

LIFT PIN ASSEMBLY

FIELD

[0001] Embodiments of the present disclosure generally relate to apparatus for handling a substrate.

BACKGROUND

[0002] Lift pins extend through a substrate support to lift a substrate off the substrate support to facilitate placement and removal of the substrate onto the substrate support. Conventionally, lift pins are formed of a metal to improve rigidity. The inventors have observed that impact between the substrate and metal surfaces results in particle generation on the substrate and in the processing chambers.

[0003] In some processes, to maintain process uniformity and ensure optimal performance of a processing chamber, a conditioning operation such as a pasting process is performed, in which a covering is applied over materials deposited on process chamber surfaces to prevent the deposited materials from flaking off the process chamber surfaces and contaminating the substrate during subsequent processes. During the pasting process, a shutter disk may be positioned atop a substrate support disposed in the process chamber to prevent the deposition of any materials upon the substrate support.

[0004] In addition, when a process chamber is opened, a target containing material to be deposited on a substrate may begin to oxidize. As such, a burn-in process may be performed to remove an oxide layer on the target. During the burn-in process, a shutter disk may be positioned atop a substrate support disposed in the process chamber to prevent the deposition of any materials upon the substrate support.

[0005] Although the inventors believe that eliminating hard lift pin surfaces altogether would address the issue of particle generation on a backside of the substrate, the inventors have observed that a hard surface is desirable for contacting the shutter disk, which is heavier and becomes hotter than the substrate.

[0006] Therefore, the inventors have provided an improved lift pin assembly.

SUMMARY

[0007] Embodiments an apparatus for handling a substrate are provided herein. In some embodiments, a lift pin assembly includes an elongate base formed of a first material and having a first feature formed in a distal end of the base to interface with and removably support a tip; and a tip formed of a second material different than the first material and having a support surface on a first side of the tip and an opposing second side of the tip, wherein the opposing second side includes a second feature to mate with the first feature of the base to removably retain the tip on the distal end of the base.

[0008] In some embodiments, a lift pin assembly includes a lift pin comprising a first material providing a first support surface and a second material providing a second support surface, wherein the first material is different than the second material, wherein the first material is an electrically conductive polymer, and wherein the second material is metallic.

[0009] In some embodiments, a substrate processing chamber includes a chamber body defining an inner volume; a substrate support disposed in the inner volume, the substrate support including a plurality of channels extending from a lower surface to an upper surface of the substrate support; and a plurality of lift pin assemblies to extend through the plurality of channels to facilitate placement or removal of a substrate or a shutter disk, each of the lift pin assemblies including a lift pin comprising a first material providing a first support surface and a second material providing a second support surface, wherein the first material is different than the second material, wherein the first material is an electrically conductive polymer, and wherein the second material is metallic.

[0010] Other and further embodiments of the present disclosure are described below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Embodiments of the present disclosure, briefly summarized above and discussed in greater detail below, can be understood by reference to the illustrative embodiments of the disclosure depicted in the appended drawings. However, the appended drawings illustrate only typical embodiments of the disclosure and are

therefore not to be considered limiting of scope, for the disclosure may admit to other equally effective embodiments.

[0012] Figure 1 depicts a process chamber suitable for use with a lift pin assembly in accordance with some embodiments of the present disclosure.

[0013] Figure 2 depicts a lift pin assembly in accordance with some embodiments of the present disclosure.

[0014] Figures 3A-B depict a lift pin assembly in accordance with some embodiments of the present disclosure.

[0015] Figures 4A-B depict a lift pin assembly in accordance with some embodiments of the present disclosure.

[0016] Figures 5A-B depict a lift pin assembly in accordance with some embodiments of the present disclosure.

[0017] Figure 6 depicts a cross sectional view of the lift pin assembly of Figures 5A-B in accordance with some embodiments of the present disclosure.

[0018] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures. The figures are not drawn to scale and may be simplified for clarity. Elements and features of one embodiment may be beneficially incorporated in other embodiments without further recitation.

DETAILED DESCRIPTION

[0019] Embodiments of lift pin assemblies are provided herein. Embodiments of the lift pin assembly may advantageously decrease particle generation on a backside of a substrate while maintaining the capability of supporting a shutter disk when present. Embodiments of the inventive lift pin assembly may advantageously be easily retrofitted to existing processing systems, thereby avoiding unnecessary and costly modification of existing processing systems. Although useful for many substrate handling apparatuses, the apparatus disclosed below is illustratively described with respect to a physical vapor deposition (PVD) processing chamber.

