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(54) **IN-SITU MASK ALIGNMENT FOR DEPOSITION TOOLS**

(75) Inventors: **Ilyoung Richard Hong**, San Jose, CA (US); **William N. Sterling**, Santa Clara, CA (US); **Dongsuh Lee**, Santa Clara, CA (US)

(73) Assignee: **Applied Materials, Inc.**, Santa Clara, CA (US)

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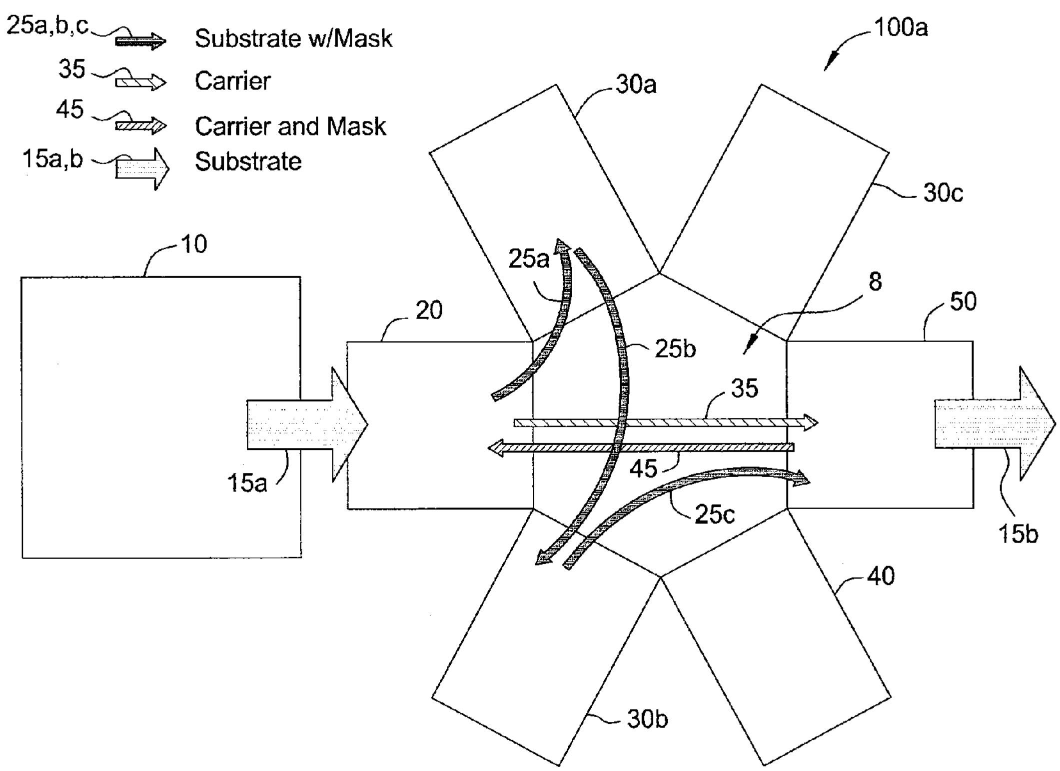
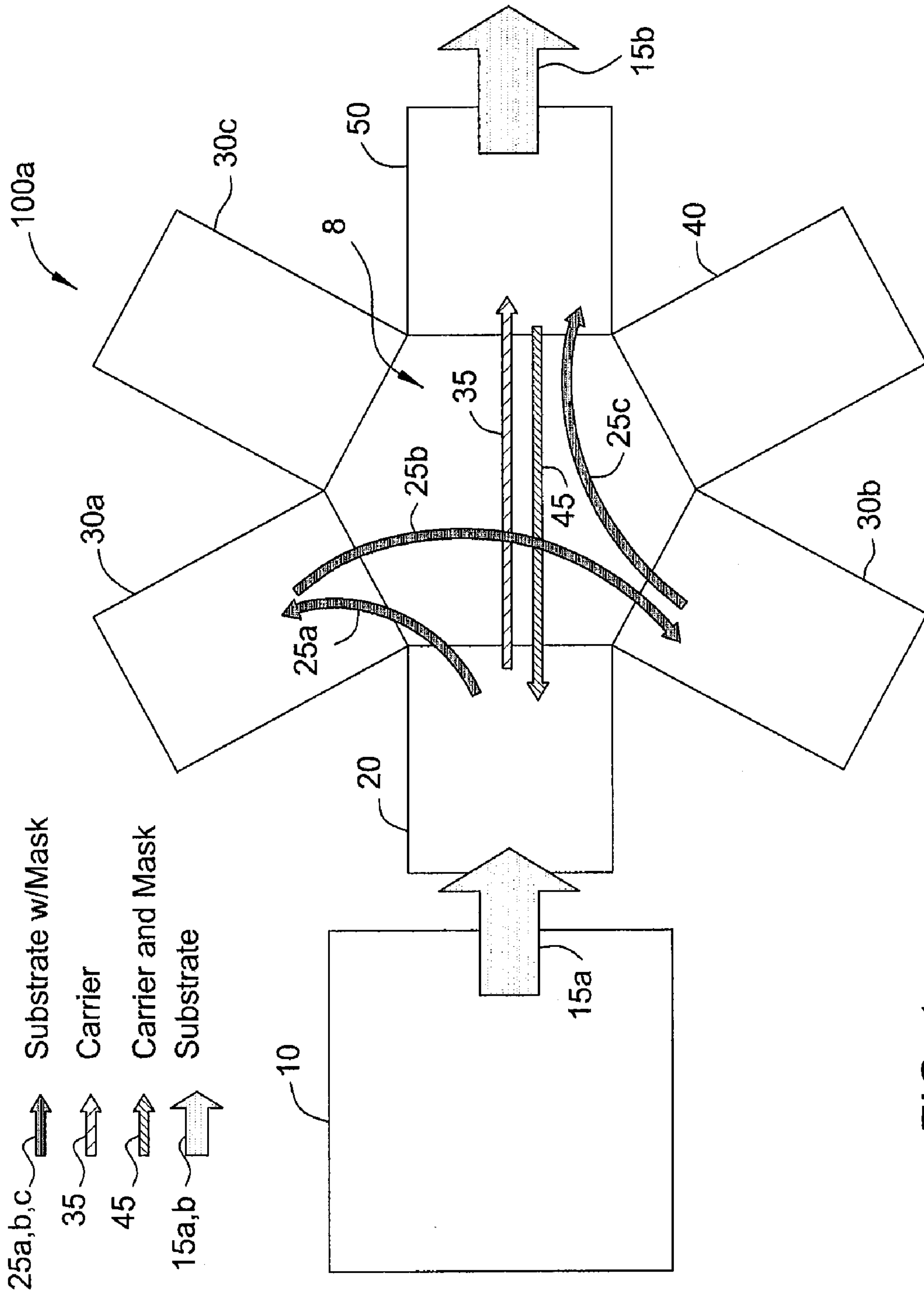
(57) **ABSTRACT**

A system for handling masked substrates comprising a chamber having a pedestal for supporting a substrate, and a chuck for supporting a mask in relation to a substrate. The system may include an alignment system operable to confirm alignment of the mask and the substrate. A method of positioning a mask on a substrate in a chamber comprises supporting the mask with a chuck disposed in the chamber and supporting the substrate with a pedestal disposed in the chamber. The method may further comprise aligning one or more reference points on the mask with one or more reference points on the substrate and positioning the mask on the substrate using at least one of the chuck and the pedestal.





