apparatus. The vacuum conditions inside the vacuum chamber and contamination inside the vacuum chamber influences the quality of the deposited material layers and the OLED devices manufactured using these material layers.

[0004] For example, an OLED device lifetime is affected by organic contamination. The contamination may originate from parts and materials used inside the vacuum and/or from cross-contamination during maintenance. Cleaning, i.e. removal of contamination, before or during production enables stable, high-quality production of OLED devices.

5 [0005] The duration or time for proper cleaning to arrive at a contamination level suitable for production (preventive maintenance (PM) recovery) is a critical resource. Every minute of tool downtime is costly for an owner of a production system. Accordingly, increasing the cleaning efficiency and decreasing the cleaning time reduces production costs.

10 [0006] Remote ozone generators can be used for cleaning, e.g. to clean large volume chambers utilized in display manufacturing. Due to the long lifetime of ozone, remote source, i.e. sources not generating ozone in the proximity of surfaces to be cleaned is possible.

[0007] Therefore, there is a need for a method and an apparatus that can improve vacuum
15 conditions inside a vacuum chamber and cleaning of a vacuum chamber. The present disclosure particularly aims at reducing contamination such that a quality of layers of an organic material deposited on a substrate can be improved.

SUMMARY

20 [0008] In light of the above, a method for cleaning a vacuum chamber, a method for cleaning a vacuum system, particularly used in the manufacture of OLED devices, a method for vacuum processing a substrate, and an apparatus for vacuum processing a substrate, particularly to manufacture OLED devices are provided. Further aspects, benefits, and features of the present disclosure are apparent from the claims, the
25 description, and the accompanying drawings.

[0009] According to one embodiment, a method for cleaning a vacuum chamber, particularly a vacuum chamber used in the manufacture of OLED devices, is provided. The method includes igniting a UV source within the vacuum chamber; and adjusting a

pressure in the vacuum chamber to a vacuum condition providing a mixture of ozone and active radicals from a process gas in the vacuum chamber.

[0010] According to one embodiment a method for vacuum processing a substrate to manufacture OLED devices is provided. The method includes a method for cleaning
5 according to any of the embodiments described herein and depositing one or more layers of an organic material on the substrate.

[0011] According to one embodiment, an apparatus for vacuum processing a substrate, particularly to manufacture OLED devices, is provided. The apparatus includes a vacuum chamber; a UV source within the vacuum chamber; a vacuum pump to evacuated the
10 vacuum chamber; and a controller to adjust the pressure to a vacuum condition providing a mixture of ozone and active radicals from a process gas in the vacuum chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] So that the manner in which the above recited features of the present disclosure
15 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 flowcharts of a method for cleaning a vacuum system used in the manufacture of OLED devices
20 according to embodiments described herein;

FIG. 2 shows a flowchart of a method for vacuum processing of a substrate to manufacture OLED devices according to
embodiments described herein;

FIG. 3 shows a schematic view of a system for vacuum processing a substrate to manufacture OLED devices
25 according to embodiments described herein; and

FIG. 4 shows a schematic view of an apparatus for cleaning a vacuum chamber according to embodiments described herein.

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DETAILED DESCRIPTION OF EMBODIMENTS

[0013] 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.

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[0014] The vacuum conditions and the amount of contamination, particularly organic contamination, inside a vacuum chamber can strongly influence the quality of material layers deposited on a substrate. In particular, for OLED mass production, a cleanliness of vacuum components strongly effects the life time of a manufactured device. Even electro-polished surfaces may still be too dirty for OLED device fabrication. Some embodiments of the present disclosure use ozone for cleaning of a vacuum chamber and/or components within the vacuum chamber. For example, the vacuum cleaning can be provided after a pre-cleaning procedure e.g. as a final cleaning procedure for a vacuum system. Embodiments of the present disclosure, relate to ultra clean vacuum (UCV) cleaning.

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[0015] As described above, remote ozone generators can be used to clean large volume chambers. Because of the long lifetime of ozone, ozone can be created remotely, i.e. distant from the surface to be cleaned. Inventors of the present disclosure have found that a synergetic effect may be reached if ozone cleaning and UV light is combined for direct cleaning, i.e. in situ ozone creation. By tuning the process parameters, a mixture of ozone

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and active radicals, such as oxygen radicals, can be generated to increase the cleaning efficiency.