[0020] Figure 1 is a schematic diagram of an exemplary process chamber 100 for use in connection with some embodiments of the present disclosure. In some embodiments, the process chamber 100 may be one of a plurality of chambers combined to form a multi-chamber processing system (e.g., a cluster tool). Alternatively, the process chamber 100 may be a standalone process chamber. In some embodiments, the process chamber 100 may be a deposition chamber, for example, a PVD chamber. Alternatively, the process chamber 100 may be any suitable process chamber in which a shutter disk assembly may be used to protect the substrate support from damage during chamber/target cleaning and or seasoning processes.

[0021] The process chamber 100 includes a chamber body 102 and a lid assembly 104 that defines an evacuable process volume 106. The chamber body 102 generally includes one or more sidewalls 108 and a bottom 110. The one or more sidewalls 108 may be a single circular sidewall or multiple sidewalls in process chambers having non-circular configurations. The sidewalls generally contain a shutter disk assembly port 112. The shutter disk assembly port 112 is configured to allow at least a portion of a shutter disk assembly 140 therethrough when the shutter disk assembly 140 is in a retracted position. A housing 116 generally covers the shutter disk assembly port 112 to maintain the integrity of the vacuum within the process volume 106. Additional ports may be provided in the sidewalls, such as a sealable access port to provide for the entrance and egress of the substrate 114 from the process chamber 100. A pumping port may be provided in the sidewalls and/or the bottom of the chamber body 102 and is coupled to a pumping system that evacuates and controls the pressure within the process volume 106. In other embodiments, a shutter garage (not shown) located outside of process chamber 100 may store the shutter disk assembly 140 when not in use and the shutter disk assembly 140 may be moved into the process chamber 100 through an opening (not shown) in process chamber 100.

[0022] The lid assembly 104 of the chamber body 102 generally supports an annular shield 118 that supports a shadow ring 120. The shadow ring 120 is generally configured to confine deposition to a portion of the substrate 114 exposed through the center of the shadow ring 120. The lid assembly 104 generally comprises a target 122 and a magnetron 124.

[0023] The target 122 provides material that is deposited on the substrate 114 during the deposition process while the magnetron 124 enhances uniform consumption of the target material during processing. The target 122 and substrate support 126 are biased relative each other by a power source 128. An inert gas, for example, argon, is supplied to the process volume 106 from a gas source 130. A plasma is formed between the substrate 114 and the target 122 from the gas. Ions within the plasma are accelerated toward the target 122 and cause material to become dislodged from the target 122. The dislodged target material is attracted towards the substrate 114 and deposits a film of material thereon.

[0024] The substrate support 126 is generally disposed on the bottom 110 of the chamber body 102 and supports the substrate 114 during processing. A lift pin assembly 133 may include a plurality of lift pins 109 mounted on a platform 117 connected to a shaft 111 which is coupled to a second lift mechanism 135 for raising and lowering the lift pin assembly 133 so that the substrate 114 or the shutter disk may be placed on or removed from the substrate support 126. The substrate support 126 includes channels 121 (e.g., thru-holes) to receive the lift pins 109. A bellows assembly 131 is coupled between the platform 117 and the bottom 110 to provide a flexible seal which maintains the chamber vacuum during vertical motion of the lift pin assembly 133.

[0025] A shutter disk assembly mechanism 132 is generally disposed proximate the substrate support 126. The shutter disk assembly mechanism 132 generally includes a blade 134 that supports the shutter disk assembly 140 and an actuator 136 coupled to the blade 134 by a shaft 138 to control the position of the blade 134.

[0026] The blade 134 may be moved between the retracted, or cleared, position shown in Figure 1 and a second position that places the shutter disk assembly 140 substantially concentric with the substrate support 126. In the second position, the shutter disk assembly 140 may be transferred (by utilizing the lift pins) to the substrate support 126 during a target burn-in (in PVD chambers) and chamber pasting (in substrate preclean chambers) processes. The blade 134 is returned to the retracted position after the target burn-in and chamber pasting processes. The actuator 136 may be any device that may be adapted to rotate the shaft 138 through an angle that moves

the blade 134 between the cleared and second positions. In other embodiments consistent with present disclosure, a robotic mechanism which positions a substrate 114 for processing may also be used to move the shutter disk assembly 140 in position to protect the substrate support 126.

[0027] Figure 2 depicts a schematic view of an upper portion of a lift pin 209 in accordance with some embodiments of the present disclosure. The lift pin 209 includes an elongate base 204 with a first feature 206 at a distal end. The first feature 206 interfaces with and retains a tip 202 for supporting a substrate or shutter disk thereon. The tip 202 includes a second feature 208 that is sized and shaped to be held by the first feature 206. In some embodiments, the first feature 206 may be a collet and the second feature is a tapered surface to be inserted into and engaged by the collet to couple the tip 202 to the elongate base 204. In other embodiments, the second feature of the tip 202 may be threaded to engage corresponding threads in the first feature 206. In order to reduce particle generation on a backside of a substrate, the tip 202 is formed of an electrically conductive polymer such as, for example, CELAZOLE®, which can withstand temperatures of up to about 400 °C. The elongate base 204 is formed of a metal such as, for example, stainless steel. Such a polymer advantageously prevents particle generation on the backside of a substrate while maintaining the ability to support a hot and heavy shutter disk.