25a,b,c
Substrate w/Mask
35
Carrier
45
Carrier and Mask
15a,b
Substrate
100a
10
15a
20
25a
25b
25c
30a
30b
30c
35
40
45
50
8
15b

FIG. 1

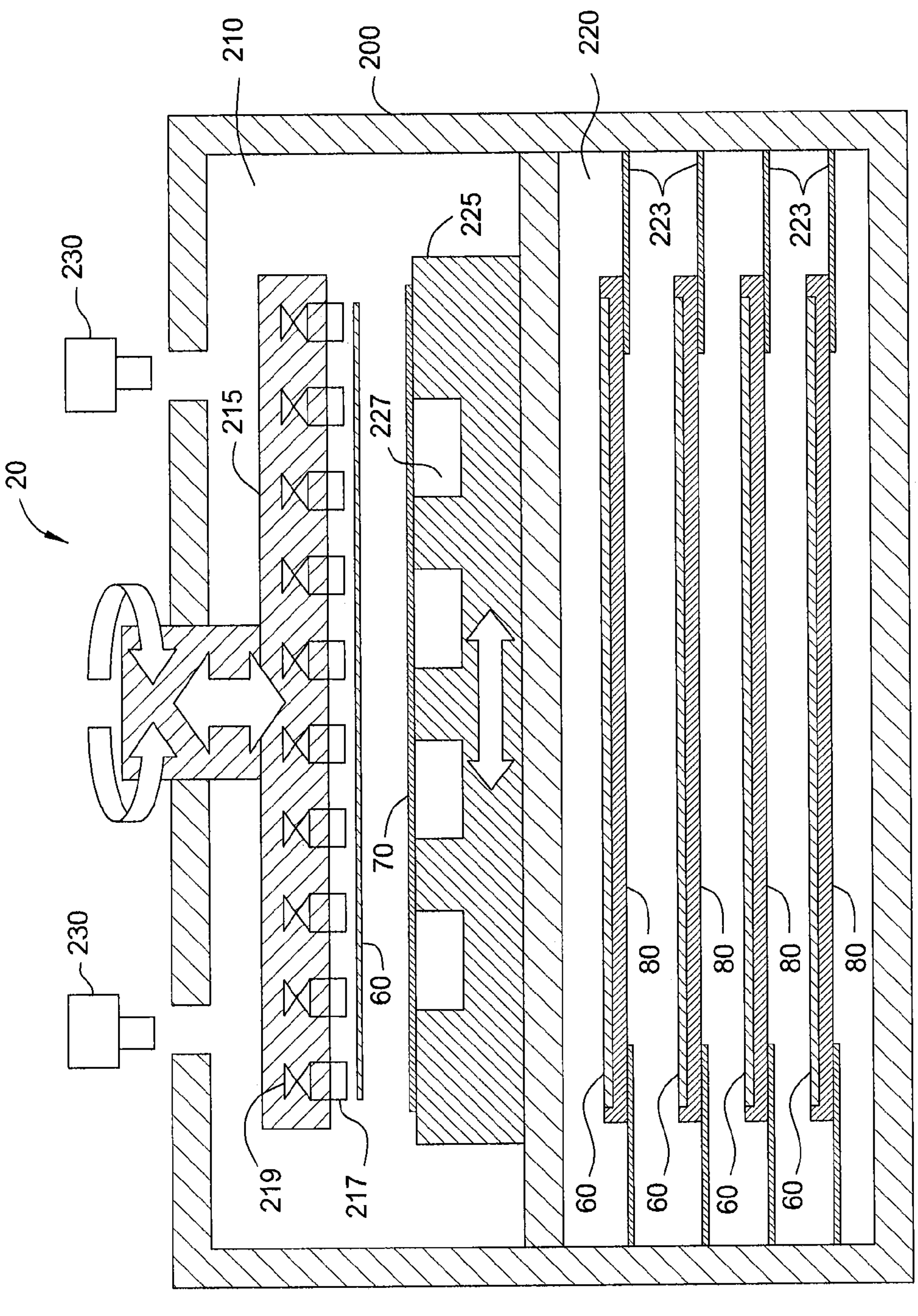
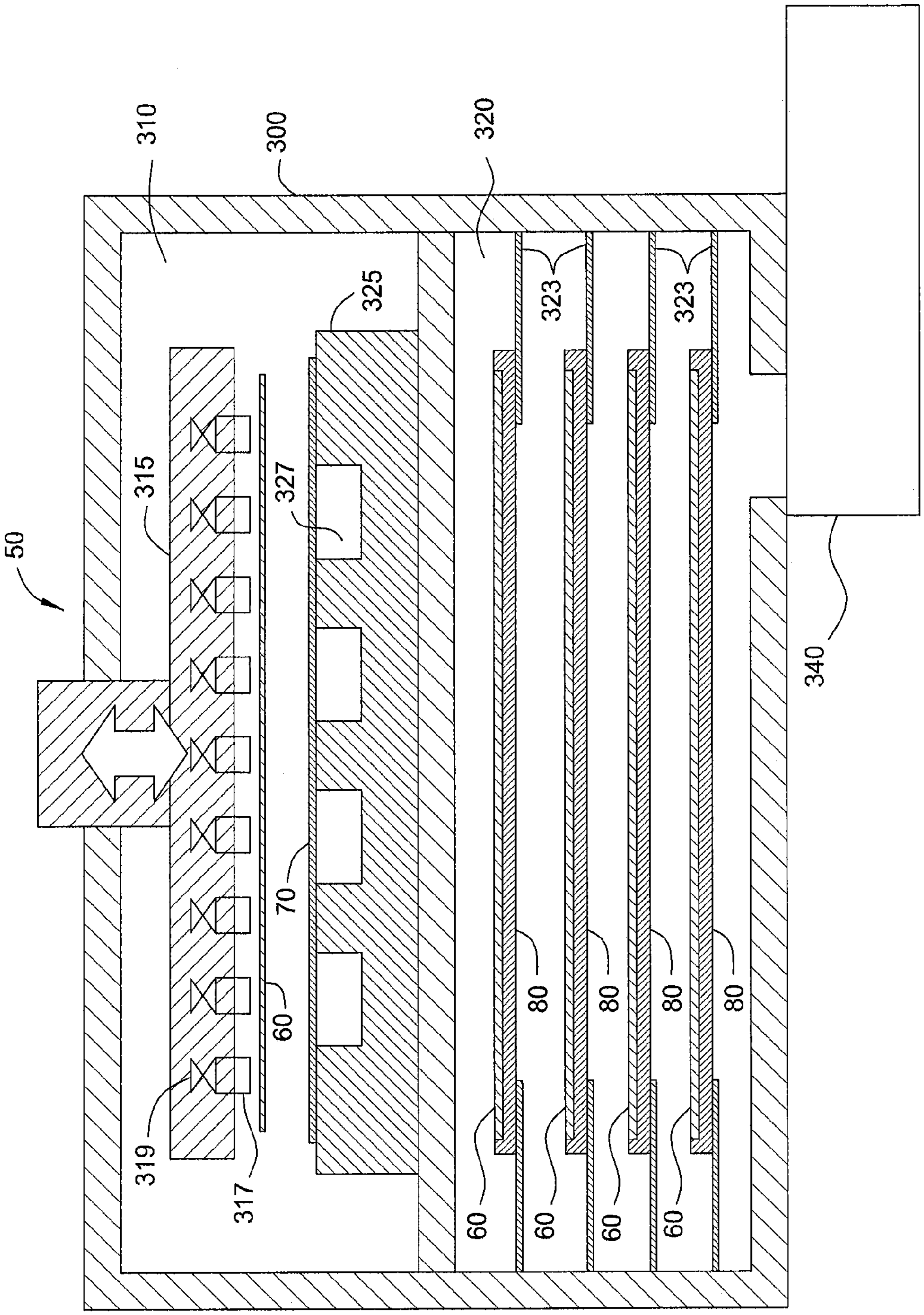


