Title: SUBSTRATE HOLDER FOR FULL AREA PROCESSING, CARRIER AND METHOD OF PROCESSING SUBSTRATES

Abstract: An assembly configured for supporting a plurality of substrates in a carrier for processing in a vertical processing apparatus is described. The assembly includes at least one frame (102; 402, 404) having a frame orientation corresponding to the vertical orientation during substrate processing, and a plurality of recesses (110) in the at least one frame, wherein each recess is configured for receiving one substrate, wherein a substrate receiving surface (312) is provided within each of the plurality of recesses, and wherein the substrate receiving surface in each of the plurality of recesses is inclined with respect to the frame orientation by 3° to 14°.
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Embodiments of the present invention relate to substrate support assemblies, carriers for substrate support and methods of processing supported substrates. Particularly, they relate to substrate support assemblies for a plurality of substrates to be simultaneously processed in an almost vertical configuration. Specifically, they relate to an assembly configured for supporting a plurality of substrates in a carrier for processing in a vertical processing apparatus, a carrier for substrate processing in a vertical processing apparatus, an apparatus for processing a plurality of substrates, and method of processing a plurality of substrates supported in a carrier.

Several methods are known for depositing a material on a substrate. For instance, substrates may be coated by a physical vapor deposition (PVD) process, a chemical vapor deposition (CVD) process, a plasma enhanced chemical vapor deposition (PECVD) process, etc. Typically, the process is performed in a process apparatus or process chamber, where the substrate to be coated is located. A deposition material is provided in the apparatus. A plurality of materials, but also oxides, nitrides or carbides thereof may be used for deposition on a substrate.

Coated materials may be used in several applications and in several technical fields. For instance, an application lies in the field of microelectronics, such as generating semiconductor devices. Also, substrates for displays are often coated by a PVD process. Further applications include insulating panels, organic light emitting diode (OLED) panels, substrates with TFT, color filters or the like.

In coating processes or other deposition processes substrates it may be useful to support the substrates in a carrier. That is substrates can be loaded in the carrier and the
carrier is transported through the substrate processing apparatus or deposition apparatus for
depositing a layer or a stack of layers on the substrate. Thereby, carriers can be used for large
area substrates, i.e., substrates having a size of 1.4 m² or above and one or a few of the
substrates can be supported by the carrier during deposition. For example, this can be done
for substrate processing applications where substrates are processes for manufacturing a
device and the substrate is separated into smaller pieces corresponding to the device size after
processing of the substrate.

[0005] Yet, there are also substrate processing applications where the substrate or the
substrates are separated into smaller pieces (small substrates) corresponding to the size of the
device to be manufactured and the small substrates corresponding to the device size need to
be processed. For example, a layer or a stack of layers can be deposited on substrates with a
size of 1 m² or below. The deposition on the substrates having the size of the device is
beneficially still conducted on a large area scale, i.e., within a processing area corresponding
to a large area substrate, e.g., 1.2 m² or above. Thereby, a plurality of substrates can be
supported by a carrier. This can be particularly challenging for vertical substrate processing
where the carrier is transported through the processing apparatus in a vertical orientation.

[0006] In light of the above, an improved carrier configured for supporting a plurality of
substrates is desired.

SUMMARY OF THE INVENTION

[0007] In light of the above, an assembly configured for supporting a plurality of substrates
in a carrier for processing in a vertical processing apparatus according to independent claim 1,
a carrier for substrate processing in a vertical processing apparatus according to claim 7, an
apparatus for processing a plurality of substrates according to claim 10, and method of
processing a plurality of substrates supported in a carrier according to claim 12 are provided.
Further aspects, advantages, and features of the present invention are apparent from the
dependent claims, the description, and the accompanying drawings.

[0008] According to one embodiment, an assembly configured for supporting a plurality of
substrates in a carrier for processing in a vertical processing apparatus is provided. The
assembly includes at least one frame having a frame orientation corresponding to the vertical
orientation during substrate processing, and a plurality of recesses in the at least one frame, wherein each recess is configured for receiving one substrate, wherein a substrate receiving surface is provided within each of the plurality of recesses, and wherein the substrate receiving surface in each of the plurality of recesses is inclined with respect to the frame orientation by 3° to 14°.