[0016] Compared to conventional cleaning strategies used in OLED industry, for example, “bake-out under vacuum”, embodiments of the present disclosure are not based on elevated temperatures to reduce and/or remove organic contamination inside the vacuum chamber. Especially when having temperature sensitive components, for example electronics, inside the system, bake-out is not a beneficial option. Furthermore, usage of a combination of ozone, active radicals, such as oxygen radicals, and UV light according to embodiments of the present disclosure show an improved cleaning efficiency compared to the conventional strategy, and particularly also without a bake-out procedure.

[0017] According to some embodiments of the present disclosure, a method for cleaning a vacuum chamber, particularly a vacuum chamber used in the manufacture of OLED devices, is provided. The method includes igniting at least one UV source, for example, a UV lamp, within the vacuum chamber and adjusting a pressure in the vacuum chamber to a vacuum condition providing a mixture of ozone and active radicals from a process gas in the vacuum chamber.

[0018] The cleanliness of the chamber or surface can for example be determined by a contact angle measurement. For example, having an ozone cleaning process under atmospheric pressure may result in a contact angle decrease by 5° to 10° for a cleaning time of about one hour or slightly above, and measured on a pre-contaminated wafer that was exposed to the cleaning treatment. Combining an in-situ ozone cleaning, i.e. ozone generation in the vacuum chamber, with a reduced pressure in the vacuum chamber and/or UV light in specific wavelengths ranges, a synergetic effect of ozone cleaning and active species or radicals created from ozone can be provided. Accordingly, a contact angle decrease may be significantly improved, for example by a factor of two or more.

[0019] According to embodiments of the present disclosure, active radicals can be generated from ozone or oxygen. According to some embodiments, the UV source or UV lamp can emit radiation (UV light) at specific wavelengths or in wavelengths ranges. For example, an UV source or UV lamp may emit radiation at a wavelengths of 170 nm to 200 nm, such as about 182 nm to 185 nm. Radiation at this wavelength may generate ozone

from oxygen. According to yet further additional or alternative modifications, the UV source or UV lamp can emit radiation at a wavelength of 230 nm to 270 nm, such as about 250 nm to 253 nm. Radiation at this wavelengths may trigger dissociation of ozone into oxygen and active species.

5 [0020] Some embodiments of the present disclosure may further be described in light of the distribution strategy of active species in the vacuum chamber to be cleaned. Contrary to the strategy of industry-standard cleaning processes, which are based on maximizing the number of active species for the cleaning process, embodiments of the present disclosure reduce the number of active species participating at the cleaning process. Yet, the
10 efficiency of the active species is increased by changing the distribution of the active species in the vacuum chamber and/or by changing the mixture of ozone and active radicals. Ozone generated in the vacuum chamber, i.e. a closed volume, generates ozone and the active radicals, such as oxygen radicals in close proximity to the UV lamp. Radiation for generating oxygen radicals may be immediately absorbed by the high
15 concentration of ozone generated at the source. Accordingly, the reach of the UV light in the vacuum chamber, particularly a large vacuum chamber for processing large area substrates utilized for display manufacturing can be limited. According to embodiments of the present disclosure, the pressure in the vacuum chamber is reduced to lower the density of available oxygen to generate ozone. Accordingly, the reach of the UV light, i.e. the
20 mean free path, increases, which results in an increased cleaning efficiency.

[0021] According to embodiments of the present disclosure, radiation wavelengths are provided within the vacuum chamber to allow for ozone generation and generation of active species or radicals, respectively, from the generated ozone. The mean free path length for the UV light is adapted to the chamber geometry and/or chamber size such that
25 the UV light may reach surfaces within the vacuum chamber to provide for an additional cleaning effect.

[0022] If, for example, UV light creating active species, such as for example, light with a wavelengths of about 251 nm, reaches surfaces be cleaned, generation of active radicals, such as oxygen radicals, from ozone is triggered in proximity of the contaminated surfaces.
30 The active species may react with the contamination on the surfaces before recombination of the active species. Further, the reduced pressure reduces the absorption of high energetic

UV radiation, which may further result in dissociation of molecules adhering to the surface to be cleaned.

[0023] A combination of ozone, active radicals reaching surfaces to be cleaned and UV light reaching surfaces to be cleaned may be provided according to embodiments described herein. Accordingly, synergetic effects of multiple effects can be provided with a UV source in the vacuum chamber, wherein reduced pressures are provided during cleaning.