FIG. 2



50
310
300
320
323
323
325
315
327
70
60
80
80
80
80
319
317
60
60
60
60
340

FIG. 3

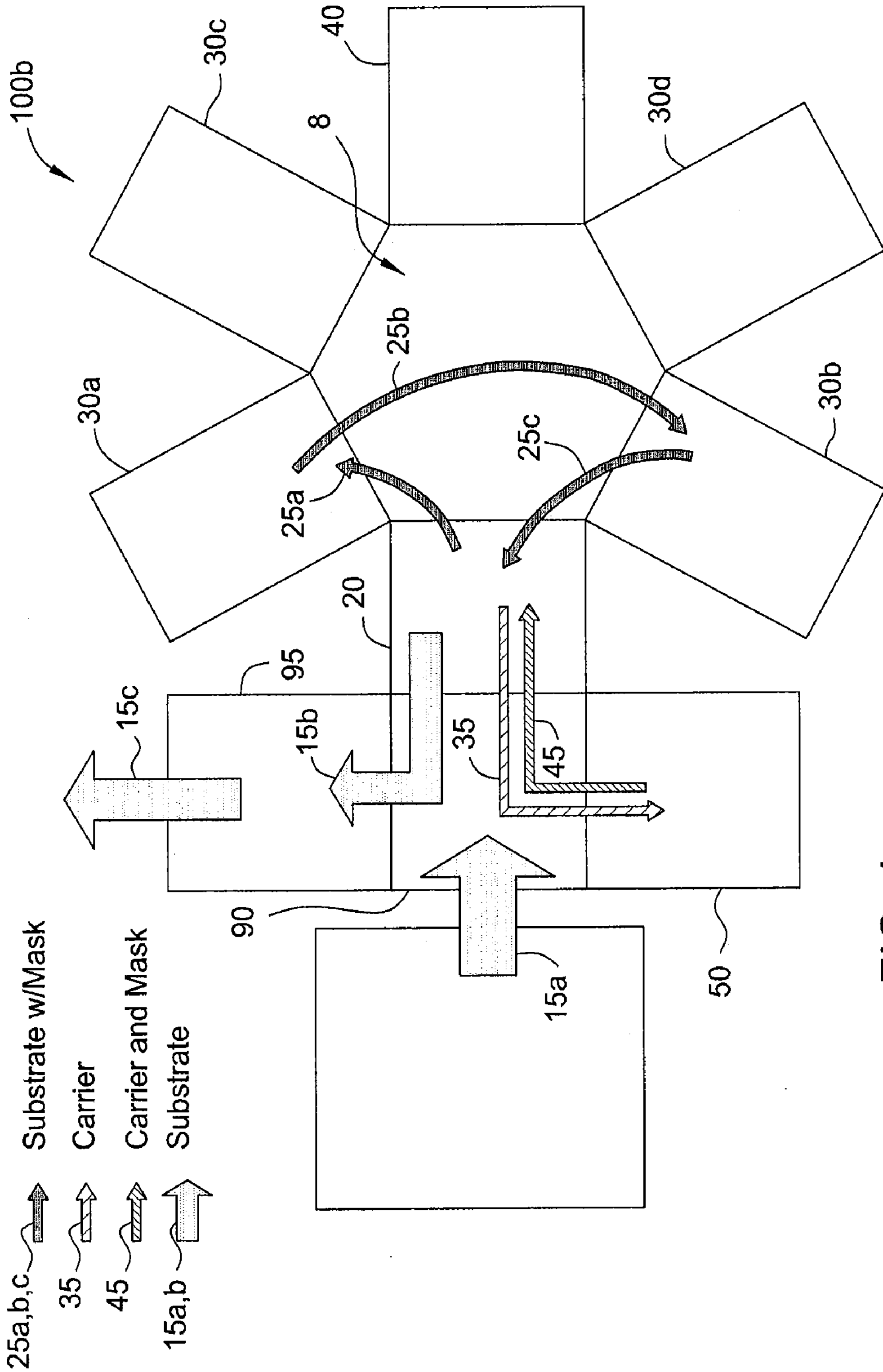

100b
30c
40
8
30d
25b
30a
30b
25c
25a
20
95
15c
15b
35
45
90
15a
50
25a,b,c Substrate w/Mask
35 Carrier
45 Carrier and Mask
15a,b Substrate