[0009] According to another embodiment, a carrier for substrate processing in a vertical processing apparatus is provided. The carrier includes an assembly for supporting a plurality of substrates in a carrier for processing in a vertical processing apparatus. The assembly includes at least one frame having a frame orientation corresponding to the vertical orientation during substrate processing, and a plurality of recesses in the at least one frame, wherein each recess is configured for receiving one substrate, wherein a substrate receiving surface is provided within each of the plurality of recesses, and wherein the substrate receiving surface in each of the plurality of recesses is inclined with respect to the frame orientation by 3° to 14°.

[0010] According to another embodiment, an apparatus for processing a plurality of substrates is provided. The apparatus includes a chamber adapted for layer deposition therein, and a carrier having a support assembly. The assembly includes at least one frame having a frame orientation corresponding to the vertical orientation during substrate processing, and a plurality of recesses in the at least one frame, wherein each recess is configured for receiving one substrate, wherein a substrate receiving surface is provided within each of the plurality of recesses, and wherein the substrate receiving surface in each of the plurality of recesses is inclined with respect to the frame orientation by 3° to 14°.

[0011] According to a further embodiment, a method of processing a plurality of substrates supported in a carrier is provided. The method includes loading the plurality of substrates in the carrier, wherein each of the plurality of substrates is inclined with respect to the carrier by 3° to 14°; and processing the plurality of substrates while the carrier is oriented vertically.

[0012] Embodiments are also directed to apparatuses for carrying out the disclosed methods and including apparatus parts for performing described method steps. Furthermore, embodiments are also directed to methods by which the described apparatus operates or by which the described apparatus is manufactured. It may include method steps for carrying out functions of the apparatus or manufacturing parts of the apparatus. The method steps may be
performed by way of hardware components, firmware, software, a computer programmed by appropriate software, by any combination thereof or in any other manner.

**BRIEF DESCRIPTION OF THE DRAWINGS**

5 [0013] So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments. The accompanying drawings relate to embodiments of the invention and are described in the following:

FIG. 1A shows a carrier for a plurality of substrates according to embodiments described herein;

FIG. 1B shows a another view of the carrier for a plurality of substrates according to embodiments described herein, which is shown in FIG. 1A;

FIG. 2 shows an enlarged view of a carrier for a plurality of substrates according to embodiments described herein;

FIG. 3 shows an enlarged view of a recess for substrates used in embodiments described herein and having a substrate support surface;

FIGS. 4A and 4B show views of a carrier and sub-frames for use in a carrier according to embodiments described herein;

FIG. 5 shows a view of a carrier having sub-frames, which are connected by a joint, according to embodiments described herein;

FIG. 6 shows a view of an apparatus for depositing a layer of material on a substrate utilizing a carrier according to embodiments described herein;
FIG. 7 shows a flow chart illustrating a method for processing a 
substrate according to embodiments described herein, wherein 
a carrier according to embodiments described herein is 
utilized.

DETAILED DESCRIPTION OF EMBODIMENTS

[0014] Reference will now be made in detail to the various embodiments of the invention, 
one or more examples of which are illustrated in the figures. Within the following description 
of the drawings, the same reference numbers refer to same components. Generally, only the 
differences with respect to individual embodiments are described. Each example is provided 
by way of explanation of the invention and is not meant as a limitation of the invention. 
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.

[0015] According to some embodiments, a carrier may be composed of several parts or 
portions, which can form a frame. The frame of a carrier may again have several frame 
portions or frame parts. According to some embodiments, the term "carrier" is used for a 
piece of carrier material, such as Invar, a carbon fiber material or a metal like aluminum, titan, 
stainless steel or the like. The carrier supports a plurality of substrates to be processed, e.g., 
coated.