[0024] For OLED chambers an average wall-to-wall distance of 3 m may be provided. The mean free path length of active species therefore may thus be less than 3 m to ensure beneficial mean free path length for the UV light, a pressure of $5 \cdot 10^{-4}$ mbar to $2 \cdot 10^{-2}$ mbar may be provided. An average wall-to-wall distance or an average distance of the walls may, for example, be defined as follows. A vacuum chamber typically has a bottom wall and top wall having a vertical distance. Further, the vacuum chamber typically has two opposing side walls having a first horizontal distance and further two opposing side walls having a second horizontal distance. For example, an average distance of walls can be the average from the vertical distance, the first horizontal distance and the second horizontal distance. The above exemplarily refers to a cuboid shape vacuum chamber. For a cylindrical chamber or a chamber having a trapezoidal cross-section, the average distance can be calculated in a similar manner.

[0025] According to some embodiments, which can be combined with other embodiments described herein, a method for cleaning a vacuum chamber, particularly a vacuum chamber used in the manufacture of OLED devices is provided. Embodiments of the present disclosure may further include determining an average distance of walls of the vacuum chamber, wherein the pressure is adjusted depending on the average distance.

[0026] FIG. 1 shows a flowchart of a method 100 for cleaning a vacuum chamber used, for example, in the manufacture of OLED devices according to embodiments described herein. The cleaning can refer to surfaces of the vacuum chamber, particularly inner surfaces of the vacuum chamber as well as surfaces of components provided in the vacuum chamber.

[0027] The method 100 includes igniting a UV source within the vacuum chamber (block 110). Further, the pressure in the vacuum chamber is adjusted (block 120) to a pressure for providing a mixture of ozone and active radicals from a process gas in the vacuum chamber. According to some embodiments, which can be combined with other
5 embodiments described herein, the process gas includes oxygen or can be oxygen. A cleaning with UV, ozone, and active species can be a final cleaning procedure before operating the vacuum system e.g. to deposit layers of one or more organic materials on a substrate. The term “final” is to be understood in the sense that no further cleaning procedures are performed after the plasma cleaning.

[0028] A pre-cleaning for cleaning at least the portion of the vacuum system and the plasma cleaning using e.g. a UV source for cleaning at least the portion of the vacuum system can be used for various components of the vacuum system. In some implementations, the pre-cleaning and the UV/ozone cleaning respectively include a cleaning of the vacuum chamber. For example, cleaning respectively includes a cleaning of
15 one or more inner walls of the vacuum chamber. Additionally or alternatively, the cleaning can include a cleaning of one or more components inside the vacuum chamber of the vacuum system. The one or more components can be selected from the group consisting of mechanical components, moveable components, drives, valves, and any combination thereof. For example, the mechanical components can be any components provided inside
20 the vacuum chamber, such as moveable components used for operating the vacuum system. An exemplary movable component includes, but is not limited to, a valve, such as a gate valve. The drives can include drives used for transportation of substrates and/or carriers in the vacuum system, drives or actuators for substrate and/or mask alignment, drives for valves, such as gate valves, separating adjacent vacuum regions or chambers,
25 and the like.

[0029] According to some embodiments, which can be combined with other embodiments described herein, a method for cleaning, for example, the method 100, can be performed after a maintenance procedure of the vacuum system or portions of the vacuum system and/or to avoid recontamination during operation. In particular, a pre-cleaning,
30 such as a wet cleaning, after maintenance may not be sufficient to achieve proper cleanliness levels for OLED mass production. The cleaning procedure, i.e., the UV/ozone

cleaning, after a pre-cleaning, can ensure cleanliness levels that can improve a quality of the layers of the organic materials deposited during a deposition process, such as a thermal evaporation process. UV/ozone cleaning can also be used to control recontamination caused by outgassing of polymers (o-rings, cables, etc) during production or system idle time.

[0030] The term “maintenance procedure” can be understood in the sense that the vacuum system is not operated to be able to perform various tasks, such as servicing and/or initial installation of the vacuum system or portions of the vacuum system. The maintenance procedure can be performed cyclically, e.g., in predetermined servicing intervals.

[0031] In some implementations, the cleaning is performed in one or more (vacuum) chambers of the vacuum system selected from the group consisting of a load lock chamber, a cleaning chamber, a vacuum deposition chamber, a vacuum processing chamber, a transfer chamber, a routing module, and any combination thereof.

[0032] As described above, embodiments of the present disclosure refer to the cleaning process at low pressure, particularly a low pressure that may be adapted to the size, and optionally the geometry, of the vacuum chamber to be cleaned. Display manufacturing, such as manufacturing of OLED displays is conducted on large area substrates. For example, the size of the substrate can be 0.67 m² or above, such as 1 m² or above.