FIG. 4

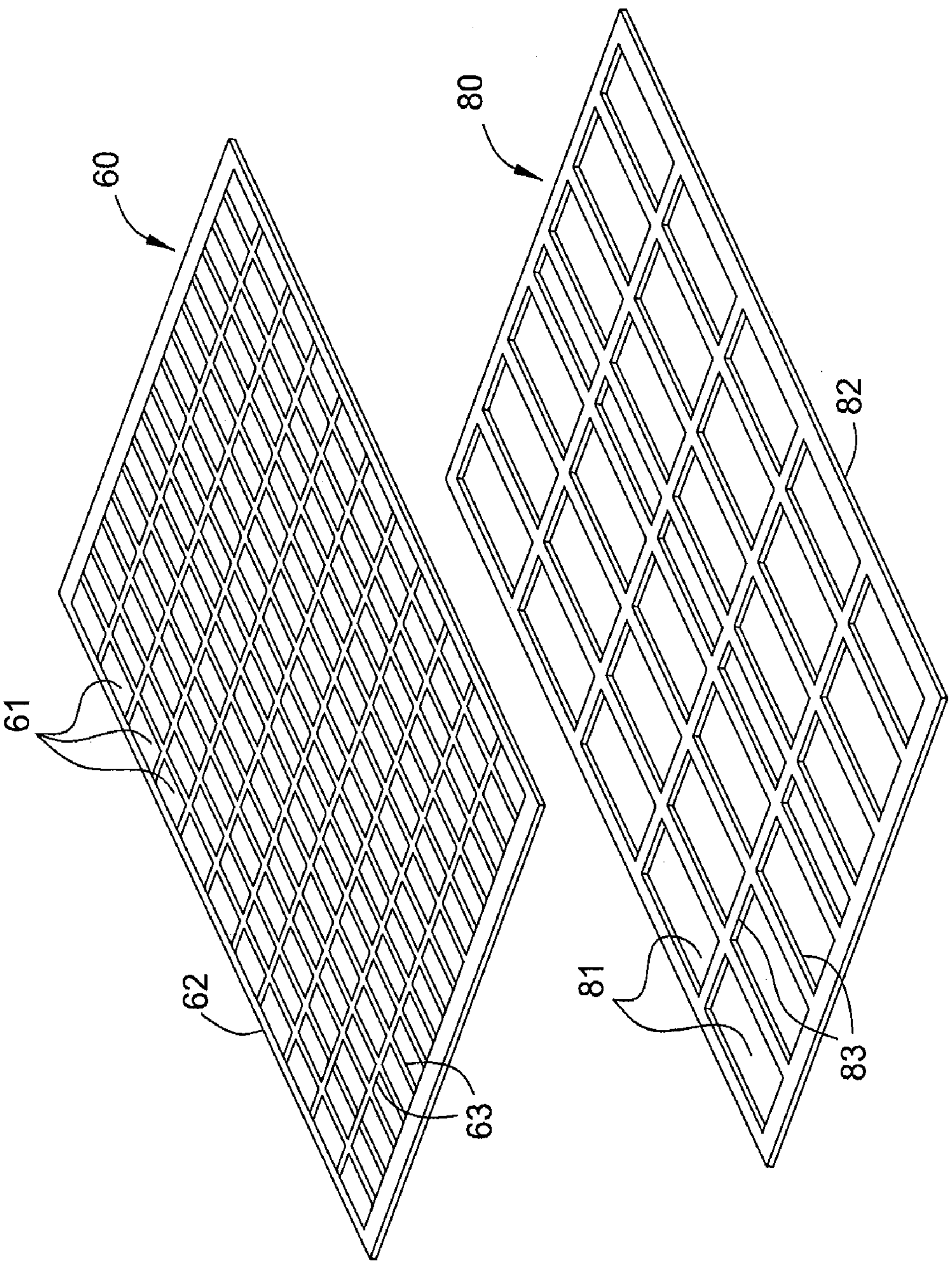


FIG. 5A

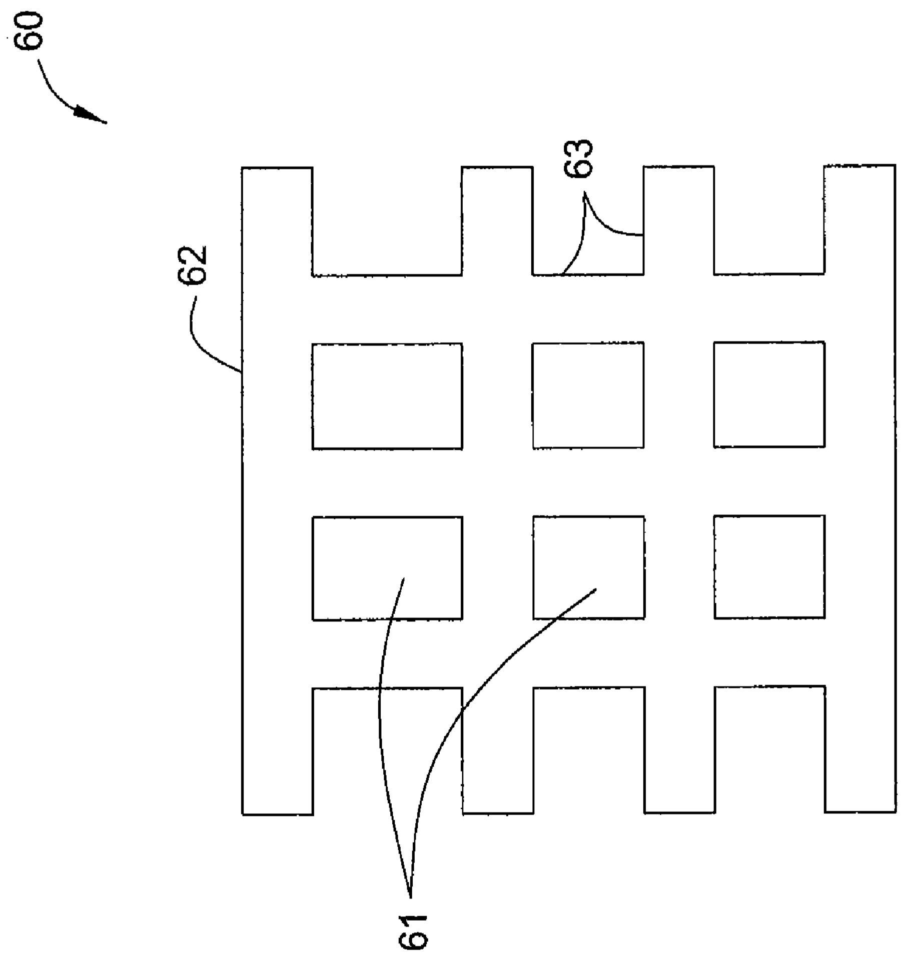


FIG. 5B

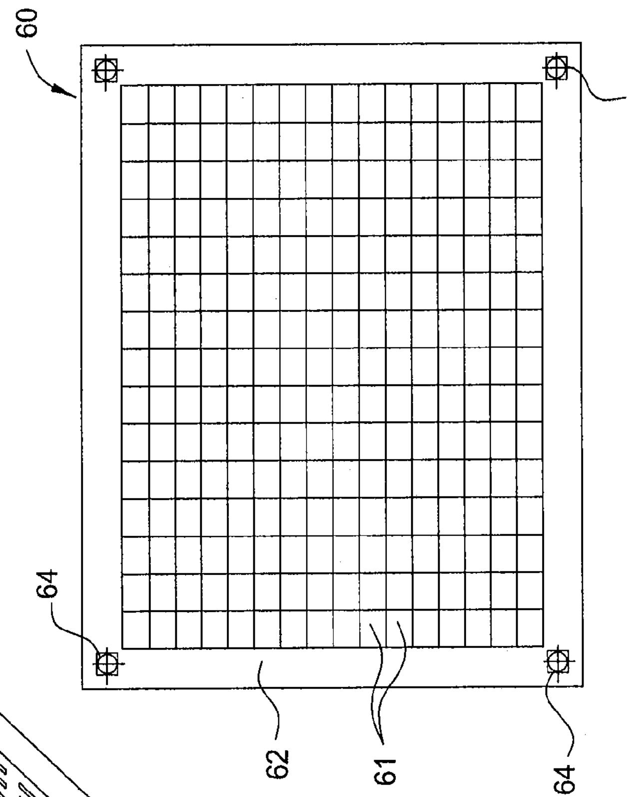


FIG. 6B

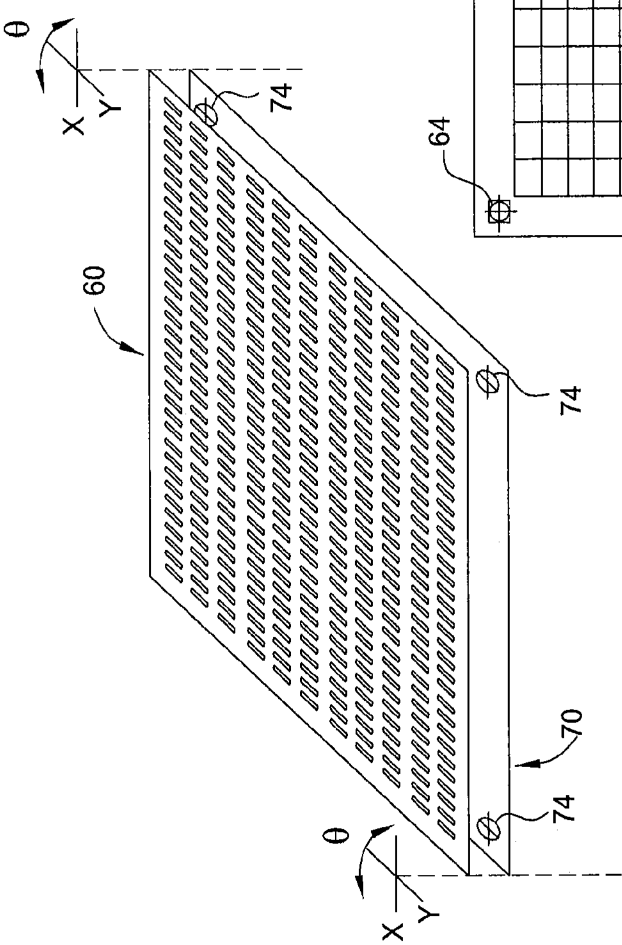


FIG. 6A

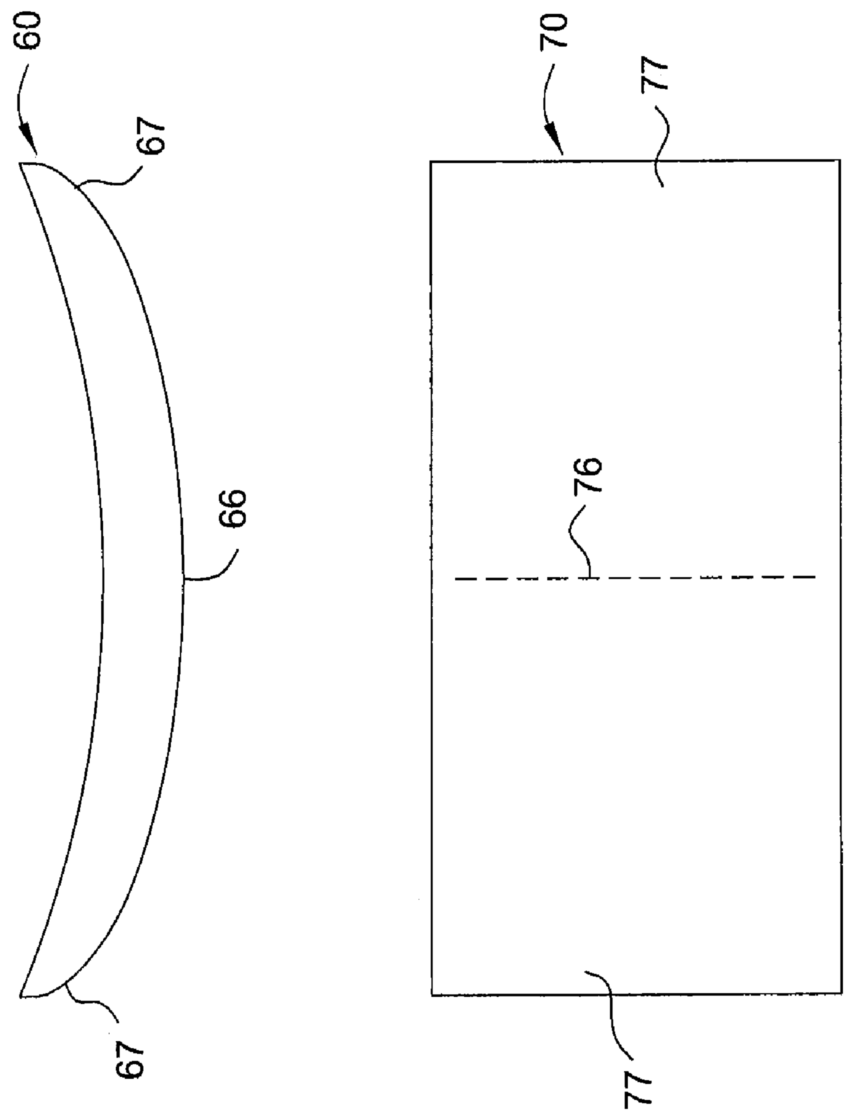


FIG. 7

IN-SITU MASK ALIGNMENT FOR DEPOSITION TOOLS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims benefit of U.S. Provisional Application Ser. No. 61/454,391, filed Mar. 18, 2011, the contents of which are herein incorporated by reference in their entirety.

BACKGROUND

[0002] 1. Field of the Invention

[0003] Embodiments of the invention relate to a substrate mask handling and processing system.

[0004] 2. Description of the Related Art

[0005] Organic light emitting diodes (OLED) are used in the manufacture of television screens, computer monitors, mobile phones, etc. for displaying information. A typical OLED may include layers of organic material situated between two electrodes that are all deposited on a substrate in a manner to form a matrix display panel having individually energizable pixels. The OLED is generally placed between two glass panels, and the edges of the glass panels are sealed to encapsulate the OLED therein.

[0006] There are many challenges encountered in the manufacture of such display devices. In one example, there are numerous labor intensive steps necessary to encapsulate the OLED between the two glass panels to prevent possible contamination of the device. In another example, different sizes of display screens and thus glass panels may require substantial reconfiguration of the process and process hardware used to form the display devices.

[0007] Therefore, there is a continuous need for new and improved apparatus and methods for forming OLED display devices.

SUMMARY

[0008] In one embodiment, a system for handling masked substrates comprises a chamber having a pedestal for supporting a substrate, and a chuck for supporting a mask in relation to a substrate; and an alignment system operable to confirm alignment of the mask and the substrate.

[0009] In one embodiment, a method of positioning a mask on a substrate in a chamber comprises supporting the mask with a chuck disposed in the chamber; supporting the substrate with a pedestal disposed in the chamber; aligning one or more reference points on the mask with one or more reference points on the substrate; and positioning the mask on the substrate using at least one of the chuck and the pedestal.