[0016] According to some embodiments, large area substrates or corresponding carriers 
may have a size of typically about 1.2 m² to about 8 m², more typically about 2 m² to about 9 
m² or even up to 12 m². Typically, the rectangular substrates, for which the arrangements, 
carriers, apparatuses, and methods according to embodiments described herein are provided, 
are a plurality of substrates in an area corresponding to a large area substrate as described 
herein. For instance, the area can correspond to a large area substrate of GEN 5, which 
corresponds to about 1.4 m² substrates (1.1 m x 1.25 m), of GEN 7.5, which corresponds to 
about 4.29 m² substrates (1.95 m x 2.2 m), of GEN 8.5, which corresponds to about 5.7m² 
substrates (2.2 m x 2.5 m), or even of GEN 10, which corresponds to about 8.7 m² substrates

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Even larger generations such as GEN 11 and GEN 12 and corresponding areas can similarly be implemented.

According to embodiments described herein, a carrier or substrate holder for holding a plurality of substrates is provided. Thereby, for example, the substrates can be coated on the entire surface of one side of the substrate. The carrier or substrate holder is configured for a vertical processing apparatus such that particle generation on the substrates can be minimized or avoided. Embodiments described herein are particularly useful for processing, for example, coating of so-called cover lenses for smart phone and tablet PCs. Thereby, the term cover lens is typically used for the outermost protective glass of the smart phone or tablet PC. According to some embodiments, the substrates can be coated on one side without edge exclusion in an almost vertical orientation. Due to this arrangement, the embodiments described herein offer the beneficial option of horizontal coating while avoiding particles from coating to pollute the surface of the substrate due to the almost vertical orientation. According to yet further embodiments, which can be combined with other embodiments described herein, the assemblies configured for supporting a plurality of substrates in a carrier for processing in a vertical processing apparatus also allow for double side coating of the substrates within the assembly.

Vertical substrate processing in processing apparatuses can be beneficial as compared to horizontal processing apparatuses due to the fact that the vertically oriented carriers and substrates supported therein are not polluted by particles, which are generated in the processing apparatus and which may fall on the substrates during processing of the substrates. For large area substrates as defined herein, the substrates can be attached to a carrier for supporting the large area substrate during processing, such as deposition. However, if cover lenses of devices, for example, smartphones and tablet PCs, are to be processed, an edge exclusion during the processing step is often not acceptable. Accordingly, it is beneficial if the substrates to be processed or coated are fixed by their own weight. For example, clamps covering a surface of a substrate might not be the preferred options.

According to embodiments described herein, assemblies configured for supporting a plurality of substrates are provided, wherein the assembly includes at least one frame and a plurality of recesses provided within the frame. A substrate can be positioned within each recess to be in contact with the substrate receiving surface. The substrate receiving services, i.e., each substrate receiving surface is individually inclined with respect to the frame for the
plurality of substrates. Thereby, each substrate can be inclined with respect to the frame and, thus, with respect to the vertical orientation of the frame during processing of the substrates. According to embodiments described herein, the inclination of the substrate receiving surfaces can be 3° to 14°, for example, 3° to 9°, such as 5° or 7°.

[0020] Figure 1 shows a carrier 100 being one example for an assembly configured for supporting a plurality of substrates for processing in a vertical processing apparatus. The carrier 100 includes a mainframe 102 and a plurality of recesses 110. The mainframe 102 has the front surface 102a and a back surface 102b, which is opposing the front surface. As shown in figure 1B a plurality of substrates 10 can be provided in the carrier 100 with an inclination as compared to that orientation of the carrier, which can be defined by the front surface 102A and/or the back surface 102b. As shown in figure 2, the substrates 10 can be provided within the carrier and can thereby be supported by support surfaces 312. The support surfaces 312 form an angle of inclination 212 with respect to the orientation of the carrier 100 or the mainframe 102. Typically, the angle of inclination can be 3° to 14° or 3° to 9°, for example 5° or 7°.

