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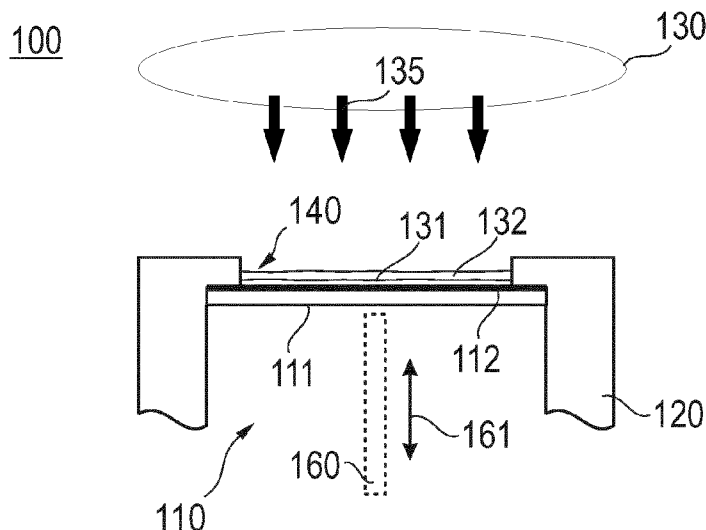


Fig. 1

(57) Abstract: A detection element for a measurement assembly adapted to measure a deposition rate of an evaporated material on a substrate. The detection element comprising: an oscillation crystal for detecting the deposition rate; and a barrier layer comprising a barrier material covering at least a portion of the oscillation crystal configured to prevent the evaporated material from diffusing into the oscillation crystal.

DIFFUSION BARRIER FOR OSCILLATION CRYSTALS,
MEASUREMENT ASSEMBLY FOR MEASURING A DEPOSITION
RATE AND METHOD THEREOF

TECHNICAL FIELD

[0001] The present disclosure relates to an oscillation crystal having a diffusion barrier, a measurement assembly for measuring a deposition rate of an evaporated material, and a method for measuring a deposition rate of an evaporated material. The present disclosure particularly relates to a measurement assembly for measuring a deposition rate of an evaporated organic material and a method therefore.

BACKGROUND

[0002] Organic evaporators are a tool for the production of a diverse range of devices such as, for example, organic photovoltaic (OPV) devices and organic light-emitting diodes (OLED). OLEDs are a special type of light-emitting diode in which the emissive layer comprises a thin-film of certain organic compounds. Organic light emitting diodes (OLEDs) are used in the manufacture of television screens, computer monitors, mobile phones, other hand-held devices, etc., for displaying information. OLEDs can also be used for general space illumination. The range of colors, brightness, and viewing angles possible with OLED displays is greater than that of traditional LCD displays because OLED pixels directly emit light and do not involve a back light. Therefore, the energy consumption of OLED displays is considerably less than that of traditional LCD displays. Further, the fact that OLEDs can be manufactured onto flexible substrates results in further applications.

[0003] The functionality of OPV devices and OLEDs depends on the coating thickness of the organic material. This thickness has to be within a predetermined range. In the production of OPV devices and OLEDs, the deposition rate at which the coating with organic material is affected is controlled to lie within a predetermined tolerance range. In other words, the deposition rate of an organic evaporator has to be controlled thoroughly in the production process.

[0004] In view thereof, for OPV and OLED applications, but also for other evaporation processes, a high accuracy of the deposition rate over a comparably long time

is needed. There is a plurality of measurement systems available for measuring the deposition rate of evaporators. However, these measurement systems suffer from either insufficient accuracy and/or insufficient stability over the sought after time period.

[0005] Hence, there is a continuing demand for providing improved deposition rate measurement systems and deposition rate measurement methods.

SUMMARY

[0006] In view of the above, according to one aspect of the present disclosure, a detection element for a measurement assembly adapted to measure a deposition rate of an evaporated material on a substrate is provided. The detection element includes: an oscillation crystal for detecting the deposition rate, and a barrier layer comprising a barrier material covering at least a portion of the oscillation crystal configured to prevent the evaporated material from diffusing into the oscillation crystal.

[0007] According to a further embodiment of the present disclosure, a measurement assembly is provided for measuring a deposition rate of an evaporated material on a substrate. The measurement assembly includes: a detection element as described above and an aperture having an opening configured to expose the barrier layer of the detection element to the evaporated material. The detection element is arranged in the measurement assembly such that the barrier layer extends beyond the opening of the aperture.

[0008] According to yet a further embodiment of the present disclosure, a method of measuring a deposition rate of an evaporated material on a substrate is provided. The method includes: installing a measurement assembly having a detection element as described above, and measuring the deposition rate of the evaporated material of the first layer with the measurement assembly, where the barrier layer is provided on the oscillation crystal before depositing the layer of the evaporated material on the substrate.

[0009] According to yet further embodiments herein, the detection element may be pre-treated. In embodiments herein, a pre-treated detection element may refer to the oscillation crystal of the detection assembly for detecting the deposition rate being pre-treated. The term “pre-treated” refers to a barrier layer including a barrier material covering at least a portion of the oscillation crystal configured to prevent an evaporated

material from diffusing into the oscillation crystal. According to embodiments herein, the barrier layer is applied to the oscillation crystal before the oscillation crystal detects a deposition rate of an evaporated material.

[0010] Further aspects, advantages and features of the present disclosure are apparent from the dependent claims, the description and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Some of the above mentioned embodiments will be described in more detail in the following description of typical embodiments with reference to the following drawings, in which:

[0012] Fig. 1 shows a schematic view of a measurement assembly adapted to measure a deposition rate of an evaporated material on a substrate according to embodiments described herein;

[0013] Fig. 2 shows a schematic top view of the measurement assembly shown in Fig. 1 according to embodiments herein;

[0014] Figs. 3a-3c show schematic views of an evaporation source according to embodiments herein;

[0015] Fig. 4 shows a schematic top view of a deposition apparatus for applying an evaporated material to a substrate in a vacuum chamber according to embodiments described herein; and

[0016] Fig. 5 schematically shows a method for measuring a deposition rate of an evaporated material on a substrate according to embodiments herein.

DETAILED DESCRIPTION OF EMBODIMENTS

[0017] Reference will now be made in detail to the various embodiments of the disclosure, one or more examples of which are illustrated in the figures. Within the following description of the figures, the same reference numbers refer to same components. In the following, 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.