[0010] In one embodiment, a method of handling a mask and a substrate comprises positioning the mask on the substrate in a first chamber; processing the substrate while the mask is positioned on the substrate in a second chamber; removing the mask from the substrate after processing the substrate in a third chamber; positioning the mask on a carrier in the third chamber; and cleaning the mask on the carrier in a fourth chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] So that the manner in which the above recited features can be understood in detail, a more particular description of embodiments of the invention, briefly summarized above, may be had by reference to the embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

[0012] FIG. **1** illustrates a system for forming OLED devices according to one embodiment.

[0013] FIG. **2** illustrates a chamber of the system according to one embodiment.

[0014] FIG. **3** illustrates another chamber of the system according to one embodiment.

[0015] FIG. **4** illustrates another system for forming OLED devices according to one embodiment.

[0016] FIG. **5**A illustrates a mask and a carrier according to one embodiment.

[0017] FIG. **5**B illustrates a mask according to one embodiment.

[0018] FIG. **6**A illustrates a mask and a substrate according to one embodiment.

[0019] FIG. **6**B illustrates a mask according to one embodiment.

[0020] FIG. **7** illustrates a mask and a substrate according to one embodiment.

DETAILED DESCRIPTION

[0021] Embodiments of the invention may include a process of forming an OLED device, and in particular a process of using chemical vapor deposition to encapsulate an OLED-based substrate. The process may include accurately aligning and positioning a mask on the substrate to mask certain areas of the substrate while enabling access to the exposed or unmasked regions of the substrate, performing a process to effect a change at the exposed surfaces of the substrate, for example deposition of a material thereon by chemical vapor deposition and/or physical vapor deposition, and thereafter separating the mask and the processed substrate. The mask may be supported on a carrier when removed from the substrate. The substrate may then be further processed and/or separated into individual devices to form one or more OLED devices.

[0022] FIG. **1** illustrates a system **100***a* for forming an OLED device according to one embodiment. The system **100***a* may include a deposition chamber **10**, an alignment chamber **20**, encapsulation chambers **30***a*, **30***b*, **30***c*, an optional chamber **40**, and a removal chamber **50** all clustered around, and selectively vacuum isolated with respect to, a transfer chamber **8**. In this embodiment, the deposition chamber **10** may be configured to create one or more OLED devices on a substrate, and the substrate, with one or more devices thereon, may then be transported via the transfer chamber to one or more additional chamber locations for processing. Deposition chamber **10** may be, for example, a single deposition chamber coupled to a transfer chamber, a final process region, or a process chamber, in an in-line deposition tool wherein an OLED device is fabricated on the substrate, a plurality of in-line deposition chambers coupled to a separate transfer chamber at the end thereof distal from the alignment chamber **20** and/or the transfer chamber **8**, a device isolation chamber, such as an etch or laser isolation chamber wherein individual OLED devices are physically isolated from one another in-situ on the substrate, or a substrate loading station, wherein substrates having an OLED device fabricated thereon in a tool(s) which are not physically attached to the alignment chamber **20** and/or the transfer chamber **8** may be loaded for encapsulation processing using the system **100***a*.

[0023] In one embodiment, the substrate may be a glass substrate with an OLED formed or positioned on the glass substrate. The alignment chamber **20** may be configured to align and position a mask on the substrate. The mask is used as a partition to divide the substrate into one or more sections during processing. The mask is supported on a carrier when it is removed from the substrate. The encapsulation chambers **30***a*, **30***b*, **30***c* may be configured to encapsulate (via chemical vapor deposition for example) portions of the substrate that are exposed through the mask. The optional chamber **40** also may be configured as an encapsulation chamber, or may be used as a storage and/or cleaning chamber to store and clean the masks. Finally, the removal chamber **50** may be configured to physically remove the mask from the encapsulated substrate so that the mask can be reused for further encapsulation processes. The encapsulated or processed substrate may be removed from the system **100***a* through the removal chamber **50** for further processing with one or more other systems.

[0024] The reference arrows identified with reference numerals **15***a*, **15***b*, **25***a*, **25***b*, **25***c*, **35**, **45** generally illustrate the relative travel paths of the substrate, mask, and carrier throughout a process of use with the system **100***a* according to one embodiment. The system **100***a* may be configured with one or more robotic arms or other similar handling mechanisms located in and extendable from transfer chamber **8** for moving the substrate, mask, and mask carrier between the chambers of the system **100***a*. An OLED initially may be created in the deposition chamber **10** on a substrate. The substrate may then be moved into the alignment chamber **20** as illustrated by reference arrow **15***a*. Prior to introduction of the substrate into the alignment chamber **20**, a mask and a carrier that supports the mask are moved into the alignment chamber **20**, as illustrated by reference arrow **45** for example. The mask and carrier may be stored in and retrieved from a storage compartment of the alignment chamber **20** or the removal chamber **50** (each of which are further described below with respect to FIGS. **2** and **3**, respectively). Once positioned in the alignment chamber **20**, the mask is removed from the carrier via a chuck or other similar handling mechanism, and the carrier is returned to and stored in the storage compartment of the alignment chamber **20** or the removal chamber **50** as illustrated by reference arrow **35**. In one embodiment, the substrate may be moved into the alignment chamber **20** prior to the mask and the carrier being moved therein.

[0025] After the substrate is located within the alignment chamber **20**, the mask may be accurately aligned over the substrate and positioned on top of the substrate using an alignment mechanism in combination with the chuck or other handling mechanism. The masked substrate may then be moved to one or more of the encapsulation chambers **30***a*, **30***b*, **30***c* and/or the optional chamber **40** to encapsulate the substrate via one or more processes. As illustrated, the masked substrate first is moved from the alignment chamber **20** to the encapsulation chamber **30***a*, indicated by reference arrow **25***a*, and then from the encapsulation chamber **30***a* to the encapsulation chamber **30***b* indicated by reference arrow **25***b*. Subsequently, the masked substrate is moved from the encapsulation chamber **30***b* to the removal chamber **50** indicated by reference arrow **25***c*. When in the removal chamber **50**, the mask may be removed from the substrate via a chuck or other handling mechanism, and the substrate may be removed from the removal chamber **50** as illustrated by reference arrow **15***b*. While the mask is being supported in the removal chamber **50**, a carrier may be moved into the removal chamber **50** and the mask may be aligned and positioned on the carrier. The mask and the carrier may be stored and/or cleaned in a storage/cleaning chamber of the removal chamber **50** for use with another substrate encapsulation process. In one embodiment, the removal chamber **50** may be configured as another encapsulation chamber, and the processed substrate may be removed through the deposition chamber **10** via the alignment chamber **20**. In one embodiment, one or more substrates, masks, and carriers may be used concurrently with the system **100***a* to process multiple substrates.

[0026] FIG. **2** illustrates an alignment chamber **20** of the system **100***a* according to one embodiment. The alignment chamber **20** includes a chamber body **200** that is divided into an upper chamber **210** and a lower chamber **220**. The lower chamber **220** may be used to store one or more masks **60** supported on one or more carriers **80**. The masks **60** and carriers **80** may be stored on one or more support members **223** in the form of opposed truncated shelves. In one embodiment, the lower chamber **220** may include any number of support members **223** to support four, six, or more masks **60** and carriers **80**. While stored in the lower chamber **220**, the masks **60** and the carriers **80** may be cleaned for use in subsequent substrate deposition processes. At least one mask **60** that is supported by at least one carrier **80** may be moved from the lower chamber **220** to the upper chamber **210** via a robotic arm or other handling mechanism for further processing as described above with respect to FIG. **1**. In one embodiment, the upper chamber **210** may include one or more openings or doors in communication with the deposition chamber **10** for receiving substrates. The upper chamber **210** may also include one or more openings or doors in communication with the transfer chamber **8** from which the robotic arm or other handling mechanism may introduce the mask and carrier and/or may retrieve the masked substrates and carriers. In one embodiment, the lower chamber **220** may also include one or more openings or doors in communication with the transfer chamber **8** from which the robotic arm or other handling mechanism may introduce and retrieve the masks and/or carriers. In one embodiment, the robotic arm or other handling mechanism may be moveable in both the vertical and horizontal directions to move the substrates, masks, and/or carriers between the upper and lower chambers **210**, **220** of alignment chamber **20**, as well as the other chambers **30***a*, **30***b*, **30***c*, **40**, **50**.

[0027] The lower chamber **220** may be configured to store and/or clean the masks, which may have been used in multiple deposition processes. The lower chamber **220** may also provide a mechanism of mask change caused by product change or damaged/end of life masks without impacting throughput of the system **100***a*. For example, different types and/or sizes of masks may be used with the system **100***a* to accommodate different types and/or sizes of substrates and/or deposition processes.