[0033] The systems described herein can be utilized for evaporation on large area substrates, e.g., for OLED display manufacturing. Specifically, the substrates for which the systems 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 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 6, which corresponds to a surface area of about 2.7 m² (1.5 m x 1.8 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.

[0034] According to embodiments of the present disclosure, an improved pressure level for cleaning with ozone assisted by active species and UV light can be provided depending on the size of the chamber. Accordingly, lower pressures may beneficially be utilized for larger chambers. For smaller chambers, the pressure may be higher, corresponding to the shorter mean free path length.

[0035] According to yet further embodiments, which can be combined with other embodiments described herein, the findings of the inventors may similarly be applicable to vacuum chambers in the semiconductor industry, for example, wafer processing or wafer inspection. As the chambers may typically be smaller, the pressures may be higher. Particularly embodiments, which refer to optimizing the mean free path length according to an average chamber wall distance, are applicable for the smaller vacuum chambers. Further, additionally or alternatively, improvement or optimization of further cleaning parameters may similarly be applied to semiconductor manufacturing.

[0036] Particularly for the manufacturing of OLED devices, the quality of the vacuum in the vacuum chamber and contamination within the vacuum chamber strongly influences the device performance. Particularly the lifetime of the manufacture devices may be dramatically reduced by contamination. Accordingly, the surfaces inside the vacuum chambers need frequent cleaning. Processing chambers, manufacturing chambers, transfer chambers, transport chambers, storage chambers, and assembly chambers are sensitive to contamination. Human interaction with the inner surfaces of such chambers introduces organic and non-organic contamination that is adsorbed by the surfaces of the chambers and/or the surfaces of the components.

[0037] Even though wet cleaning processes of inner surfaces by human operators may be time-consuming and labor-intensive, wet cleaning is beneficial to remove microscopic contamination like solvent received use, particles, and the like. Further, human operators may introduce additional organic contamination into the system and some services may not be reached efficiently by a human operator.

[0038] According to embodiments of the present disclosure, a wet cleaning process may be introduced to remove microscopic contamination. An in situ cleaning process may be provided after the wet cleaning process or another pre-cleaning process according to embodiments described herein.

5 [0039] FIG. 3 shows a portion of a processing system 300 for e.g. vacuum deposition on a substrate to manufacture OLED devices according to embodiments described herein.

[0040] In FIG. 3 a process modules 310 is connected to a routing module 320. A maintenance module 340 may be coupled to the process module. A transit module 330 provides a path along a transportation direction from the first routing module to a second routing module (not shown). Each of the modules may have one or more vacuum chambers. Further, the transit module may provide two or more tracks, e.g. four transportation tracks 352, wherein a carrier can be moved out of one of the routing modules. As shown in FIG. 3, a transportation direction along the routing module and/or the transit module may be a first direction. Further routing modules may be connected to a further process modules (not shown). As shown in FIG. 3, gate valves 305 can be provided between neighboring modules or vacuum chambers, respectively, along the first direction, for example, between the transit module and an adjacent routing module and along a second direction. The gate valves 305 can be closed or opened to provide a vacuum seal between the vacuum chambers. The existence of a gate valve may depend on the application of the processing system, e.g. on the kind, number, and/or sequence of layers of organic material deposited on a substrate. Accordingly, one or more gate valves can be provided between transfer chambers.

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[0041] According to typical embodiments, the first transportation track 352 and the second transportation track 352 are configured for contactless transportation of the substrate carrier and/or the mask carrier to reduce contamination in the vacuum chambers. In particular, the first transportation track and the second transportation track may include a holding assembly and a drive structure configured for a contactless translation of the substrate carrier and/or the mask carrier.

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[0042] As illustrated in FIG. 3, in the first routing module 320, two substrates 301 are rotated. The two transportation tracks, on which the substrates are located, are rotated to be

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aligned in the first direction. Accordingly, two substrates on the transportation tracks are provided in a position to be transferred to the transit module and the adjacent further routing module.

[0043] According to some embodiments, which can be combined with other
5 embodiments described herein, the transportation tracks of the transportation track arrangement may extend from the vacuum process chamber into a vacuum routing chamber, i.e. can be oriented in the second direction which is different from the first direction. Accordingly, one or more of the substrates can be transferred from a vacuum process chamber to an adjacent vacuum routing chamber. Further, as exemplarily shown in
10 FIG. 3, a gate valve 305 may be provided between a process module and a routing module which can be opened for transportation of the one or more substrates. Accordingly, it is to be understood that a substrate can be transferred from the first process module to the first routing module, from the first routing module to the further routing module, and from the further routing module to a further process module. Accordingly, several processes, e.g.
15 depositions of various layers of organic material on a substrate can be conducted without exposing the substrate to an undesired environment, such as an atmospheric environment or non-vacuum environment.