[0018] In the present disclosure, the term “oscillation crystal” as used herein may, for example, refer to a crystal exhibiting piezoelectric properties. Non-limiting examples of oscillation crystals of natural and synthetic origin as used herein may, for instance, include quartz, langasite, berlinite and gallium orthophosphate.

[0019] In general, the expression “oscillation crystal for measuring the deposition rate” as used herein may be apprehended as an oscillation crystal for measuring a mass variation of deposited material on the oscillation crystal per unit area by measuring the change in frequency of an oscillation crystal resonator over time. Without limiting the scope, in the present disclosure an oscillation crystal may be understood as a quartz crystal resonator. More particularly, an “oscillation crystal for measuring the deposition rate” may be understood as a quartz crystal microbalance (QCM). QCMs, also referred to as quartz monitors or quartz resonators, or other so called piezoelectric microbalances can be used for the determination of the deposition rate of an evaporated material on a surface as mentioned above. In embodiments herein, the measured deposition rate of evaporated material may also be referred to as the coating rate.

[0020] Use of QCMs in the emerging organic light emitting diode (OLED) manufacturing industry has increased in the past years. OLED processes usually employ the use of exotic organic materials including dopants having metal atoms such as iridium (Ir) or platinum (Pt). These metals may diffuse into the oscillation crystal or be absorbed by the oscillation crystal and lead to failures in the measurement assembly. The indiffusion or absorption of metals into the oscillation crystal is highly undesirable as this may, for instance, influence the measuring accuracy of the QCM. In OLED manufacturing processes, measuring inaccuracies of the QCM may pose a particular problem. Generally, OLED materials are very light and the deposited layers often very thin such that the associated mass load on the QCM is relatively small. Any measuring inaccuracies of the deposition rate may skew the amount of deposited material past an acceptable level of tolerance, which may lead to unwanted changes in the properties of the OLED in, for instance, high quality display manufacturing. Moreover, if oscillation crystal failure occurs

during the deposition of a particular layer in a multilayer deposition process, it may be necessary to scrap the entire work product with significant loss in investment.

[0021] According to embodiments herein, the oscillation crystal for use in a measurement assembly adapted to measure a deposition rate of an evaporated material on a substrate may include a thin barrier layer. The thin barrier layer may cover at least a portion of the surface of the oscillation crystal. In embodiments herein, the oscillation crystal having a barrier layer may also be referred to as “detection element”. According to embodiments herein, the detection element may be a pre-treated detection element. The term “pre-treated detection element” used to describe embodiments herein, is to be apprehended as a detection element on which a layer of barrier material has been deposited before the use of the detection element in a measurement assembly for detecting the deposition rate of an evaporated material deposited on a substrate. In embodiments herein, the pre-treated detection element includes a barrier layer having a barrier material deposited on the oscillation crystal and covering at least a portion of the surface of the oscillation crystal. According to embodiments herein, the barrier layer is not any electrode layer that may be applied to the surface of the oscillation crystal. The barrier layer is also not the first layer of evaporated material on the substrate. In embodiments herein, the barrier layer includes a barrier material that differs from the first layer of evaporated material on the substrate and prevents in-diffusion of the evaporated material into the oscillation crystal.

[0022] According to embodiments herein, the barrier layer may include a barrier material that prevents the evaporated material, such as the metal from a metal-organic compound used in the production of OLEDs, from diffusing into the oscillation crystal. According to embodiments herein, the barrier layer is not an electrode or electrode layer but rather a layer of a barrier material that is adjusted to the diffusion properties of the evaporated material into the oscillation crystal. For instance, the barrier material may be adjusted to the in-diffusion properties of metals such as iridium and platinum used as part of the deposited material layers in manufacturing processes of devices such as OLEDs. According to embodiments, which can be combined with other embodiments described herein, the barrier layer may be adjusted to at least the first layer of evaporated material on the substrate. In embodiments herein, the barrier material may, for instance, be any one or more of: silicon nitride, an oxide and a metal.

[0023] According to embodiments herein, the oscillation crystal of a detection element has a front side adapted to face the evaporated material and a back side adapted to face away from the evaporated material. The barrier layer is provided on the front side of the oscillation crystal. In embodiments herein, the barrier layer covers at least all of the surfaces on the front side of the oscillation crystal that are exposed to the evaporated material. The back side of the oscillation crystal may include one or more electrodes configured to determine a change in the oscillation frequency of the oscillation crystal, which may be indicative of the deposition rate. The one or more electrodes may also function to excite the oscillation crystal.

[0024] With exemplary reference to Fig. 1, a measurement assembly 100 for measuring a deposition rate of an evaporated material according to embodiments herein includes a detection element 110 having an oscillation crystal 111 for detecting the deposition rate and a barrier layer 112 for protecting the oscillation crystal 111 from indiffusion of metals from evaporated material. According to embodiments herein, the term “detection element” may be used interchangeably with the term “pre-treated detection element”. With reference to Fig. 1, the general deposition direction of the evaporated material 130 is indicated with the arrows 135. In embodiments herein, during a deposition rate measurement, the evaporated material to be deposited on a substrate forms at least a first material layer 131 on the surface of the detection element 110. According to embodiments which can be combined with other embodiments described herein, a manufacturing process may include the deposition of a plurality of material layers of the same or different evaporated materials on a substrate. During the same manufacturing process, a plurality of material layers of the same or different evaporated materials would be deposited on the surface of the detection element. Exemplarily, Fig. 1 shows an additional material layer 132 on the first material layer 131.

[0025] According to embodiments herein, the barrier layer 112 is provided directly on the surface of the oscillation crystal 111, which during a deposition rate measurement would otherwise be exposed to the evaporated material 130. In embodiments herein, the barrier layer may have a thickness from 15 nm to 110 nm, particularly, from 20 nm to 10 nm. In further embodiments herein, the barrier layer may have a thickness that does not interfere with detection abilities of the oscillation crystal. For instance, the barrier layer may have a thickness of 1 μm or less. According to embodiments herein, the barrier layer may be applied to the surface of the oscillation crystal 111 by at least one of a

plasma-enhanced chemical vapor deposition (PECVD) process, a sputter process and an evaporation process.

[0026] In embodiments herein, the back side of the oscillation crystal of the detection element may include at least one electrode. With respect to Fig. 2, a first electrode 171 and a second electrode 172 are shown provided on the back side of the oscillation crystal 111.