[0021] As shown in figure 2, the carrier 100 can support a plurality of substrates 10 in an inclined manner. The support surfaces 312 are inclined for example with respect to the front surface 102a and/or the back surface 102b of the mainframe 102. Further, the recesses 110 have the front side aperture 210a and the backside aperture 210b. The front side aperture 210a is larger than the backside aperture 210b due to the support surfaces 312 at which the substrates 10 can be supported. Accordingly, the assembly for supporting the plurality of substrates is configured such that the substrates 10 can be processed without an edge exclusion from the front side, i.e., the front surface 102a of the carrier 100. From the backside, i.e., the back surface 102b of the carrier, an edge exclusion is provided by the support surfaces 312. For example, the size of the substrate receiving surface extending around the recess can be about 0.5 mm to 1.5 mm, e.g., 1 mm. Thereby, this portion is excluded from processing such as coating. This can be better understood with respect to figure 3.

[0022] Figure 3 shows one recess 110 provided in the frame of an assembly configured for supporting the plurality of substrates. The surface 302 can be the surface of the frame. Within the surface the recess 110 is provided. The substrate support surface 312 surrounds the recess. As can be seen by the side surface 314 of the recess, and inclination is provided for the
substrate support surface. That is the height of the side surface 314 is higher at one end of the recess as compared to the other end of the recess.

[0023] According to some embodiments, which can be combined with other embodiments described herein, the recess 110 can further include protrusions 342. The protrusions 340 provide for the space 343 into which the handler of a robot, an arm of a robot or the finger of robot can be inserted such that the substrates can be automatically loaded onto and from the support surface 314.

[0024] According to yet further optional modifications, clamp elements such as springs or the like can be provided in the recess, e.g., next to or within the protrusions 342. The clamp elements can contact the side edges of the respective substrate of the plurality of substrates such that increased friction is provided and additional fixation of the substrates can be achieved. As the clamp elements contact the side edges of the substrates, there is no edge exclusion. Further, as the substrate receiving surfaces are inclined the substrates are held by their own weight and the clamping might be comparably small or not existing at all.

[0025] The inclination of the substrate support surfaces within the recess can be defined with respect to a vertical carrier orientation during processing. That is the carrier is oriented essentially vertical, e.g., with a deviation of ± 1°, e.g., due to manufacturing tolerances and the substrates are inclined or tilted relative to the vertical orientation such that the substrates are stable in the recesses by their own weight. Irrespective of the carrier orientation, the substrate support surfaces can be inclined with respect to surface orientation of the frame of the support assembly. For example, the frame has a front surface 102a and a back surface (102b) opposing the front surface. The front surface and/or the back surface provide a frame surface which defines a frame orientation. Thereby, it should be understood that the frame surface is a surface considered for the entire frame. That is, even though the frame or carrier might include a plurality of surface structures for technical reasons, the frame surface is considered e.g., as an average surface, a surface corresponding to at least 50% of the area of the frame surface, or the surface provided by a linear regression of the surface including the surface structure.

[0026] According to some embodiments, the term "recess" should be understood as a window of a carrier, through which the deposition material may pass during the deposition process. Typically, the "recess" may also be denoted as a window as it defines the area of the
substrate on which coating material is deposited. According to some embodiments of support
arrangements for two-sided deposition, the recesses are recesses extending from one side of
the frame to the other side of the frame, i.e., the recesses are openings. However, it is also
possible to have a recess that does not fully extend through the frame such that only a one side
substrate processing can be conducted. Therein, the substrate receiving surface in the recess
is also inclined as described herein.

[0027] According to embodiments described herein, the substrate receiving surfaces extend
essentially along the entire periphery of the recess. Thereby, a gap between the front side and
the back side of the support arrangement can be avoided. Accordingly, the substrate and the
substrate receiving surfaces seal the front side of the support assembly from the backside of
the support assembly and vice versa. Thereby, coating of the side opposing a deposition
surface ("back side coating") can be avoided.

FIGS. 4A and 4B illustrate another carrier 100. The carrier 100 includes a main frame
102 and one or more sub-frames 402/404. FIG. 4A illustrates a carrier equipped with two
sub-frames 402 and with two sub-frames 404. The sub-frames can also be denoted as sub-
hanger or sub-holder. Typically, the one or more sub-frames are configured to be provided in
the carrier 100 in a position in which commonly a large area substrate would be provided.