[0028] Figures 3A and 3B depict a schematic view of an upper portion of a lift pin 309 in accordance with some embodiments of the present disclosure. The lift pin 309 includes a pin 302 that extends through a sheath 304. The pin 302 is formed of a first material and the sheath 304 is formed of a second material different from the first material. In some embodiments, the first material is an electrically conductive polymer and the second material is metallic. The pin 302 provides a first support surface 306 for supporting a substrate thereon. The sheath 304 provides a second support surface 308 for supporting a shutter disk thereon. The pin 302 extends beyond the second support surface 308 so that the first and second support surfaces 306, 308 are offset. As depicted in Figure 3A, the shutter disk includes a recess, such as an annular groove 310, to advantageously center the shutter disk on the lift pin assembly 133. The annular groove 310 is sized and shaped so that, when the shutter disk is placed atop the lift pin

assembly, the pin 302 extends into the annular groove 310 and is spaced apart from the shutter disk by a distance D1. In some embodiments, D1 may be at least 0.01 inches. As such, the shutter disk rests on the second support surface 308 of the sheath 304. As depicted in Figure 3B, when a substrate is placed atop the lift pin assembly 133, the substrate rests on the first support surface 306 of the pin 302. Because the pin 302 extends beyond the sheath 304, the substrate never contacts the sheath 304, thereby avoiding particle generation on a backside of the substrate. In some embodiments, the first support surface 306 may be round shaped to reduce a contact area between the pin 302 and the substrate.

[0029] Figures 4A and 4B depict a schematic view of a lift pin 409 according to some embodiments of the present disclosure. The lift pin 409 includes a pin 402 that extends through a sheath 404. The pin 402 is formed of a first material and the sheath 404 is formed of a second material. In some embodiments, the first material is an electrically conductive polymer and the second material is metallic. In other embodiments, both the first and second materials are metallic (*e.g.*, stainless steel). The pin 402 includes a collar 406, beneath which a spring 408 is disposed. The spring 408 extends between the collar 406 and the platform 117. When a substrate is placed atop the lift pin 409, the spring 408 is in an uncompressed state. When a shutter disk is placed atop the lift pin 409, the spring 408 is in a compressed state. The spring 408 is selected so that the spring constant is sufficient to support the weight of a substrate and remain uncompressed. The specific spring constant required may be determined by the respective weights of the substrate and the shutter disk as well as the number of lift pins (*e.g.*, three or more) that support the substrate and shutter disk. When a shutter disk is placed atop the pin 402, the weight of the shutter disk compresses the spring 408 so that the shutter disk rests on an upper support surface 414 of the sheath 404. A polymer tip 412 is disposed atop the pin 402. The polymer tip 412 advantageously prevents particle generation on a backside of the substrate if the pin 402 is metallic. In some embodiments, the polymer tip 412 may be a ball.

[0030] Figures 5A and 5B depict a schematic view of a lift pin 509 according to some embodiments of the present disclosure. The lift pin 509 includes a pin 502 that extends through a sheath 504. The pin 502 is formed of a first material and the sheath 504 is

formed of a second material different from the first material. In some embodiments, the first material is an electrically conductive polymer and the second material is metallic. The lift pin 509 also includes a locking mechanism 506 that moves the pin 502 to a raised (Figure 5B) or lowered (Figure 5A) position. The locking mechanism 506 includes an actuator 508 with a lower portion extending through the platform 117 and a spring 514 that biases the locking mechanism 506 towards the platform 117. To move the pin 502 to either of the two positions, the lift pin assembly 133 is lowered until the actuator 508 is pressed against the bottom 110 of the process chamber 100 and subsequently lifted off of the bottom 110. The actuator 508 has a length D_2 that is long enough to contact the bottom 110 of the process chamber 100 when the lift pin assembly 133 is lowered, thereby depressing the actuator 508. As a result, the pin 502 is pushed upwards and then is lowered into a resting position (raised or lowered position). To move the pin 502 to the other position, the lift pin assembly 133 is lowered again until the actuator 508 is pressed against the bottom 110 of the process chamber 100 and subsequently lifted off of the bottom 110. When a substrate is to be placed atop the lift pin 509, the locking mechanism 506 is actuated to move the pin 502 to the raised position so that the substrate rests on a first support surface 510 of the pin 502 (Figure 5B). When a shutter disk is to be placed atop the lift pin 509, the locking mechanism 506 is actuated to move the pin 502 to the lowered position so that the shutter disk rests on a second support surface 512 of the sheath 504.