[0028] The upper chamber **210** may be configured with a pedestal **225** for supporting both carriers **80** (and masks **60**) and as illustrated substrates **70**. In one embodiment, the pedestal **225** may be provided with linear or axial motion capabilities (e.g. up to 3 degrees of freedom including x and y axial movement to aid in alignment of the mask with the substrate, and z-motion for interaction with a robot for placing and removing substrates with respect thereto). The pedestal **225** may be configured with permanent magnets and/or electromagnets. The pedestal **225** may further include one or more pockets **227** into which end effectors of a robot arm may be moved to locate the carriers **80** and the substrates **70** onto the pedestal **225**. In this manner, the pedestal **225** may be operable to support the substrates **70** while the masks **60** are positioned on the substrates **70**, and may be operable to support the carriers **80** while the masks **60** are removed from the carriers **80**.

[0029] The upper chamber **210** is configured with a chuck **215** for supporting the masks **60** for removal and placement of the masks on the substrates. In one embodiment, the chuck **215** may be an electromagnetic chuck and/or vacuum chuck with rotational and linear or axial motion capabilities (e.g. up to 3 degrees of freedom including x, y, z axial movement). The chuck **215** may further include one or more electromagnets **217**, or alternatively one or more vacuum cups, that are configured to engage and lift the mask **60** from the carrier **80** for example. The surfaces of the vacuum cups or electromagnets **217** that contact the mask **60** may be coated with a soft material, such as polytetrafluoroethylene or Teflon, to minimize potential damage to the mask **60**, such as to prevent surface abrasion of the mask **60**. The vacuum cups or electromagnets **217** may also be biased by one or more springs **219** to provide a range of compliancy between the vacuum cups or electromagnets **217** and the masks **60** to further minimize potential damage to the masks **60** when initially engaging the masks **60** from above. In one embodiment, the chuck **215** may be configured to generate a pressure differential sufficient to engage and lift the mask **60** from the carrier **80**. In one embodiment, the chuck **215** may include an array of strips of magnetic material that are electrically magnetized to lift the mask **60** from the carrier **80**. In one embodiment, the chuck **215** may include an array of strips with a series of vacuum suction holes to lift the mask **60** from the carrier **80**. In this manner, the chuck **215** may be operable to lift the mask **60** from the carrier **80**, hold the mask **60** while the carrier **80** is removed and the substrate **70** is introduced into the upper chamber **210**, and lower the mask **60** onto the substrate **70**, and/or perform this sequence to remove the mask **60** from the substrate **70** if necessary.

[0030] The alignment chamber **20** further may be configured with an alignment system **230** to assist with the alignment of the mask **60** and the substrate **70**. In one embodiment, the alignment system **230** may include a vision system having one or more cameras to provide a visual indication of the alignment between the mask **60** and the substrate **70**. In one embodiment, the masks **60** and the substrates **70** may include one or more alignment or reference points (as shown in FIGS. **6**A and **6**B) to facilitate accurate alignment of the mask **60** on the substrate **70**. In one embodiment, the cameras of the alignment system **230** may be used to provide a visual indication and confirmation if and when the reference points on the masks **60** and the substrates **70** are aligned. When the respective mask **60** and substrate **70** are aligned, the chuck **215** may lower the mask **60** onto the substrate **70**. Using the reference points, the alignment system **230**, and the motion capabilities of the chuck **215** and/or the pedestal **225**, the masks **60** may be accurately aligned and positioned on the substrates **70**. In one embodiment, the masks **60** may be aligned relative to the substrates **70** within about a 100 μm range of accuracy. The masked substrate **70** may then be moved to one or more encapsulation chambers **30***a*, **30***b*, **30***c* for further processing as described above with respect to FIG. **1**. In one embodiment, the alignment chamber **20** may also be configured as a deposition chamber, such as deposition chamber **10** and/or encapsulation chambers **30***a*, **30***b*, **30***c*, for performing one or more deposition processes on the masked substrate in addition to the alignment process.

[0031] In one embodiment, aligning the mask relative to the substrate may be accomplished using one or more (multiple) cameras of the alignment system **230**. In one embodiment, at least three cameras may be used. The reference points on the mask and substrate may be marked with mating alignment marks. The mask may be moved into the alignment chamber **20** and lifted by the chuck **215**, the carrier may be removed, and then a substrate may be moved into the alignment chamber **20**. In one embodiment, the substrate may first be moved into the alignment chamber **20** and positioned on the pedestal **225**, and then a mask on a carrier may be moved into the alignment chamber **20** so that the chuck **215** may lift the mask from the carrier while being supported by the robotic arm or other handling mechanism. The cameras may optically locate the reference points on the mask and/or the substrate. The alignment system **230** may accurately calculate the position and/or differences in the reference point positions on the mask and/or the substrate in relation to a fixed coordinate system. The positions and/or differences in positions of the mask and the substrate may be compared and analyzed to then communicate directional coordinates to the chuck **215** and/or pedestal **225**. Based on the direction from the alignment system **230**, the chuck **215** and/or pedestal **225** may be operated manually, remotely, and/or automatically to move the mask and/or the substrate to match and align the reference points. In one embodiment, the pedestal **225** may move the substrate in the x-plane, the y-plane, and rotationally within the x-y plane to align the substrate with the mask. In one embodiment, the chuck **215** may move the mask in the x-plane, the y-plane, and rotationally within the x-y plane to align the mask with the substrate. Both the substrate and the mask can be moved for alignment. The mask and/or substrate may then be moved closer to each other in the z-plane via the chuck **215** and/or pedestal **225**, and the alignment system **230** may validate the alignment between the reference points prior to placing the mask on the substrate.

[0032] FIG. **3** illustrates a removal chamber **50** of the system **100***a* according to one embodiment. The removal chamber **50** may be substantially similar to the alignment chamber **20**. The similar features are identified with the same reference numerals except having a "300" series designation, such as the body **300**, the springs **319**, and the pockets **327** for example. The embodiments of the alignment chamber **20** may be used with the embodiments of the removal chamber **50** and vice versa. As illustrated, the chuck **315** may be operable to remove the mask **60** from the substrate **70**, and may be operable to position the mask **60** on a carrier **80**, the carrier **80** being placed under the mask **60** by the robot when the mask **60** has been lifted and secured from the substrate **70**. In one embodiment, the pedestal **325** may be fixed (non-movable), and the chuck **315** may be movable in the vertical direction. In this embodiment, if the substrate **70** is to be left on the pedestal **325**, the robot may have vertical or z-axis motion capability. A cleaning system **340** may be coupled to or in communication with the lower chamber **320** where the masks **60** supported on the carriers **80** are stored. While stored in the lower chamber **320**, the cleaning system **340** may be activated to clean the masks **60** and the carriers **80** for use in subsequent substrate deposition processes. In one embodiment, the cleaning system may include a remote plasma source chamber, a gas panel, a pump, and/or other components for cleaning the masks **60** and carriers **80**. In one embodiment, the upper and lower chambers **310**, **320** may each include one or more openings or doors in communication with the transfer chamber **8** from which the robotic arm or other handling mechanism may introduce and retrieve the substrates, masks, and/or mask carriers. In one embodiment, the upper chamber **310** may also include one or more openings or doors opposite the transfer chamber **8** from which the substrates may be removed from the system **100***a*. In one embodiment, the robotic arm or other handling mechanism may be moveable in both the vertical and horizontal directions to move the substrates, masks, and/or carriers between the upper and lower chambers **310**, **320** of removal chamber **50**, as well as the other chambers **20**, **30***a*, **30***b*, **30***c*, **40**.

[0033] FIG. **4** illustrates a system **100***b* for forming an OLED device according to one embodiment. The system **100***b* may be substantially similar to the system **100***a*. The similar features are identified with the same reference numerals. The embodiments of the system **100***b* may be used with the embodiments of the system **100***a* and vice versa. In one embodiment, one or more of the processes described herein with respect to the systems **100***a* and **100***b* may be repeated and/or performed in any order.