[0027] In embodiments herein, the measurement assembly further includes a holder 120 for holding the oscillation crystal 111. The holder may include materials that have a low thermal conductivity to reduce or eliminate any negative effects of high temperature on the quality, accuracy and stability of the deposition rate measurement. According to embodiments herein, the measurement assembly 100 includes an aperture 101 that provides an opening configured to expose the barrier layer 112 of the oscillation crystal 111 to the evaporated material 130. In embodiments herein, the opening may also be referred to as the measuring opening.

[0028] In embodiments herein, the detection element 110 may be removable from the measurement assembly 100. Since the useful lifetime of the oscillation crystal may be limited, the detection element 110 including the oscillation crystal may be replaced periodically without having to replace the measurement assembly 100.

[0029] According to embodiments herein, the measurement assembly 100 includes a holder 120 for holding the detection element 110. According to embodiments which can be combined with other embodiments described herein, the detection element 110 may be arranged inside the holder 120. As exemplarily shown in Fig. 1, the holder may define the measurement opening of the aperture 101. In particular, the measurement opening may be configured and arranged such that evaporated material may be deposited on the detection element for measuring the deposition rate of the evaporated material. According to embodiments herein, the evaporated material is deposited on the barrier layer of the oscillation crystal.

[0030] With reference to Fig. 2, which shows a top view of the measurement assembly of Fig. 1, the diameter 102 of the opening of the aperture 101 of the measurement assembly is less than the diameter 103 of the detection element 110, in particular, less than the diameter of the barrier layer 112 of the detection element 110.

According to embodiments herein, the barrier layer 112 of the detection element 110 extends further than the diameter 102 of the opening of the aperture 101. In embodiments herein, arranging the detection element 110 such that the barrier layer 112 extends beyond the opening of the aperture 101 ensures that no evaporated material diffuses into the oscillation crystal 111 at the junction 140 between the opening of the aperture 101 and the detection element 110. The junction 140 between the opening of the aperture 101 and the detection element 110 may be defined as the seam between a circumferential inner edge of the holder 120, which defines the boundary of the opening of the aperture 101, and the barrier layer of the detection element 110.

[0031] According to embodiments which can be combined with other embodiments described herein, the opening of the aperture of the measurement assembly may have an oval-, square-, rectangular- or triangular-shape. For instance, the figures depict a measurement assembly with an aperture having a circular-shaped opening. In embodiments, having an aperture with an opening other than circular-shaped, the barrier layer of the detection element may extend further than the opening of the aperture.

[0032] According to embodiments herein, the measurement assembly may include an oscillator. In embodiments herein, the oscillator may be mechanically coupled to the detection element for exciting the detection element. For example, an oscillator 160 may apply mechanical energy to the oscillation crystal 111 of the detection element. The oscillator 160 may be movable with respect to the detection element 110. For example, the double headed arrow 161 in Fig. 1 illustrates a movement direction of the oscillator. According to embodiments which can be combined with other embodiments described herein, the oscillator may also be implemented in other forms, for instance, as a generator that produces an alternating potential to excite the oscillation crystal. Changes in a response signal from the oscillation crystal over time may be processed to determine the deposition rate of evaporated material.

[0033] In embodiments herein, the measurement assembly 100 may include a control unit configured to measure changes in the oscillation frequency of the oscillation crystal. According to embodiments herein, a control unit 150 is shown in Fig. 2. The control unit 150 may, for instance, control the oscillator 160. According to embodiments herein, the control unit 150 may be connected to one or more electrodes of the detection element 110. According to embodiments which can be combined with other embodiments

described herein, the control unit may be configured to detect a change in frequency of the signal from the oscillation crystal over time. This information may be processed by the control unit to provide a thickness measurement of a layer of evaporated material deposited on a substrate and/or a deposition rate of evaporated material on the substrate.

[0034] According to embodiments which can be combined with other embodiments described herein, the control unit may, for instance, be configured to be part of a feedback loop, which may terminate a deposition process or adjust the deposition rate of a deposition process in cases when the measured deposition rate exceeds a predetermined threshold. Providing such a feedback function in combination with the detection element and measurement assembly described herein may increase the reliability of the evaporation process and produce products of a very high quality.

[0035] Figs. 3a, 3b, and 3c show schematic views of an evaporation source according to embodiments herein. Fig. 3a and Fig. 3b show schematic side views of an evaporation source according to embodiments as described herein. The evaporation sources in Fig. 3a and Fig. 3b differ with respect to the position of an evaporation crucible and heating unit along the distribution pipe. In order to avoid repetition, all other elements described with respect to one of the embodiments are also applicable to the other embodiment.

[0036] The evaporation source 300 includes an evaporation crucible 310 configured to evaporate a material. Further, the evaporation source 300 includes a distribution pipe 320 with one or more outlets 322 provided along the length of the distribution pipe for providing evaporated material, as exemplarily shown in Fig. 3b. According to embodiments, the distribution pipe 320 is in fluid communication with the evaporation crucible 310, for example by a vapor conduit 332, as exemplarily shown in Fig. 3b. The vapor conduit 332 can be provided to the distribution pipe 320 at the central portion of the distribution pipe or at another position between the lower end of the distribution pipe and the upper end of the distribution pipe. According to embodiments herein, the evaporation source includes a measurement assembly 100 that enables measuring a deposition rate with high accuracy. Employing an evaporation source according to embodiments described herein may be beneficial for high quality display manufacturing, particularly OLED manufacturing.

[0037] As exemplarily shown in Fig. 3a, according to embodiments which can be combined with other embodiments described herein, the distribution pipe 320 may be an elongated tube including a heating element 315. The evaporation crucible 310 can be a reservoir for material, e.g. organic material, to be evaporated with a heating unit 325. For example, the heating unit 325 may be provided within the enclosure of the evaporation crucible 310. According to embodiments, which can be combined with other embodiments described herein, the distribution pipe 320 may provide a line source. For example, as exemplarily shown in Fig. 3b, a plurality of outlets 322, such as nozzles, can be arranged along at least one line. According to an alternative embodiment (not shown in the figures), one elongated opening, e.g. a slit, extending along the at least one line may be provided. According to some embodiments, which can be combined with other embodiments described herein, the line source may extend essentially vertically.

