

[0056] Rather than locating the actuator 110 between annular portions of the edge coupling ring, the actuator 110 may also be attached to a radially outer wall or other structure identified at 114. Alternately, the actuator 110 may be supported from below by a wall or other structure identified at 116.

[0057] Referring now to FIG. 7-8, another example of an edge coupling ring 150 and a piezoelectric actuator 154 is shown. In this example, the piezoelectric actuator 154 moves the edge coupling ring 150. The piezoelectric actuator 154 is mounted in the first annular portion 72 and the third annular portion 76 of the edge coupling ring 150. In FIG. 8, the piezoelectric actuator 154 moves the first annular portion 72 of the edge coupling ring 150 to adjust a position of an edge 156 of the first annular portion 72.

[0058] Referring now to FIG. 9, an example of a substrate processing chamber 500 for performing etching using RF plasma is shown. The substrate processing chamber 500 includes a processing chamber 502 that encloses other components of the substrate processing chamber 500 and contains the RF plasma. The substrate processing chamber 500 includes an upper electrode 504 and a pedestal 506 including a lower electrode 507. An edge coupling ring 503 is supported by the pedestal 506 and is arranged around the substrate 508. One or more actuators 505 may be used to move the edge coupling ring 503. During operation, a substrate 508 is arranged on the pedestal 506 between the upper electrode 504 and the lower electrode 507.

[0059] For example only, the upper electrode 504 may include a showerhead 509 that introduces and distributes process gases. The showerhead 509 may include a stem portion including one end connected to a top surface of the processing chamber. A base portion is generally cylindrical and extends radially outwardly from an opposite end

[0062] A heater 542 may be connected to a heater coil (not shown) arranged in the pedestal 506. The heater 542 may be used to control a temperature of the pedestal 506 and the substrate 508. A valve 550 and pump 552 may be used to evacuate reactants from the processing chamber 502. A controller 560 may be used to control components of the substrate processing chamber 500. The controller 560 may also be used to control the actuator 505 to adjust a position of one or more portions of the edge coupling ring 503.

[0063] A robot 570 and a sensor 572 may be used to measure erosion of the edge coupling ring. In some examples, the sensor 572 may include a depth gauge. The robot 570 may move the depth gauge in contact with the edge coupling ring to measure erosion. Alternately, a laser interferometer (with or without the robot 570) may be used to measure erosion without direct contact. The robot 570 may be omitted if the laser interferometer can be positioned with a direct line of sight to the edge coupling ring.

[0064] Another robot arm 573 may be used to deliver and remove substrates onto the pedestal 506. Additionally, the robot arm 573 may be used to deliver unused edge coupling rings onto a lifting ring and to replace used edge coupling rings after sufficient wear as will be described further below in conjunction with FIGs. 15-23. While the same robot arm 573 may be used for both substrates and edge coupling rings, dedicated robot arms may also be used.

[0065] Referring now to FIG. 10, an example of a method 600 for operating the actuator to move the edge coupling ring is shown. At 610, at least part of an edge coupling ring is positioned in a first location relative to the substrate. At 614, the substrate processing system is operated. The operation may include etching or other

[0073] In FIG. 13B, the actuators 836-1 and 836-2 move the respective portions of the edge coupling ring 830 such that the edge coupling ring 830 moves to a second arrangement 850 that is different than the first arrangement 840 shown in FIG. 13A. As can be appreciated, the substrates may be inspected after treatment and the tilt relative to the substrate may be adjusted as needed without opening the processing chamber.

[0074] Referring now to FIG. 14, a method 900 for moving an edge coupling ring during processing of a substrate is shown. In other words, different treatments may be performed on a single substrate in the same processing chamber. The edge coupling effect of the edge coupling ring may be adjusted between the multiple treatments performed on the substrate in the same processing chamber before proceeding to a subsequent substrate. At 910, a substrate is positioned on a pedestal and a position of the edge coupling ring is adjusted if needed. At 914, treatment of the substrate is performed. If processing of the substrate is done as determined at 918, the substrate is removed from the pedestal at 922. At 924, control determines whether another substrate needs to be processed. If 924 is true, the method returns to 910. Otherwise the method ends.