[0031] As illustrated in Figure 6, the locking mechanism 506 includes a first cam 516 at a lower end of the pin that engages with a second cam 518 at an upper end of the actuator 508. The first cam 516 has a first profile and the second cam 518 has a second profile. An inner surface of the sheath 504 surrounding the first cam 516 includes a plurality of protrusions 520 separated by a plurality of channels. In the resting position (shown in Figure 6), the first cam 516 rests on the plurality of protrusions 520 or extends into the plurality of channels. When the lift pin assembly 133 is lowered and the actuator 508 is pushed up, the second cam 518 is forced against the first cam 516, thereby pushing the pin 502 upward. The second profile of the second cam 518 is configured to rotate the first cam 516 (and the pin 502) when the second cam 518 engages the first cam 516. When the lift pin assembly 133 is raised, the spring 514 forces the pin 502

back to the resting position, in which the first cam 516 either rests against the plurality of protrusions 520 or extends into the channels between them. The rotation of the pin 502 facilitates the switching between the raised position and the lowered position of the pin 502 because the pin either rests on plurality of protrusions 520 or extends into the channels between them.

[0032] While the foregoing is directed to embodiments of the present disclosure, other and further embodiments of the disclosure may be devised without departing from the basic scope thereof.

Claims:

1. A lift pin assembly, comprising:
a platform;
an elongate base extending from the platform and formed of a first material and having a first feature formed in a distal end of the base to interface with and removably support a tip; and
a tip formed of a second material different than the first material and having a support surface on a first side of the tip and an opposing second side of the tip, wherein the opposing second side includes a second feature to mate with the first feature of the base to removably retain the tip on the distal end of the base.
2. The lift pin assembly of claim 1, wherein the first material is stainless steel.
3. The lift pin assembly of claim 1, wherein the second material is an electrically conductive polymer.
4. The lift pin assembly any of claims 1 to 3, wherein the first feature is a collet and the second feature has a tapered surface to be inserted into and engage with the collet.
5. A lift pin assembly, comprising:
a platform; and
a lift pin extending from the platform and comprising a first material providing a first support surface and a second material providing a second support surface, wherein the first material is different than the second material, wherein the first material is an electrically conductive polymer, and wherein the second material is metallic.
6. The lift pin assembly of claim 5, wherein the lift pin includes a sheath and a pin extending through the sheath.

7. The lift pin assembly of claim 6, wherein the first support surface is an upper surface of the pin and the second support surface is an upper surface of the sheath, and wherein the first support surface is above the second support surface.
8. The lift pin assembly of any of claims 5 to 7, wherein the first support surface is round.
9. The lift pin assembly of any of claims 6 to 7, wherein the pin is moveable between a first position and a second position, the lift pin assembly further comprising:
 - a spring supporting a collar of the pin and moveable between an uncompressed state in the first position and a compressed state in the second position, wherein the spring has a spring constant such that the pin is in the first position when a substrate is disposed on the lift pin assembly and in the second position when a shutter disk is disposed on the lift pin assembly.
10. The lift pin assembly of claim 9, further comprising:
 - a polymer tip disposed on an upper surface of the pin, wherein the first support surface is an upper surface of the polymer tip and the second support surface is an upper surface of the sheath.
11. The lift pin assembly of claim 10, wherein, in the first position, the first support surface is above the second support surface and, in the second position, the first surface is even with or below the second surface.
12. The lift pin assembly of any of claims 6 to 7, further comprising:
 - a locking mechanism moveable between a first position and a second position, wherein, in the first position, the first support surface is below the second support surface so that a shutter disk, when present, rests on the second support surface, and wherein, in the second position, the first support surface is above the second support surface so that a substrate, when present, rests on the first support surface.

13. The lift pin assembly of claim 12, wherein the locking mechanism comprises:
 - a first cam at a lower end of the pin, the first cam having a first profile;
 - an actuator including a lower portion extending through the platform and an upper portion including a second cam having a second profile; and
 - a plurality of protrusions disposed on an inner surface of the sheath and separated by a plurality of channels.
14. The lift pin assembly of claim 13, wherein the actuator is depressed by a bottom of a process chamber when the lift pin assembly is lowered.
15. A substrate processing chamber, comprising:
 - a chamber body defining an inner volume;
 - a substrate support disposed in the inner volume, the substrate support including a plurality of channels extending from a lower surface to an upper surface of the substrate support; and
 - a plurality of lift pins to extend through the plurality of channels to support a substrate or a shutter disk when present, wherein each lift pin is as described in any of claims 1-3 or 5-8.