[0038] According to some embodiments, which can be combined with other embodiments described herein, the length of the distribution pipe 320 may correspond to a height of a substrate onto which material is to be deposited in a deposition apparatus. Alternatively, the length of the distribution pipe 320 may be longer than the height of the substrate onto which material is to be deposited, for example at least by 10% or even 20%. A uniform deposition at the upper end of the substrate and/or the lower end of the substrate can be provided. For example, the length of the distribution pipe 320 can be 1.3 m or above, for example 2.5 m or above. In embodiments herein, the distribution pipe may be provided on a support 302.

[0039] According to embodiments, which can be combined with other embodiments described herein, the evaporation crucible 310 may be provided at the lower end of the distribution pipe 320, as exemplarily shown in Fig. 3a. The material, e.g. an organic material, can be evaporated in the evaporation crucible 310. The evaporated material may enter the distribution pipe 320 at the bottom of the distribution pipe and may be guided essentially sideways through the plurality of outlets 322 in the distribution pipe 320, e.g. towards an essentially vertical substrate. With exemplary reference to Fig. 3b, the measurement assembly 100 according to embodiments described herein may be provided at an upper portion, particularly at an upper end, of the distribution pipe 320. In other embodiments, the measurement assembly may be positioned at a lower end of the distribution pipe or may be positioned in proximity of the substrate to be coated in the vacuum chamber.

[0040] With exemplarily reference to Fig. 3b, according to embodiments which can be combined with other embodiments described herein, a measurement outlet 350 may be provided in a wall of the distribution pipe 320 or an end portion of the distribution pipe 320, for example, in a wall at the backside 324a of the distribution pipe 320 as exemplarily shown in Fig. 3b and Fig. 3c. Alternatively, the measurement outlet 350 may be provided in a top wall 324b of the distribution pipe 320. As exemplarily indicated by the arrow 351 in Fig. 3c, the evaporated material may be provided from the inside of the distribution pipe 320 through the measurement outlet 350 to the measurement assembly 100. According to embodiments, which can be combined with other embodiments described herein, the measurement outlet 350 may have an opening with a diameter from 0.5 mm to 4 mm. The measurement outlet 350 may, for instance, include a nozzle. For example, the nozzle may include an adjustable opening for adjusting the flow of evaporated material provided to the measurement assembly 100.

[0041] In embodiments herein, the nozzle may be configured to provide a measurement flow selected from a range between a lower limit of $1/70$ of the total flow provided by the evaporation source, particularly a lower limit of $1/60$ of the total flow provided by the evaporation source, more particularly a lower limit of $1/50$ of the total flow provided by the evaporation source and an upper limit of $1/40$ of the total flow provided by the evaporation source, particularly an upper limit of $1/30$ of the total flow provided by the evaporation source, more particularly an upper limit of $1/25$ of the total flow provided by the evaporation source. For example, the nozzle may be configured to provide a measurement flow of $1/54$ of the total flow provided by the evaporation source.

[0042] Fig. 3c shows a perspective view of an evaporation source 300 according to embodiments described herein. As exemplarily shown in Fig. 3c, the distribution pipe 320 may be designed in a triangular shape. A triangular shape of the distribution pipe 320 may be beneficial in case two or more distribution pipes are arranged next to each other. In particular, a triangular shape of the distribution pipe 320 makes it possible to bring the outlets of neighboring distribution pipes as close as possible to each other. This allows for achieving an improved mixture of different materials from different distribution pipes, e.g. for the case of the co-evaporation of two, three or even more different materials. As exemplarily shown in Fig. 3c, according to embodiments which can be combined with other embodiments described herein, the measurement assembly 100

may be provided in the hollow space of the distribution pipe 320, particularly at the upper end of the distribution pipe.

[0043] According to embodiments, which can be combined with other embodiments described herein, the distribution pipe 320 may include walls, for example side walls 324c and a wall at the backside 324a of the distribution pipe, e.g. an end portion of the distribution pipe, which can be heated by a heating element 315. The heating element 315 may be mounted or attached to the walls of the distribution pipe 320. According to some embodiments, which can be combined with other embodiment described herein, the evaporation source 300 may include a shield 304. The shield 304 may reduce the heat radiation towards the deposition area. Further, the shield 304 may be cooled by a cooling element 316. For example, the cooling element 316 may be mounted to the shield 304 and may include a conduit for cooling fluid.

[0044] Fig. 4 shows a schematic top view of a deposition apparatus 400 for applying material to a substrate 433 in a vacuum chamber 410 according to embodiments described herein. According to embodiments which can be combined with other embodiments described herein, the evaporation source 300 as described herein may be provided in the vacuum chamber 410, for example on a track, e.g. a linear guide 420 or a looped track. The track or the linear guide 420 may be configured for a translational movement of the evaporation source 300. According to embodiments which can be combined with other embodiments described herein, a drive for the translational movement can be provided for the evaporation source 300, at the track and/or the linear guide 420, within the vacuum chamber 410. According to embodiments, which can be combined with other embodiments described herein, a first valve 405, for example a gate valve, may be provided which allows for a vacuum seal to an adjacent vacuum chamber (not shown in Fig. 4). The first valve can be opened for transport of the substrate 433 or a mask 432 into the vacuum chamber 410 or out of the vacuum chamber 410.

[0045] According to some embodiments, which can be combined with other embodiments described herein, a further vacuum chamber, such as maintenance vacuum chamber 411 may be provided adjacent to the vacuum chamber 410, as exemplarily shown in Fig. 4. The vacuum chamber 410 and the maintenance vacuum chamber 411 may be connected with a second valve 407. The second valve 407 may be configured for opening and closing a vacuum seal between the vacuum chamber 410 and the maintenance vacuum

chamber 411. The evaporation source 300 can be transferred to the maintenance vacuum chamber 411 while the second valve 407 is in an open state. Thereafter, the second valve 407 can be closed to provide a vacuum seal between the vacuum chamber 410 and the maintenance vacuum chamber 411. If the second valve 407 is closed, the maintenance vacuum chamber 411 can be vented and opened for maintenance of the evaporation source 300 without breaking the vacuum in the vacuum chamber 410.

[0046] As exemplarily shown in Fig. 4, two substrates may be supported on respective transportation tracks within the vacuum chamber 410. Further, two tracks for providing masks thereon can be provided. During coating, the substrate 433 can be masked by respective masks. For example, the mask may be provided in a mask frame 431 to hold the mask 432 in a predetermined position.