[0028] FIG. 4B shows sub-frames 402 and 404, each of which can be an example of an
assembly configured for supporting a plurality of substrates for processing in a vertical
processing apparatus. The sub-frames include a frame portion 403 and 405, respectively and a
plurality of recesses 110. The frame portions have a front surface and a back surface, which is
opposing the front surface. A plurality of substrates can be provided in the sub-frames.
Similar to the embodiments described with respect to FIGS. 1A to 3, the substrates are
provided with an inclination as compared to that orientation of the sub-frames, which can be
defined by the front surface and/or the back surface, or e.g. as described above with respect to
a macroscopic frame surface such as a surface determined by regression or averaging. The
support surfaces form an angle of inclination with respect to the orientation of the sub-frames.
The angle of inclination can be 3° to 14° or 3° to 9°, for example 5° or 7°.

[0029] According to some embodiments, which can be combined with other embodiments
described herein the frame thickness of the support arrangement, for example the thickness of
the main frame or the thickness of the sub-frame can be about 8 mm to about 20 mm, e.g., 10 mm to 14 mm, such as 12 mm.

As can be seen in FIG. 4B, the sub frames can have recesses 110 of different sizes. Thereby, for example, the sub-frame 402 can have recesses sized for a smart phone cover lens and the sub frame 404 can have recesses sized for a tablet PC cover lens. Accordingly, the use of the sub-frames in the carrier provides for increased flexibility as a carrier 100 as shown in FIG. 4A can be equipped with a variety of different combinations of sub-frames depending on the need of substrate sizes. Further, as the sub-frames are provided instead of a large area substrate, existing carriers can be equipped with sub-frames and thereby provide support assemblies according to embodiments described herein.

According to yet further embodiments, which can be combined with other embodiments described herein, the sub-frames 402 and 404 and the carrier 100 can be configured for having tongue-groove joints. This indicated in FIG. 4 by areas 502 and 503. The carrier can have, for example, grooves in areas 502 and also in an area at the bottom of the sub-frame in vertical orientation. The sub-frame can have tongues corresponding to the grooves. The depth of the grooves typically longer than the length, i.e., the dimensions corresponding to the depth of the grooves, of the tongues such that the sub-frame can expand as need might be for thermal expansion during substrate processing. Similarly, in the area 503, adjacent sub-frames can include a tongue-groove-joint such that also a horizontal (with respect to FIG. 5) expansion due to thermal expansion can be allowed for by the tongue-groove joint.

[0030] FIG. 6 shows a schematic view of a deposition chamber 600 according to embodiments. The deposition chamber 600 is adapted for a deposition process, such as a PVD or CVD process. One or more carriers 100 are shown being located on a substrate transport device 620. According to some embodiments, the substrate support may be movable to allow adjusting the position of the substrate 100 in the chamber 612. Particularly, for large area deposition as described herein, the deposition can be conducted having a vertical carrier orientation and an almost vertical, slightly inclined substrate orientation. Thereby, the transport device can have lower rollers 622, which are driven by one or more drives 625, e.g., motors. The drives 625 can be connected to a roller 622 by a shaft 623 for rotation of the roller. Thereby, it is possible that one motor 625 drives more than one roller, e.g., by connecting rollers with a belt, a gear system, or the like.
[0031] Rollers 624 can be used for support of the carrier in the vertical or essentially vertical position. Large area carriers having processing area sizes of 1 m² to 9 m² can support a plurality of substrates, e.g., at least 10 substrates or even at least 24 substrates. For example up to 160 or even 200 smaller smart phone cover lenses can be supported in the carrier, wherein each substrate is provided in a recess and supported by an inclined substrate support surface. Accordingly, the substrates can be transported by the transport system including, e.g., a plurality of rollers and drives while being supported in a carrier. For example, the carrier with the substrates therein is supported by the system of rollers 622 and rollers 624.