[0044] FIG. 3 further illustrates masks 303 and substrates 301 in the process module 310. A deposition source 309 can be provided between the masks and/or substrates,
20 respectively.

[0045] Each vacuum chamber of the modules shown in FIG. 3 includes a UV source 350. For example, a UV source may be provided within the respective vacuum chamber. Even though the processing system 300 shows vacuum chambers with UV sources at each chamber, a processing system may include at least one UV source 350. Particularly, a
25 processing system 300 may include a first vacuum chamber with a first UV source 350 and a second vacuum chamber with a second UV source 350.

[0046] The UV source 350, e.g. of the process module 310, is connected to the vacuum chamber. A controller connected to the UV source is configured to perform UV/ozone cleaning according to embodiments of the present disclosure. In particular, the controller
30 can be configured to implement the method for cleaning a vacuum system or vacuum

chamber used, for example in the manufacture of OLED devices, of the present disclosure. An exemplary vacuum chamber with a UV source is described in more detail with respect to FIG. 4.

[0047] One or more vacuum pumps, such as turbo pumps and/or cryo-pumps, can be connected to the vacuum chamber e.g. via one or more tubes such as bellow tubes for the generation of a technical vacuum inside the vacuum chamber. A controller can further be configured to control the one or more vacuum pumps to reduce the pressure in the vacuum chamber e.g., prior to the plasma cleaning procedure.

[0048] The term “vacuum” as used throughout the present disclosure 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 may be $5 \cdot 10^{-4}$ mbar to $2 \cdot 10^{-2}$ mbar.

[0049] As shown in FIG. 3, a vacuum processing system 300 may have a plurality of different modules. Each module may have at least one vacuum chamber. The vacuum chambers may differ in size and geometry. As described above, according to some embodiments of the present disclosure, which can be combined with other embodiments described herein, the cleaning efficiency of a cleaning with active species and UV light can be increased by adapting the mean free path length of the UV light to the size and the geometry of the vacuum chamber. A good compromise between ozone cleaning, active species cleaning and UV cleaning can be provided.

[0050] Embodiments described exemplarily with respect to FIG. 4 below allow for a cleaning process with high-efficiency also during short interruptions or idle times. Accordingly, control of the recontamination and overall contamination level can be provided during production. Consistent high quality of OLED devices can be ensured. Accordingly, embodiments described herein also allow for efficient cleaning of the contamination, since idle times during short interruptions can be utilized for cleaning.

[0051] FIG. 4 shows an apparatus 400 for vacuum processing a substrate. For example, the substrate can be a large area substrate as described herein or a wafer for semiconductor industry. Particularly, the apparatus for vacuum processing can be configured for manufacturing of OLED devices or included in a processing system to manufacture OLED

devices. The apparatus includes a vacuum chamber 410. The vacuum chamber 410 can be evacuated with a vacuum pump 420. Particularly for OLED processes, the vacuum pump can be a cryo pump. UV source 350 is provided within the vacuum chamber 410. An in-situ ozone generation within the enclosure of the vacuum chamber can be provided according to embodiments of the present disclosure, which can be combined with other embodiments described herein.

[0052] The UV source can include one or more UV lamps, for example 4 or more UV lamps. For example, the UV lamps may have a quartz glass housing. Quartz glass can reduce absorption of UV radiation, i.e. short wavelength radiation. Yet further, according to additional or alternative modifications the UV lamp(s) can be a mercury lamp. Ozone can be created in situ from a process gas in the vacuum chamber 410, e.g. oxygen. Reducing the pressure by operating the vacuum pump 420 increases the mean free path length of the UV light. Accordingly, generation of active species can be provided close to surfaces to be cleaned. Further UV light may reach the surface to be cleaned to assist the cleaning process. Accordingly a mixture of ozone cleaning and cleaning with active species can be provided. The synergetic effect of the combined cleaning process improves the cleaning efficiency as compared to ozone cleaning aiming for higher ozone densities.

[0053] In light of the above, according to one embodiment, an apparatus for vacuum processing of a substrate, particularly to manufacture OLED devices is provided. The apparatus includes a vacuum chamber, at least one UV source within the vacuum chamber; a vacuum pump to evacuate the vacuum chamber; and a controller to adjust the pressure to a vacuum condition providing a mixture of ozone and active radicals from a process gas in the vacuum chamber.