[0047] According to some embodiments, which can be combined with other embodiments described herein, the substrate 433 may be supported by a substrate support 426, which can connect to an alignment unit 412. The alignment unit 412 may adjust the position of the substrate 433 with respect to the mask 432. As exemplarily shown in Fig. 4, the substrate support 426 may be connected to the alignment unit 412. In embodiments herein, the substrate may be moved relative to the mask 432 in order to provide for a proper alignment between the substrate and the mask during deposition of the material, which may be beneficial for high quality display manufacturing. Alternatively or additionally the mask 432 and/or the mask frame 431 holding the mask 432 can be connected to the alignment unit 412. According to embodiments herein, either the mask 432 can be positioned relative to the substrate 433 or the mask 432 and the substrate 433 can both be positioned relative to each other.

[0048] As shown in Fig. 4, the linear guide 420 may provide a direction of the translational movement of the evaporation source 300. On both sides of the evaporation source 300 a mask 432 may be provided. The masks may extend essentially parallel to the direction of the translational movement. Further, the substrates at the opposing sides of the evaporation source 300 can also extend essentially parallel to the direction of the translational movement. As exemplarily shown in Fig. 4, the evaporation source 300 provided in the vacuum chamber 410 of the deposition apparatus 400 may include a support 302 which may be configured for the translational movement along the linear guide 420. For example, the support 302 may support two evaporation crucibles and two

distribution pipes 320 provided over the evaporation crucible 310. The vapor generated in the evaporation crucible can move upwardly and out of the one or more outlets of the distribution pipe. The deposition apparatus as described herein provides for improved quality display manufacturing, particularly OLED manufacturing.

[0049] Fig. 5 schematically shows a method for measuring a deposition rate of an evaporated material on a substrate according to embodiments herein. The method 500 for measuring a deposition rate of an evaporated material includes installing 510 a measurement assembly having a detection element as described herein into the vacuum chamber of a deposition apparatus. According to embodiments herein, the detection element may be a pre-treated detection element. The term “pre-treated detection element” used to describe embodiments herein, is to be apprehended as a detection element on which a layer of barrier material has been deposited before the use of the detection element in a measurement assembly for detecting the deposition rate of an evaporated material deposited on a substrate. In embodiments herein, the pre-treated detection element includes a barrier layer having a barrier material deposited on the oscillation crystal and covering at least a portion of the surface of the oscillation crystal. According to embodiments herein, the barrier layer is not any electrode layer that may be applied to the surface of the oscillation crystal. The barrier layer is also not the first layer of evaporated material on the substrate. In embodiments herein, the barrier layer includes a barrier material that differs from the first layer of evaporated material on the substrate and prevents in-diffusion of the evaporated material into the oscillation crystal.

[0050] In embodiments herein, the method 500 further includes depositing 520 a first layer of the evaporated material, for example, an organic material on the substrate. The evaporated material may, for instance, include dopants containing metal atoms such as iridium (Ir) or platinum (Pt). Further yet, the method includes measuring 530 the deposition rate of the evaporated material of the first layer with the measurement assembly. In the method 500, the barrier layer is provided on the oscillation crystal of the detection element before depositing the first layer of the evaporated material on the substrate. Yet further, according to embodiments herein, the barrier layer may be provided on the oscillation crystal of the detection element before installing the measurement assembly including the detection element into the vacuum chamber of the deposition apparatus.

[0051] Optionally, according to embodiments herein, the method 500 may include pre-treating 508 the oscillation crystal of the detection element of a measurement assembly by applying a barrier layer onto at least a portion of the oscillation crystal. The barrier layer including a barrier material configured to prevent the evaporated material from diffusing into the oscillation crystal. According to embodiments herein, the diffusion barrier may be provided to completely cover a front side of the oscillation crystal. The front side of the oscillation crystal being defined as the side of the oscillation crystal that faces the evaporated material during the measurement of a deposition rate of an evaporated material being deposited on a substrate.

[0052] In embodiments herein, the method 500 for measuring a deposition rate of an evaporated material may include installing 509 the oscillation crystal having a barrier layer as described above into a measurement assembly. In particular, the oscillation crystal may be installed into the measurement assembly so that the barrier layer extends beyond the opening of the aperture of the measurement assembly.

[0053] According to embodiments herein, the method 500 for measuring a deposition rate of an evaporated material may include depositing 531 at least one or more additional layers of evaporated material on the first layer. In embodiments herein, the first layer of evaporated material and the one or more additional layers of evaporated material may be dissimilar evaporated materials. In embodiments herein, the barrier layer of the detection element may be configured to the diffusion properties of both of the dissimilar evaporated materials into the oscillation crystal. For instance, the barrier layer may prevent the diffusion of metals from the first layer of evaporated material from diffusing into the oscillation crystal. Further, the barrier layer may also prevent the diffusion of metals from the one or more additional layers of dissimilar evaporated material from diffusing through the first layer and into the oscillation crystal.

[0054] According to embodiments herein, the method 500 for measuring a deposition rate of an evaporated material may include measuring 532 the deposition rate of the evaporated material of the at least one or more additional layers with the measurement assembly. According to embodiments herein, measuring the deposition rate of the evaporated material on the substrate comprises determining changes in the oscillation frequency of the oscillation crystal. In embodiments herein, which can be combined with other embodiments described herein, the method may further include terminating a

deposition process and/or adjusting 533 a deposition rate of a deposition process in cases when a measured deposition rate exceeds a predetermined threshold.

[0055] According to embodiments herein, pre-treating an oscillation crystal of a detection element with a barrier layer having a barrier material covering at least a portion of the oscillation crystal that is exposed to evaporation material in order to prevent evaporated material from diffusing into the oscillation crystal may improve the quality, accuracy and stability of the deposition rate measurement. Further, the measurement assembly for measuring a deposition rate of an evaporated material and the method for measuring a deposition rate according to embodiments described herein provide an improved deposition rate measurement and an improved manufacturing of high quality displays, for example, for high quality OLED manufacturing.