[0034] The system **100***b* may include a deposition chamber **10**, a pass-thru chamber **90**, an alignment chamber **20**, encapsulation chambers **30***a*, **30***b*, **30***c*, **30***d*, an optional chamber **40**, a removal chamber **50**, and an exit chamber **95**. In one embodiment, the deposition chamber **10**, the alignment chamber **20**, the encapsulation chambers **30***a*, **30***b*, **30***c*, the optional chamber **40**, and the removal chamber **50** may be the same chambers as described above with respect to the system **100***a*. The system **100***b* may further include an additional encapsulation chamber **30***d* similar to the encapsulation chambers **30***a*, **30***b*, **30***c*. The optional chamber **40** may be configured as an encapsulation chamber, may be used as a storage and/or cleaning chamber to store and clean the masks, or may be used as a removal chamber **50** to remove the masks **60** from the substrates **70** and allow removal of the substrates **70** from the system **100***b*. In one embodiment, with reference to FIG. **3**, the removal chamber **50** may be configured as a storage and cleaning chamber only, such that the chuck **315** and pedestal **325** are removed, and the upper chamber **310** includes one or more support members **323** in the form of truncated shelves for storing the masks **60** and carriers **80**, while the lower chamber **320** also includes one or more support members **323** in the form of truncated shelves with the cleaning system **340** operable to clean the masks **60** and carriers **80**. In one embodiment, the alignment chamber **20**, encapsulation chambers **30***a*, **30***b*, **30***c*, **30***d*, and optional chamber **40** are clustered around, and selectively vacuum isolated with respect to, a transfer chamber **8**. In one embodiment, the deposition chamber **10**, the alignment chamber **20**, the removal chamber **50**, and the exit chamber **95** are clustered around, and selectively vacuum isolated with respect to, the pass-thru chamber **90**. The reference arrows identified with reference numerals **15***a*, **15***b*, **15***c*, **25***a*, **25***b*, **25***c*, **35**, **45** generally illustrate the relative travel paths of the substrates, masks, and carriers throughout a process of use with the system **100***b* according to one embodiment. The system **100***b* may be configured with one or more robotic arms or other similar handling mechanisms located in and extendable from transfer chamber **8** for moving the substrates, masks, and mask carriers between the chambers of the system **100***b*. The system **100***b* may be configured with one or more robotic arms or other similar handling mechanisms located in and extendable from the pass-thru chamber **90** for moving the substrates, masks, and mask carriers between the chambers of the system **100***b*. An OLED initially may be created in the deposition chamber **10** on a substrate. The substrate may then be moved through the pass-thru chamber **90** and into the alignment chamber **20** as illustrated by reference arrow **15***a*. Prior to introduction of the substrate into the alignment chamber **20**, a mask and a carrier that supports the mask are moved into the alignment chamber **20**, as illustrated by reference arrow **45** for example. The mask and carrier may be stored in and retrieved from the removal chamber **50**. Once positioned in the alignment chamber **20**, the mask is removed from the carrier via a chuck or other similar handling mechanism (such as chucks **215**, **315** described above), and the carrier is returned to and stored in the removal chamber **50** as illustrated by reference arrow **35**.

[0035] After the substrate is located within the alignment chamber **20**, the mask may be accurately aligned over the substrate and positioned on top of the substrate using an alignment mechanism (such as alignment system **230** described above) in combination with the chuck or other handling mechanism. The masked substrate may then be moved to one or more of the encapsulation chambers **30***a*, **30***b*, **30***c*, **30***d* and/or the optional chamber **40** to encapsulate the substrate via one or more processes. As illustrated, the masked substrate first is moved from the alignment chamber **20** to the encapsulation chamber **30***a*, indicated by reference arrow **25***a*, and then from the encapsulation chamber **30***a* to the encapsulation chamber **30***b* indicated by reference arrow **25***b*. Subsequently, the masked substrate is moved from the encapsulation chamber **30***b* back to the alignment chamber **20** indicated by reference arrow **25***c*. When in the alignment chamber **20**, the mask may be removed from the substrate via the chuck or other handling mechanism, and the substrate may be removed from the alignment chamber **20** to the exit chamber **95** via the pass-thru chamber **90** as illustrated by reference arrow **15***b*. Once in the exit chamber **95**, the substrate may be removed from the system **100***b* as illustrated by reference arrow **15***c*. While the mask is being supported in the alignment chamber **20**, a carrier (from the removal chamber **50**) may be moved into the alignment chamber **20** and the mask may be aligned and positioned on the carrier. The mask and the carrier may be stored and/or cleaned in a storage/cleaning chamber of the removal chamber **50** for use with another substrate encapsulation process. In one embodiment, one or more substrates, masks, and carriers may be used concurrently with the system **100***b* to process multiple substrates. In one embodiment, the alignment chamber **20** may comprise an upper chamber (such as upper chamber **210**) only having one or more doors in communication with the pass-thru chamber **90** and one or more doors in communication with the transfer chamber **8** from which the robotic arms or other handling mechanisms may introduce and remove the substrates, masks and/or carriers. In one embodiment, the removal chamber **50** may include upper and lower chambers (such as chambers **220**, **320**), and each chamber may have one or more doors in communication with the pass-thru chamber **90** from which the robotic arm or other handling mechanism may introduce and retrieve the masks and/or carriers. In one embodiment, the exit chamber **95** may include only one chamber having one or more doors in communication with the pass-thru chamber **90** from which the robotic arm or other handling mechanism may introduce substrates, and one or more doors opposite the pass-thru chamber **90** to remove the substrates from the system **100***b*. In one embodiment, the robotic arms or other handling mechanisms may be moveable in both the vertical and horizontal directions to move the substrates, masks, and/or carriers between the chambers of the system **100***b*. In one embodiment, to ensure the accuracy of mask alignment, magnetic forces can be used to hold the masks and substrates together. This can be achieved using permanent and/or electromagnets on the pedestals **225**, **325**, as well as the robotic arms.

[0036] In one embodiment, a single mask may be re-used one or more times on different substrates for encapsulation processing without having to be cleaned after each process. In this manner, while the mask is being supported in the alignment chamber **20**, rather than a carrier (from the removal chamber **50**) being brought into the alignment chamber **20** to remove the mask, another substrate (from the deposition chamber **10**) may be moved into the alignment chamber **20** and the mask may be accurately aligned and positioned on the substrate. The newly masked substrate may then be move through one or more of the encapsulation chambers **30***a*, **30***b*, **30***c*, **30***d* and/or optional chamber **40** as described above.

[0037] In one embodiment, the masks **60** and/or carriers **80** may be cleaned within the encapsulation chambers **30***a*, **30***b*, **30***c*, **30***d* (and optional chamber **40** when used for deposition processing) simultaneously when the chambers themselves are cleaned after each deposition process. The chambers may include conventional "shadow frame" or truncated shelves upon which the carriers **80** and masks **60** may be positioned during the cleaning of the chambers. This dual cleaning option provides a significant advantage in that two cleaning processes can be achieved in one step and in particular one chamber.

[0038] In one embodiment, the encapsulation chambers may be processing chambers for performing various deposition processes on the substrate. In one embodiment, any one of the chambers described herein may include openings or doors, preferably valved, on opposite sides of the chamber body to allow substrates, masks, and/or carriers to be moved into the chamber from a first side and removed from the chamber on a second opposite side. In one embodiment, any one of the chambers described herein may be operable similar to conventional load lock chambers to introduce and remove substrates, masks, and/or carriers into and from the chambers under pressure controlled, vacuum environments to prevent contamination of the substrates, masks, carriers, and/or chambers. In one embodiment, any type of handling mechanisms, such as a vacuum robot for example, may be used to move the substrates, masks, and/or carriers into and out of the chambers under pressure controlled, vacuum environments to prevent contamination of the substrates, masks, carriers, and/or chambers.

[0039] In one embodiment, the systems **100***a* and/or **100***b* may be configured to process and output about 1 to about 10 substrates per hour, about 10 to about 20 substrates per hour, about 20 to about 40 substrates per hour, and about 40 to about 100 substrates per hour. The systems **100***a* and/or **100***b* provide the advantages of spatially compact systems for processing multiple OLED substrates using a mechanical mask. The systems **100***a* and/or **100***b* also provide the advantages of accurate alignment of masks on OLED substrates, as well as efficient handling, removing, storing, and cleaning of the masks in single compact processing systems.