[0032] A deposition material source 630 is provided in chamber 612 facing the side of the substrate to be coated. The deposition material source 630 provides deposition material 635 to be deposited on the substrate. As shown in FIG. 6 and according to embodiments described herein, the source 630 may be a target with deposition material thereon or any other arrangement allowing material to be released for deposition on substrate 100. Typically, the material source 630 may be a rotatable target. According to some embodiments, the material source 630 may be movable in order to position and/or replace the source 630. According to other embodiments, the material source may also be a planar target.

[0033] According to some embodiments, the deposition material, which is indicated by reference numeral 635 during layer deposition, may be chosen according to the deposition process and the later application of the coated substrate. For instance, the deposition material of the source may be a material selected from the group consisting of: a metal, such as aluminum, molybdenum, niobium, titanium, copper, or the like, silicon, indium tin oxide, and other transparent conductive oxides. Typically, oxide-, nitride- or carbide-layers, which can include such materials, can be deposited by providing the material from the source or by reactive deposition, i.e., the material from the source reacts with elements like oxygen, nitride, or carbon from a processing gas. According to some embodiments, materials like siliconoxides, siliconoxynitrides, siliconitriles, aluminumoxide, aluminumoxynitrides may be used as deposition material. For example, a stack of dielectric layers for depositing an anti-reflection coating can be provided on one side of the substrate.

[0034] According to typical embodiments, which can be combined with other embodiments described herein, the one or more chambers 612 can be provided as vacuum chambers. Thereby, the chambers are adapted for processing and/or coating the substrates in a vacuum environment. Typically, the pressure can be below 10 mbar, e.g., between 1x10⁻⁷ mbar and
1x10^{-1} \text{ mbar}. \text{ Thus, the deposition system may include a pumping system (not shown), which can be connected to vacuum flanges 613, and capable of achieving a pressure within processing chamber 612 sufficiently low enough for enabling the deposition system to be operable for a particular application, such as a pressure of 1x10^{-7} \text{ mbar. The pressure during deposition, such as PVD processes, (i.e., deposition pressure) may be between 0.1 \text{ Pa} and 1 \text{ Pa}. For particular embodiments, e.g., PVD applications, wherein the processing gas includes argon and at least one of oxygen or nitrogen, the argon partial pressure may be between 0.1 \text{ Pa} and 1 \text{ Pa}, and the oxygen, hydrogen, and/or nitrogen partial pressure may be between 0.1 \text{ Pa} and 1 \text{ Pa}. Typically, the pressure ranges for CVD applications can be about 2 orders of magnitude larger, particularly at the high pressure end of the ranges given above.}

As shown in FIG 6, the processing system includes at least two deposition chambers 612. The chambers can be arranged in two chambers lines, each line having a transport system with a transport rail provided by rollers or the like. FIG. 2 shows two chambers in the cross-section. The carriers 100 can be moved with a translation movement from one transport rail of a transport system 620 to a parallel transport rail of another transport system 620. Thereby, as shown in FIG. 6, one side of the substrates 10 in the carrier 100 can be deposited in one chamber 612 and the opposing side of the substrates 10 in the carrier 100 can be deposited in the other chamber 612. As described with respect to figures 2 and 3 above, at least one of the sides of the substrate to be deposited is not covered by an exclusion mask such that the entire surfaces of the plurality of substrates can be coated on at least one side of the substrates.

According to some embodiments, a method is provided for processing a plurality of substrates in vertically oriented carrier. FIG. 7 shows a flow diagram of the described method. Typically, the substrates supported by a carrier and are provided in a chamber of a processing or deposition apparatus.