[0054] FIG. 4 shows a controller 490. The controller 490 is connected to the vacuum pump 420 and the UV source 350. The controller 490 may include a central processing unit (CPU), a memory and, for example, support circuits. To facilitate control of the apparatus for processing a substrate, the CPU may be one of any form of general purpose computer processor that can be used in an industrial setting for controlling various chambers and sub-processors. The memory is coupled to the CPU. The memory, or a computer readable medium, may be one or more readily available memory devices such as random access memory, read only memory, floppy disk, hard disk, or any other form of digital storage

either local or remote. The support circuits may be coupled to the CPU for supporting the processor in a conventional manner. These circuits include cache, power supplies, clock circuits, input/output circuitry and related subsystems, and the like. Inspecting process instructions and/or instructions for generating a notch in an electronic device provided on the substrate are generally stored in the memory as a software routine typically known as a recipe. The software routine may also be stored and/or executed by a second CPU (not shown) that is remotely located from the hardware being controlled by the CPU. The software routine, when executed by CPU, transforms the general purpose computer into a specific purpose computer (controller) that controls the apparatus operation such as controlling inter alia the vacuum pump 420 and the UV source 350. Although the method and/or process of the present disclosure is discussed as being implemented as a software routine, some of the method steps that are disclosed therein may be performed in hardware as well as by the software controller. As such, the embodiments may be implemented in software as executed upon a computer system, and hardware as an application specific integrated circuit or other type of hardware implementation, or a combination of software and hardware. The controller may execute or perform a method for cleaning the vacuum chamber and/or processing a substrate, for example, for display manufacturing according to embodiments of the present disclosure.

[0055] According to embodiments described herein, the method for vacuum processing of a substrate 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.

[0056] While the foregoing is directed to embodiments of the disclosure, other and further embodiments of the disclosure may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

CLAIMS

1. A method for cleaning a vacuum chamber, particularly a vacuum chamber used in the manufacture of OLED devices, comprising:

5 igniting a UV source within the vacuum chamber; and

 adjusting a pressure in the vacuum chamber to a vacuum condition providing a mixture of ozone and active radicals from a process gas in the vacuum chamber.

2. The method of claim 1, wherein the active radicals are generated from ozone.

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3. The method of any of claims 1 to 2, wherein the UV source emits radiation at a wavelength of 170 nm to 200 nm.

4. The method of any of claims 1 to 3, wherein the UV source emits radiation at a
15 wavelength of 230 nm to 270 nm.

5. The method of any of claims 1 to 4, wherein the UV source includes a mercury lamp

20 6. The method of any of claims 1 to 5, wherein the pressure is adjusted to be in a range of $5 \cdot 10^{-4}$ mbar to $2 \cdot 10^{-2}$ mbar.

7. The method of any one of claims 1 to 6, wherein a process gas includes oxygen.

8. The method of any of claims 1 to 7, further comprising:

determining an average distance of walls of the vacuum chamber, wherein the pressure is adjusted depending on the average distance.

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9. A method for vacuum processing a substrate to manufacture OLED devices, comprising:

a method for cleaning according to any of claims 1 to 8; and

depositing one or more layers of an organic material on the substrate.

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10. An apparatus for vacuum processing a substrate, particularly to manufacture OLED devices, comprising:

a vacuum chamber;

a UV source within the vacuum chamber;

15 a vacuum pump to evacuated the vacuum chamber; and

a controller to adjust the pressure to a vacuum condition providing a mixture of ozone and active radicals from a process gas in the vacuum chamber.

11. The apparatus according to claim 10, wherein the controller further comprises:

20 a processor and a memory storing instructions that, when executed by the processor, cause the apparatus to perform a method according to any of claims 1 to 8.