[0056] This written description uses examples to disclose the disclosure, including the best mode, and also to enable any person skilled in the art to practice the described subject-matter, including making and using any devices or systems and performing any incorporated methods. While various specific embodiments have been disclosed in the foregoing, mutually non-exclusive features of the embodiments described above may be combined with each other. The patentable scope is defined by the claims, and other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

CLAIMS

1. A detection element for a measurement assembly adapted to measure a deposition rate of an evaporated material on a substrate, the detection element comprising:
 - an oscillation crystal for detecting the deposition rate; and
 - a barrier layer comprising a barrier material covering at least a portion of the oscillation crystal configured to prevent the evaporated material from diffusing into the oscillation crystal.
2. The detection element according to claim 1, wherein the oscillation crystal comprises a front side adapted to face the evaporated material and a back side adapted to face away from the evaporated material, and wherein the barrier layer is provided on the front side of the oscillation crystal and optionally one or more electrodes are provided on the back side of the oscillation crystal.
3. The detection element according to claim 1 or 2, wherein the barrier material comprises at least one of silicon nitride, an oxide and a metal.
4. The detection element according to any of claims 1 to 3, wherein the evaporated material comprises an organic compound or a metal-organic compound, and wherein the barrier material is adjusted to diffusion properties of the evaporated material into the oscillation crystal.
5. The detection element according to claim 4, wherein the organic compound or the metal-organic compounds comprise at least one of Platinum (Pt) and Iridium (Ir).
6. Measurement assembly for measuring a deposition rate of an evaporated material on a substrate, wherein the measurement assembly comprises:

a detection element according to any of claims 1 to 5; and

an aperture having an opening configured to expose the barrier layer of the detection element to the evaporated material,

wherein the detection element is arranged in the measurement assembly such that the barrier layer extends beyond the opening of the aperture.

7. The measurement assembly according to claim 6, further comprising a holder for holding the detection element and wherein the holder defines boundaries of the opening of the aperture.

8. The measurement assembly according to claim 6 or 7, further comprising:

a control unit configured to measure changes in an oscillation frequency of the oscillation crystal.

9. The measurement assembly according to any of claims 6 to 8, further comprising:

an oscillator mechanically coupled to the detection element for exciting the detection element.

10. Method of manufacturing a detection element for a measurement assembly adapted to measure a deposition rate of an evaporated material on a substrate, wherein the method includes:

pre-treating an oscillation crystal of the detection element by depositing a barrier layer comprising a barrier material on the oscillation crystal to prevent the evaporation material from diffusing into the oscillation crystal.

11. The method of claim 10, wherein pre-treating the oscillation crystal of the detection element includes selecting a barrier material that is adjusted to diffusion properties of the evaporated material into the oscillation crystal.

12. The method according to any of claims 10 or 11, wherein depositing the barrier layer includes depositing the barrier layer by any one or more of a plasma-enhanced chemical vapor deposition (PECVD) process, a sputter process and an evaporation process.

13. Method of measuring a deposition rate of an evaporated material on a substrate, the method comprising

installing a measurement assembly having a detection element according to any of claims 1 to 5 into a vacuum chamber of a deposition apparatus;

depositing a first layer of the evaporated material on the substrate; and

measuring the deposition rate of the evaporated material of the first layer with the measurement assembly,

wherein the barrier layer is provided on the oscillation crystal before depositing the first layer of the evaporated material on the substrate.

14. The method according to claim 13, wherein the barrier layer is provided on the oscillation crystal before installing the measurement assembly into the vacuum chamber of the deposition apparatus.

15. The method according to any of claims 13 or 14, wherein the detection element is manufactured by any of claims 10 to 12.

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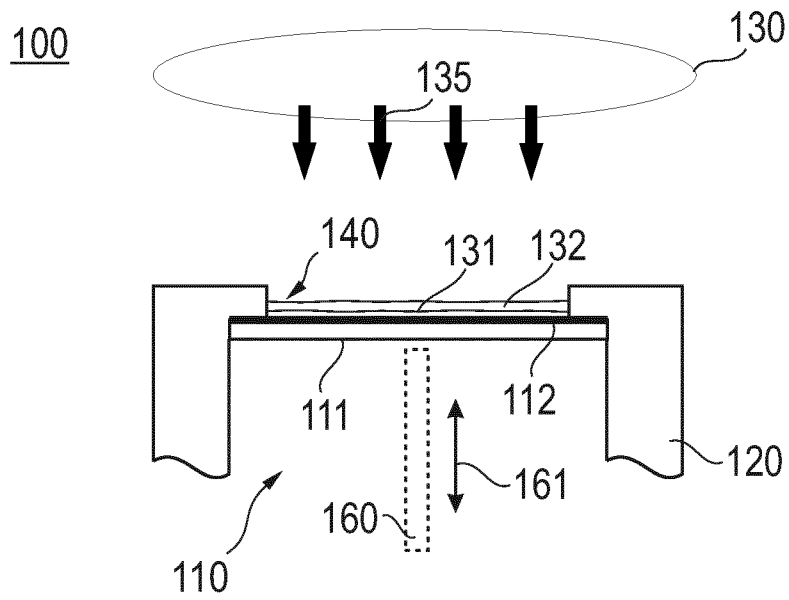