Typically, a substrate may be made from any material suitable for material deposition. For instance, the substrate may be made from a material selected from the group consisting of glass (for instance, soda-lime glass, borosilicate glass, etc.), metal, polymer, ceramic, compound materials, carbon fiber materials or any other material or combination of materials which can be coated by a deposition process. According to embodiments described herein, a support assembly or a carrier is utilized for substrate processing, for PVD deposition processes, CVD deposition process or combinations of the deposition processes.
In step 702, the plurality of substrates is loaded in the support arrangement or carrier. In step 704, the substrates are processed, e.g., a layer is coated on one or both sides of the plurality of substrates. According to different implementations, the loading of the plurality of substrates can be conducted in an automated manner. For example, a robot can load the substrates onto the substrate receiving surfaces in a carrier, a robot can load the substrates onto the substrate receiving surfaces of sub-frames, which are in turn provided in a carrier, or a robot can load the substrates onto the substrate receiving surfaces in sub-frame, which is thereafter attached to the main frame of the carrier. Thereby, pre-loading of the substrates might be beneficial if there are a plurality of substrates (e.g., 80 and more) and the time for loading might be a limitation for throughput of a processing application.

The processing of the substrates typically includes a full area coating from one side (see, e.g., front side 102a in FIG. 2). In addition coating can also be conducted on the back side (see, e.g., back side 102b in FIG. 2). Both sides can be coated in the support assembly while the substrates remain loaded. According to some embodiments, which can be combined with other embodiments described herein, the coating steps can be conducted in a non-stationary deposition system, where the carrier with the plurality of substrates is mover along the deposition sources during deposition.

According to some embodiments, which can be combined with other embodiments described herein, the frame includes more than one frame portion to form the frame.

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.
CLAIMS

1. An assembly configured for supporting a plurality of substrates (10) in a carrier (100) for processing in a vertical processing apparatus (600), the assembly comprising:

   5. at least one frame (102; 402, 404) having a frame orientation corresponding to the vertical orientation during substrate processing; and

   a plurality of recesses (110) in the at least one frame, wherein each recess is configured for receiving one substrate, wherein a substrate receiving surface (312) is provided within each of the plurality of recesses, and wherein the substrate receiving surface in each of the plurality of recesses is inclined with respect to the frame orientation by 3° to 14°.

2. The assembly according to claim 1, wherein the at least one frame is the main frame (102) of the carrier.

3. The assembly according to claim 1, wherein the at least one frame comprises a sub-frame (402, 404) configured for being supported by the carrier.

4. The assembly according to claim 3, wherein the sub-frame is configured to be supported by the carrier with a tongue-and-groove joint (502).

5. The assembly according to any of claims 1 to 4, wherein the plurality of recesses comprises at least 10 recesses, particularly at least 24 recesses.

6. The assembly according to any of claims 1 to 5, further comprising:
a clamping mechanism provided in each of the recesses and configured for clamping the substrate provided in the corresponding recess at a side edge of the substrate, particularly wherein the clamping mechanism is a spring.

7. A carrier (100) for substrate processing in a vertical processing apparatus (600), the carrier comprising:

an assembly according to any of claims 1 to 6.

8. The carrier according to claim 7, wherein the depth of the groove and the length of the tongue of the tongue-and-groove joint (502) is configured to allow for thermal expansion of the sub-frame.

9. The carrier according to any of claims 7 to 8, wherein the at least one frame comprises two or more sub-frames (402, 404) configured for being supported by the carrier, wherein the sub-frames are attached to each other with a second tongue-and-groove joint (503), and particularly wherein the depth of the groove and the length of the tongue of the second tongue-and-groove joint is configured to allow for thermal expansion of the two or more sub-frames.

10. An apparatus for processing a plurality of substrates, comprising:

a chamber (612) adapted for substrate processing therein,

a carrier (100) according to any of claims 7 to 9 within the chamber; and

in particular, a deposition source (630) for depositing material forming a layer.

11. The apparatus according to claim 10, further comprising:
a transport system (620) adapted for transportation of the carrier supporting the plurality of substrates, wherein the carrier is transported in a vertical orientation and the substrates are inclined by 3° to 14°.

12. A method of processing a plurality of substrates (10) supported in a carrier (100), the method comprises:

   loading the plurality of substrates in the carrier, wherein each of the plurality of substrates is inclined with respect to the carrier by 3° to 14°; and

   processing the plurality of substrates while the carrier is oriented vertically.