[0075] If 918 is false and the substrate needs additional treatment, the method determines whether adjustment of the edge coupling ring is required at 930. If 930 is false, the method returns to 914. If 930 is true, at least part of the edge coupling ring is moved using one or more actuators at 934 and the method returns to 914. As can be appreciated, the edge coupling ring can be adjusted between treatments of the same substrate in the same processing chamber.

[0087] Referring now to FIGs. 21-22, the lifting ring can be omitted in some examples. An edge coupling ring 1310 is arranged on the bottom edge coupling ring 1034 and a radially outer edge of the pedestal. The edge coupling ring 1310 may include one or more self-centering features 1316 and 1320. The edge coupling ring 1310 may further include a groove 1324 for receiving a top surface of the pillar 1210, which is biased by the actuator 1214. The self-centering feature 1320 may be arranged against a corresponding self-centering feature 1326 of the bottom edge coupling ring 1034. In some examples, the self-centering features 1320 and 1326 are inclined planes.

[0088] In FIG. 22, the actuator 1214 and the pillar 1210 bias the edge coupling ring 1310 upwardly to remove the edge coupling ring 1310 or to adjust a plasma profile after erosion has occurred. The robot arm 1102 and the holder 1104 can be moved into position below the edge coupling ring 1310. The self-centering feature 1316 may be engaged by the self-centering feature 1110 on the holder 1104 connected to the robot arm 1102. Either the robot arm 1102 moves in an upward direction to provide clearance between the groove 1324 and the pillar 1210 or the pillar 1210 is moved downwardly by the actuator 1214 to provide clearance for the groove 1324.

[0089] Referring now to FIG. 23, a method 1400 for replacing an edge coupling ring without opening a processing chamber to atmospheric pressure is shown. At 1404, the method determines whether the edge coupling ring is located on the lifting ring. If 1404 is false, the method moves an edge coupling ring into position on the lifting ring using a robot arm at 1408. After the edge coupling ring is located on the lifting ring in the processing chamber, the process is run at 1410. At 1412, the method determines whether the edge coupling ring is worn using any of the criteria described above. If 1412 is false, the method returns to 1410 and the process may be run again. If the edge coupling ring is determined to be worn at 1412, the edge coupling ring is replaced at 1416 and the method continues at 1410.

[0090] Referring now to FIG. 24, a method 1500 adjusts a position of the movable edge coupling ring as needed to offset for erosion and selectively replaces the movable edge coupling ring when the movable edge coupling ring is determined to be worn. At 1502, the method determines whether a movable edge coupling ring is located on the lifting ring. If 1502 is false, an edge coupling ring is moved into position on the lifting ring at 1504 and the method continues at 1502.

[0091] If 1502 is true, the method determines whether a position of the movable edge coupling ring needs to be adjusted at 1506. If 1506 is true, the method adjusts a position of the movable edge coupling ring using an actuator and returns to 1506. When 1506 is false, the method runs the process at 1510. At 1512, the method determines whether the movable edge coupling ring is worn. If false, the method returns to 1510.

[0092] If 1512 is true, the method determines whether the movable edge coupling ring is in a highest (or fully adjusted) position at 1520. If 1520 is false, the method adjusts a position of the movable edge coupling ring using the actuator 1214 at 1524 and the method returns to 1510. If 1520 is true, the method replaces the movable edge coupling ring using the actuator 1064, the lifting ring 1018 and the robot arm 1102.

[0093] Referring now to FIG. 25, a method 1600 for replacing the edge coupling ring without opening the process chamber to atmospheric pressure is shown. At 1610, the lifting ring and edge coupling ring are biased upwardly using an actuator. At 1620, the