Fig. 1

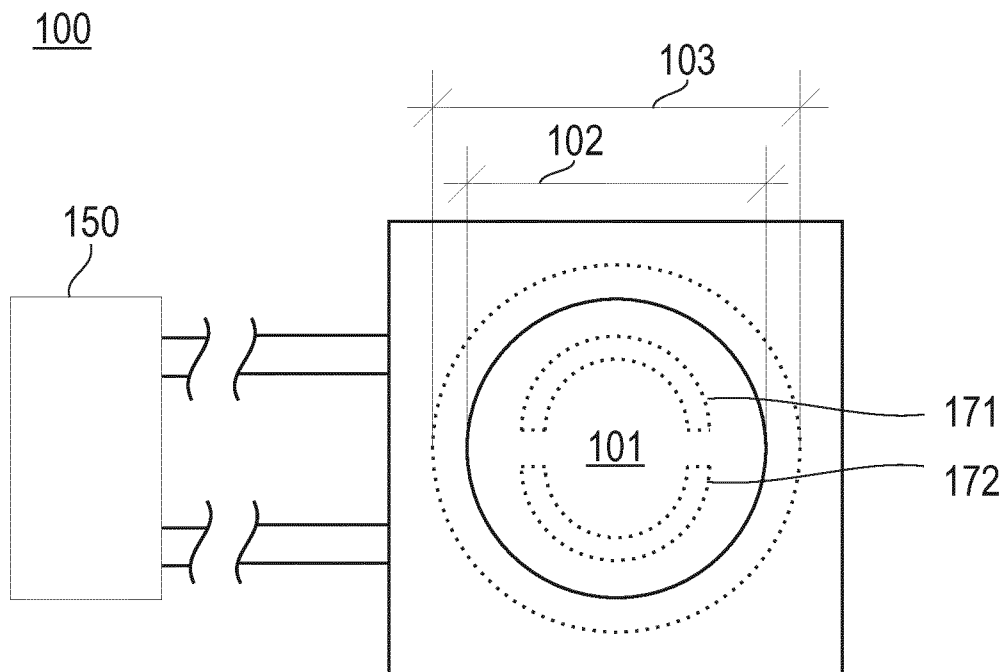


Fig. 2

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300

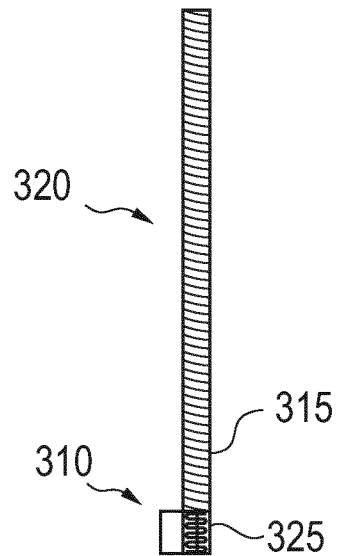


Fig. 3a

300

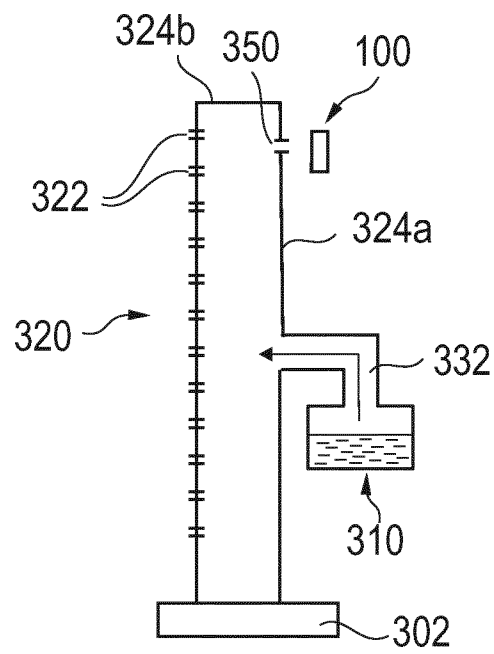


Fig. 3b

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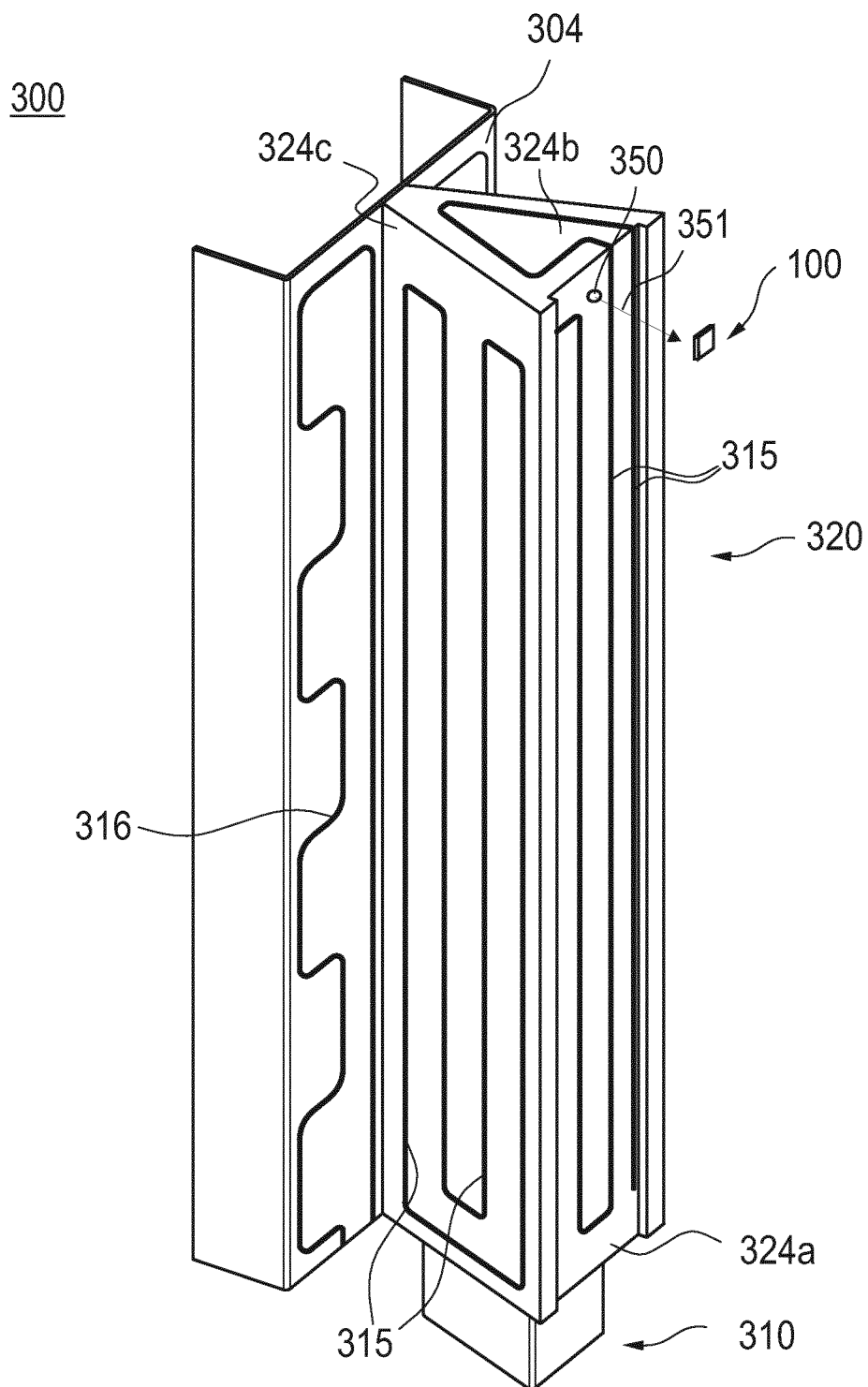