13. The method according to claim 12, wherein the processing comprises deposition of a layer over an entire first substrate surface of each of the plurality of substrates.

14. The method according to any of claims 12 to 13, wherein the processing includes processing another layer on a second substrate surface of each of the plurality of substrates, wherein each of the second substrate surfaces opposes each of corresponding entire first substrate surfaces.
FIG 7
INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/072229

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L21/687 H01L21/673 C23C16/458
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)
H01L C23C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tr>
<td>X</td>
<td>US 3 659 552 A (BRIDDY THOMAS F) 2 May 1972 (1972-05-02) abstract; figures 1-5 col umn 2, line 44 - line 47 col umn 3, line 20 - line 27 col umn 4, line 8 - line 18</td>
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<td>1,2,5,7,10-13</td>
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Further documents are listed in the continuation of Box C. X

See patent family annex.

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<th>Relevant to claim No.</th>
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<td>US 3 645 230 A (HUGLE WILLIAM B ET AL) 29 February 1972 (1972-02-29) abstract; figure 1 column 2, line 52 - line 67</td>
<td>1-3,5,7, 10-13</td>
</tr>
<tr>
<td>Patent document cited in search report</td>
<td>Publication date</td>
<td>Patent family member(s)</td>
</tr>
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<td>-------------------------</td>
</tr>
<tr>
<td></td>
<td>JP 11219913 A</td>
<td>10-08-1999</td>
</tr>
<tr>
<td></td>
<td>US 2001055865 Al</td>
<td>27-12-2001</td>
</tr>
<tr>
<td></td>
<td>US 2002042190 Al</td>
<td>11-04-2002</td>
</tr>
<tr>
<td></td>
<td>DE 1621394 Al</td>
<td>03-06-1971</td>
</tr>
<tr>
<td></td>
<td>ES 348706 A</td>
<td>01-07-1969</td>
</tr>
<tr>
<td></td>
<td>FR 1561186 A</td>
<td>28-03-1969</td>
</tr>
<tr>
<td></td>
<td>GB 1210537 A</td>
<td>28-10-1970</td>
</tr>
<tr>
<td></td>
<td>IL 29056 A</td>
<td>28-01-1971</td>
</tr>
<tr>
<td></td>
<td>NL 6717117 A</td>
<td>17-06-1968</td>
</tr>
<tr>
<td></td>
<td>SE 323353 B</td>
<td>04-05-1970</td>
</tr>
<tr>
<td></td>
<td>US 3659552 A</td>
<td>02-05-1972</td>
</tr>
<tr>
<td>Wo 0008401 Al 17-02-2000</td>
<td>US 6157003 A</td>
<td>05-12-2000</td>
</tr>
<tr>
<td></td>
<td>Wo 0008401 Al</td>
<td>17-02-2000</td>
</tr>
<tr>
<td>US 3645230 A 29-02-1972</td>
<td>NONE</td>
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</tr>
<tr>
<td>US 2007020885 Al 25-01-2007</td>
<td>AU 2002311863 Al</td>
<td>03-12-2002</td>
</tr>
<tr>
<td></td>
<td>US 2002170487 Al</td>
<td>21-11-2002</td>
</tr>
<tr>
<td></td>
<td>US 2004129203 Al</td>
<td>08-07-2004</td>
</tr>
<tr>
<td></td>
<td>US 2007020885 Al</td>
<td>25-01-2007</td>
</tr>
<tr>
<td></td>
<td>Wo 02095807 A2</td>
<td>28-11-2002</td>
</tr>
<tr>
<td>US 2009317215 Al 24-12-2009</td>
<td>CN 101615571 A</td>
<td>30-12-2009</td>
</tr>
<tr>
<td></td>
<td>KR 20100000146 A</td>
<td>06-01-2010</td>
</tr>
<tr>
<td></td>
<td>TW 201009980 A</td>
<td>01-03-2010</td>
</tr>
<tr>
<td></td>
<td>US 2009317215 Al</td>
<td>24-12-2009</td>
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