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Fig. 1

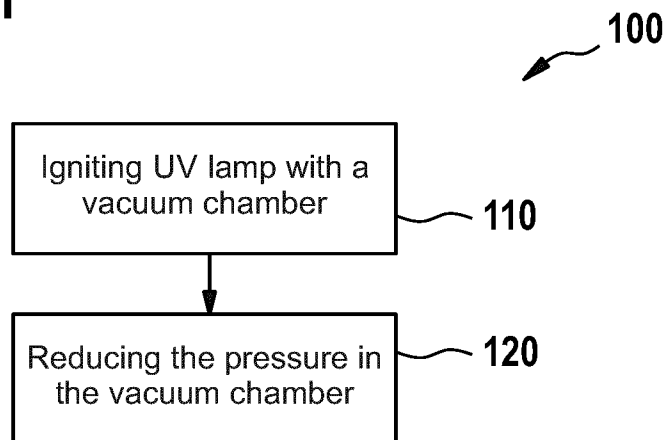
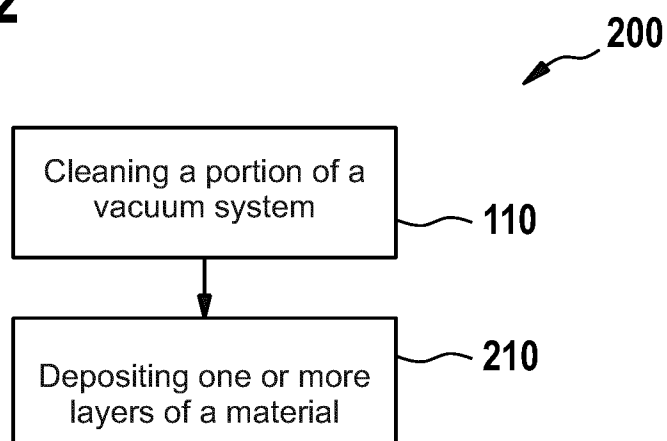
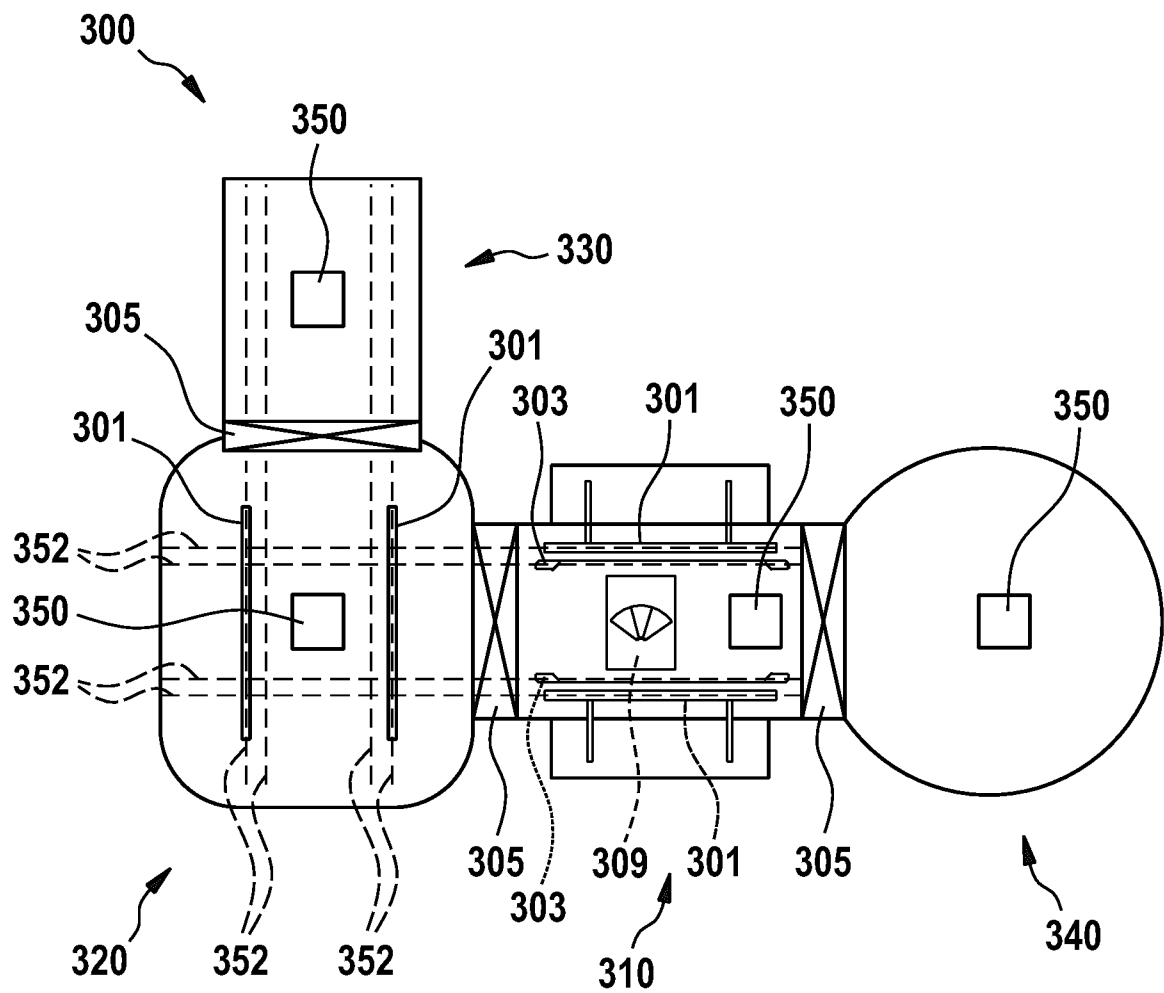