[0040] FIGS. **5**A and **5**B illustrate embodiments of a mask **60** having a plurality of openings **61** formed by a plurality of longitudinal and cross members **63** and surrounded by a border **62**. In one embodiment, each mask **60** may include a "picture frame" type design such that the border **62** encloses the openings **61** and the longitudinal and cross members **63** on each side of the mask **60**, as illustrated in FIG. **5**A. In one embodiment, each mask **60** may include a "frame-less" type design such that the mask **60** includes a border **62** only at the side edges of the mask **60** and does not enclose the outermost openings **61** or the ends of the longitudinal or cross members **63** as illustrated in FIG. **5**B. The border **62** at the side edges of the mask **60** may be provided for engagement by the chucks **215**, **315**. The advantages of a "frame-less" type mask design include smaller mask sizes, less expensive masks, and a simpler construction that requires little or no welding. The systems **100***a*, **100***b* are operable with frame and/or frame-less type masks. In one embodiment, the masks **60** may be formed from a magnetic material. In one embodiment, the masks **60** may comprise thin sheets of a metallic material. In one embodiment, the masks **60** may be formed from a nickel steel alloy, such as an Invar material. The Invar material mask may be coated with another material to protect the Invar from corrosion during cleaning of the masks **60**. In one embodiment, the Invar material mask may be coated with a Teflon-type material to protect the Invar from corrosion during cleaning of the masks **60**. In one embodiment, the masks **60** may be formed from a material having similar thermal expansion properties of solid glass. Each mask **60** may be formed from a single piece of material or may be formed from multiple pieces of material that are joined together, such as by welding using stick, butt, tack or spot welding methods. In one embodiment, each mask **60** may be less than 1 mm in thickness. In one embodiment, each mask **60** may have a thickness of less than about 1 mm or about 0.5 mm. In one embodiment, each mask **60** may be greater than about 0.5 m in length by 0.5 m in width. In one embodiment, each opening **61** of the masks **60** may be about 3 inches in width by about 5 inches in height, but may be dependent on the final product dimensions. In one embodiment, each longitudinal and cross member **63** may be about 2 mm wide. In one embodiment, the border **62** may be about 15 mm wide. The masks **60** may be operable in temperatures up to 100 degrees Celsius. In one embodiment, the sizes and shapes of the masks may be dependent on the final product dimensions.

[0041] FIG. **5**A also illustrates one embodiment of a carrier **80** having a plurality of openings **81** formed by a plurality of longitudinal and cross members **83** that are surrounded by a border **82**. In one embodiment, the carrier **80** may be any type of support structure that can be used to support the masks **60**. In one embodiment, the carriers **80** may be formed from a non-magnetic material. In one embodiment, the carriers **80** may comprise thin sheets of a metallic material. In one embodiment, the carriers **80** may be formed from an aluminum alloy. Each carrier **80** may be formed from a single piece of material or may be formed from multiple pieces of material that are joined together, such as by welding. In one embodiment, each carrier **80** may be light weight but with sufficient stiffness (such as configured with longitudinal and cross members **83** or "ribs" to stiffen the carriers **80**) to support the masks **60**, and may be geometrically compatible with the chuck and pedestals described above.

[0042] FIGS. **6**A and **6**B illustrate a mask **60** and a substrate **70**, each having one or more reference points **64** and **74**, respectively. In one embodiment, the masks **60** and/or the substrates **70** each have at least three reference points **64**, **74**. The alignment system **230** illustrated in FIG. **2** having one or more cameras may be used to visually align reference points **64** on the mask **60** with the reference points **74** on the substrates **70** to ensure proper placement of the mask **60** on the substrate **70**.

[0043] FIG. **7** illustrates a process of positioning a mask **60** on a substrate **70** according to one embodiment. The mask **60** is shown in an exaggerated bent or curved position to illustrate that a center point **66** of the mask **60** may be arranged to contact a center point **76** on the substrate **70** prior to the edges **67** contacting the edges **77** of the substrate **70**. The portions of the mask **60** between the center point **66** and the edges **67** may push the air outward away from the center as the mask **60** begins to contact the substrate **70**. In this manner, any potential air pockets may be prevented from developing between the mask **60** and the substrate **70**, which may otherwise cause the mask **60** to move relative to the substrate **70** and thereby create a misalignment therebetween.

[0044] In one embodiment, the chuck **215**, **315** may include a non-planar contact surface (e.g. concave or convex surface) relative to the substrate **70** to facilitate positioning of the mask **60** on the substrate **70**. In one embodiment, the chuck **215**, **315** may include an inclined contact surface relative to the substrate **70** to facilitate positioning of the mask **60** on the substrate **70**. In one embodiment, the surface portions of the chuck **215**, **315** that engage the mask **60** may be formed with a curved (concave) surface to bend the mask **60** so that the center point **66** contacts the substrate **70** prior to the edges **67** contacting. In one embodiment, the electromagnets **217**, **317** of the chucks **215**, **315** that engage the mask **60** adjacent the center point **66** may be deactivated prior to the electromagnets **217**, **317** adjacent to the edges **67** to release the mask **60** so that the center point **66** contacts the substrate **70** prior to the edges **67** contacting. In one embodiment, the chucks **215**, **315** may be configured to position the mask **60** on the substrate **70** such that the edges **67** contact the substrate **70** prior to the center point **66**. In one embodiment, the chucks **215**, **315** may be configured to sequentially release the mask **60** starting from a specific point, such as at a corner or edge of the mask **60**, onto the substrate **70**. In one embodiment, the chucks **215**, **315** may be configured to remove the mask **60** from the substrate **70** in the same manner or in a reverse manner as when the mask **60** is initially positioned on the substrate **70**.

[0045] While the foregoing is directed to embodiments of the invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

1. A system for handling masked substrates, comprising:
a chamber having a pedestal for supporting a substrate, and a chuck for supporting a mask in relation to a substrate; and
an alignment system operable to confirm alignment of the mask and the substrate.

2. The system of claim **1**, wherein the alignment system is operable to detect one or more reference points on the substrate and on the mask, and calculate a position of the reference points relative to a fixed coordinate system to assist in alignment of the mask and the substrate to one another.

3. The system of claim **2**, wherein the alignment system is operable to communicate directional coordinates to at least one of the pedestal and the chuck, and wherein the at least one pedestal and chuck are operable to move the substrate, the mask, or both to align the reference points.

4. The system of claim **3**, wherein the alignment system includes at least three cameras for detecting at least three reference points on the substrate and the mask.

5. The system of claim **1**, wherein the chuck is an electromagnetic chuck having one or more electromagnets configured to move the mask with respect to a plane of the substrate, and wherein the surfaces of the electromagnets are coated with a soft material and the soft material selectively contacts the mask.

6. The system of claim **1**, wherein the chuck is a vacuum chuck having one or more vacuum cups configured move the mask with respect to a plane of the substrate, and wherein the surfaces of the vacuum cups are coated with a soft material and the soft material selectively contacts the mask.

7. The system of claim **1**, wherein the chamber comprises a body, an upper chamber, and a lower chamber, wherein the chuck and the pedestal are disposed in the upper chamber, and wherein the lower chamber comprises one or more support members for storing masks that are supported on carriers.

8. A method of positioning a mask on a substrate in a chamber, comprising:
supporting the mask with a chuck disposed in the chamber;
supporting the substrate with a pedestal disposed in the chamber;
aligning one or more reference points on the mask with one or more reference points on the substrate; and
positioning the mask on the substrate using at least one of the chuck and the pedestal.

9. The method of claim **8**, wherein the chuck is one of an electromagnetic chuck and a vacuum chuck, each having one or more engagement members operable to engage and support the mask, and wherein the surfaces of the engagement members that contact the mask are coated with a soft material.

10. The method of claim **9**, wherein the engagement members comprise at least one of electromagnets, electromagnetic strips, vacuum cups, and suction holes.

11. The method of claim **10**, further comprising positioning the mask on the substrate using the engagement members by placing a center portion of the mask into contact with the substrate prior to an outer portion of the mask.

12. The method of claim **11**, wherein the one of the electromagnetic chuck and the vacuum chuck includes a non-planar surface relative to a surface of the substrate that the mask is positioned on.

13. The method of claim **11**, further comprising releasing the center portion of the mask from one or more of the engagement members prior to releasing the outer portion.

14. The method of claim **8**, further comprising detecting the one or more reference points on the mask and the substrate using one or more cameras, calculating a position of the one or more reference points on the mask and the substrate relative to a fixed coordinate system to assist in aligning the mask and the substrate, and moving at least one of the mask with the chuck and the substrate with the pedestal to align the one or more reference points on the mask and the substrate.

15. The method of claim **8**, further comprising performing a deposition process on the substrate after positioning the mask on the substrate, and removing the mask from the substrate after performing the deposition process.

16. The method of claim **15**, further comprising moving the mask into the chamber on a carrier and then lifting the mask from the carrier using the chuck.

17. The method of claim **15**, further comprising positioning the mask on a carrier and moving the mask and the carrier to another chamber, and further comprising cleaning the mask and the carrier.

18. A method of handling a mask and a substrate, comprising:

positioning the mask on the substrate in a first chamber;

processing the substrate while the mask is positioned on the substrate in a second chamber;

removing the mask from the substrate after processing the substrate in a third chamber;

positioning the mask on a carrier in the third chamber; and

cleaning the mask on the carrier in a fourth chamber.

19. The method of claim **18**, wherein the first chamber and the fourth chamber are formed from a chamber body, such that the first chamber is an upper chamber of the chamber body and the fourth chamber is a lower chamber of the chamber body.

20. The method of claim **18**, wherein the third chamber and the fourth chamber are formed from a chamber body, such that the third chamber is an upper chamber of the chamber body and the fourth chamber is a lower chamber of the chamber body.

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