Fig. 3c

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400

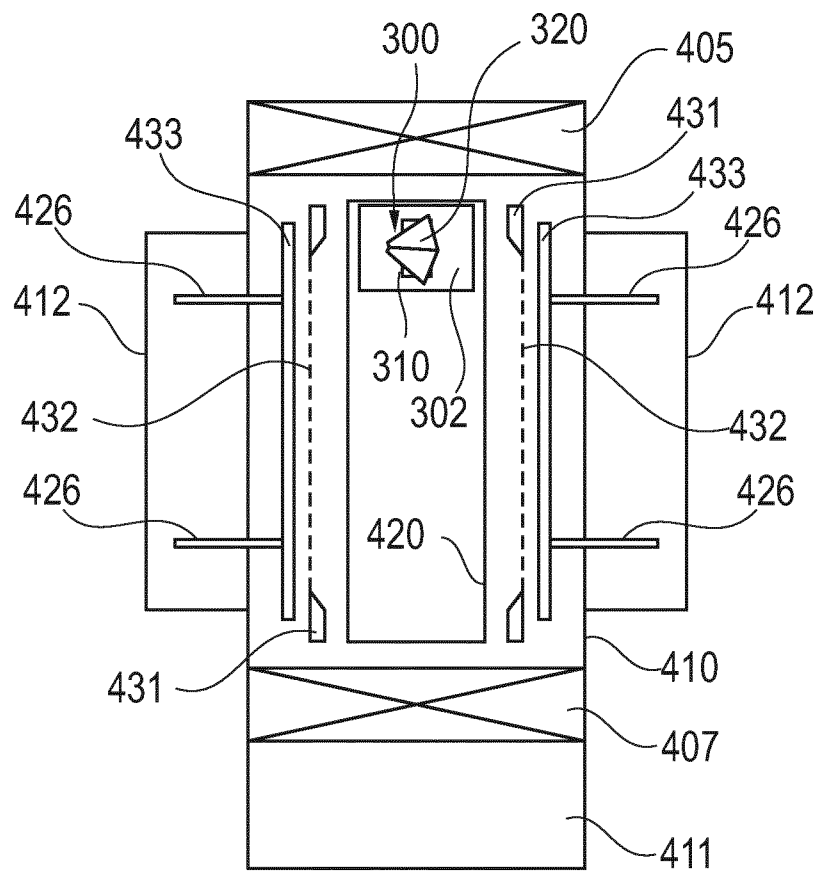


Fig. 4

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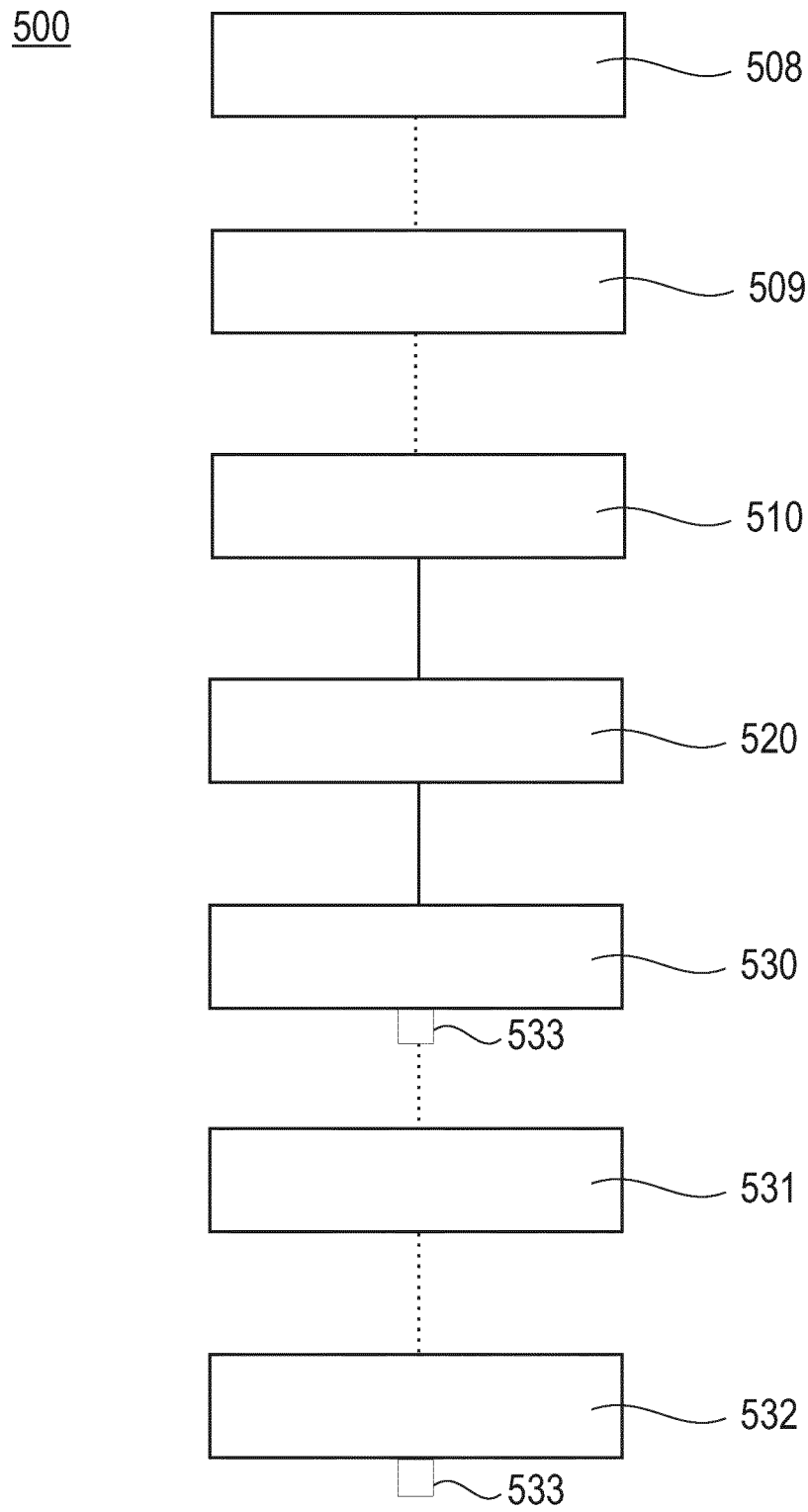


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/071758

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01N29/02 C23C14/54 G01N29/24 G01N29/32 H01L41/113
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)
G01N 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, INSPEC, COMPENDEX, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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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

12 May 2016

Date of mailing of the international search report

20/05/2016

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Authorized officer

Filipas, Alin

INTERNATIONAL SEARCH REPORT

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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