Fig. 2



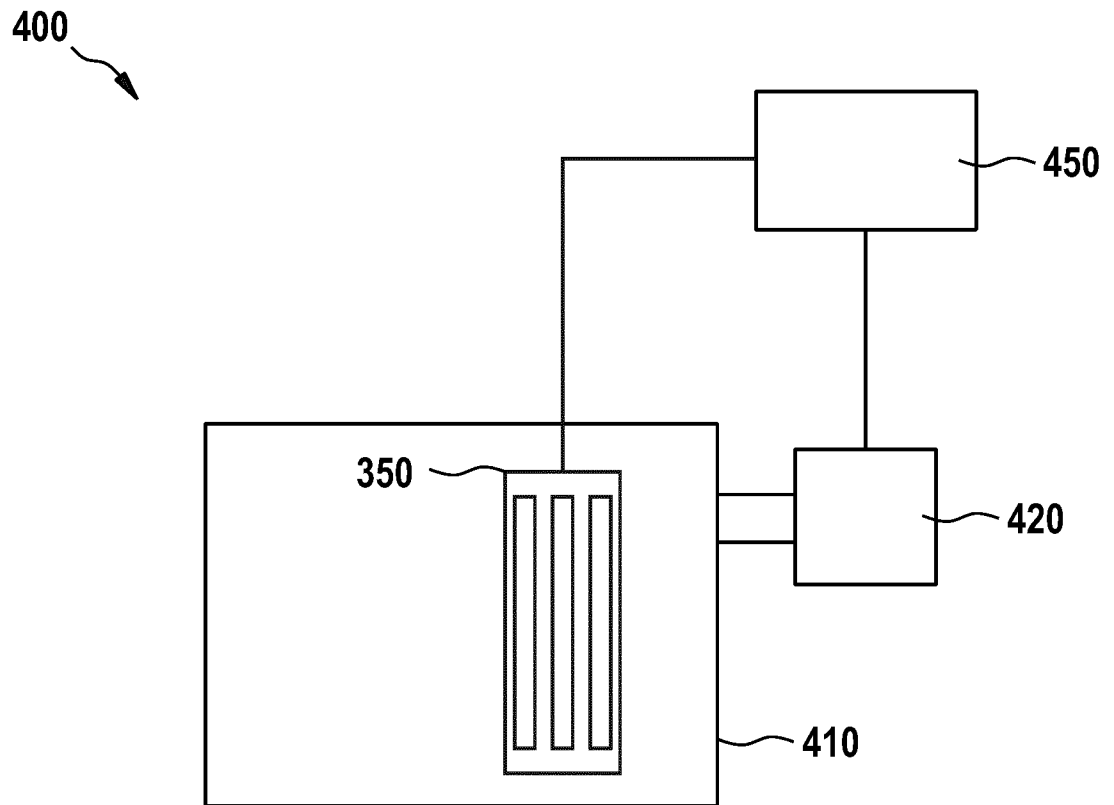
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Fig. 3



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Fig. 4



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/053413

A. CLASSIFICATION OF SUBJECT MATTER		
INV. B08B7/00	B08B9/00	B08B7/04 C23C16/44 C23C14/12
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) B08B C23C		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 098 637 A (PARKE VIJAY [US]) 8 August 2000 (2000-08-08) column 3, line 6 - line 24 column 5, line 66 - column 6, line 8 -----	1-11
X	US 2006/249175 A1 (NOWAK THOMAS [US] ET AL) 9 November 2006 (2006-11-09) paragraphs [0025], [0027]; claims -----	1-11
X	US 2013/284204 A1 (XIE BO [US] ET AL) 31 October 2013 (2013-10-31) paragraphs [0022], [0038] -----	1-11
A	WO 2018/184949 A1 (APPLIED MATERIALS INC [US]; KELLER STEFAN [DE] ET AL.) 11 October 2018 (2018-10-11) claims; figures ----- -/-	1-11
☒ 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 15 October 2019		Date of mailing of the international search report 22/10/2019
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 Engelen, Karen

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2019/053413

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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