(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
6 October 2005 (06.10.2005)

PCT

(10) International Publication Number
WO 2005/093116 A2

(51) International Patent Classification[7]: C23C 14/00

(21) International Application Number:
PCT/US2005/005374

(22) International Filing Date: 22 February 2005 (22.02.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
10/803,805 18 March 2004 (18.03.2004) US

(71) Applicant *(for all designated States except US)*: **TOKYO ELECTRON LIMITED** [JP/JP]; TBS Broadcast Center, 3-6 Akasaka 5-chome, Minato-ku, Tokyo 107 (JP).

(71) Applicant *(for JP only)*: **TOKYO ELECTRON AMERICA, INC.** [US/US]; 2400 Grove Boulevard, Austin, TX 78741 (US).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **MOSDEN, Aelan** [US/US]; 3 Justbrand Lane, Poughkeepsie, NY 12603 (US).

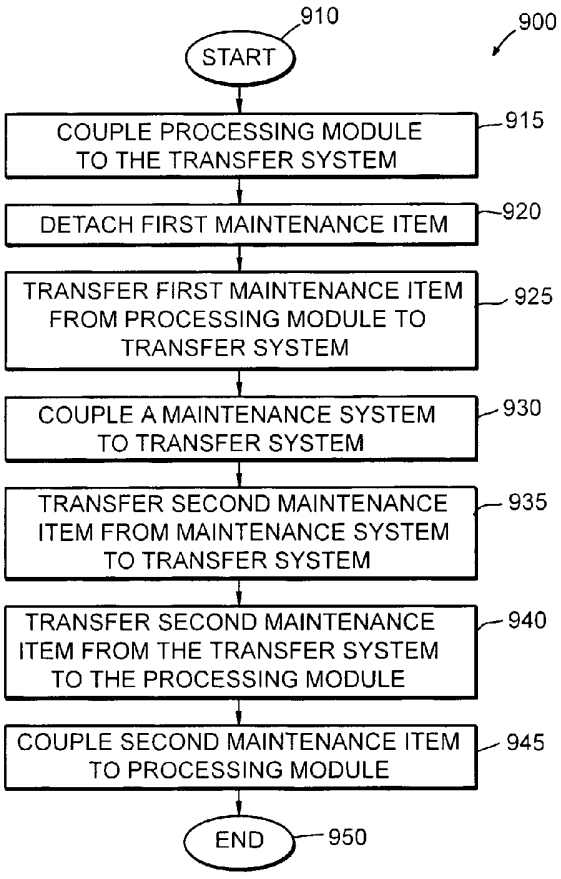
(74) Agents: **FREI, Donald, F.** et al.; Wood, Herron & Evans, L.L.P., 2700 Carew Tower, Cincinnati, OH 45202 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH,

[Continued on next page]

(54) Title: REPLACING CHAMBER COMPONENTS IN A VACUUM ENVIRONMENT



(57) Abstract: An apparatus (100) and method are provided for replacing parts in a vacuum chamber (131) without venting the vacuum. A transfer system (140) is used to transfer a removably mounted component (170) from a processing module (130) that is attached to a transfer system and replacing the component with another component from a maintenance system (110) that is connected through an isolation assembly to a transfer module. The maintenance system may include a supply of replacement parts and receive expended or otherwise serviceable items that are to be replaced. These serviceable items may include chamber component that has a tendency to degrade during processes being performed in the processing module. Typically, such items are etched or eroded away or accumulate coatings, requiring occasional removal and replacement. Focus rings (136), chamber shields, dark space shields, insulators, deposition baffles (146) and adaptors are some of the items requiring periodic replacement. Such items are installed in the process module in a way that permits their removal and replacement by a transfer arm or other transfer mechanism of the transfer system or otherwise by robotic mechanisms. The processing module may be an etching, deposition ALD, patterning, developing, metrology, thermal processing, cleaning or other module used in a vacuum process, particularly for processing of semiconductor wafers.

WO 2005/093116 A2

GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

REPLACING CHAMBER COMPONENTS IN A VACUUM ENVIRONMENT

Field of the Invention

[0001] The invention relates to a system and method for replacing chamber components, and more particularly to a system and method for replacing chamber components in a vacuum environment.

Background of the Invention

[0002] It is common in the routine maintenance of a vacuum chamber to require venting of a vacuum chamber in order to replace parts, which have been consumed or damaged in the normal operation of the chamber. Venting of these chambers typically has a negative effect on the operation of the vacuum chamber and causes the owners time and money to return the system to a normal state. If other methods could be used to perform these activities it would be advantageous to system owners.

[0003] One solution to this problem was addressed to a degree by Hurwitt in U.S. Patent No. 5,620,578, owned by applicant's assignee. Hurwitt proposes replacing a fixture or such other device that accumulates an undesired coating in a deposition module of a cluster tool by providing a service module having replacement devices therein and using a transfer arm in the transfer module of the tool to exchange the coated device in the deposition module with one of the replacement devices within the vacuum environment of the cluster tool. The example shown by Hurwitt envisions some releaseable mounting mechanism, such as a pin and slot structure, which requires some manipulation with actions by the transfer arm to remove the part being replaced and to install the replacement.

[0004] With the trend toward submicron features on semiconductor wafers being processed, emphasis is placed on avoiding particle generation. Manipulating parts with a transfer arm to lock and unlock them can produce unacceptable contamination. Further, modification of the wafer handling components of a processing tool, such as a transfer arm mechanism or wafer handler, cannot as a practical matter be required of the owner of the tool to accommodate the service of a module that is but one of many of which the tool owner may purchase. This limits the actions that a transfer arm can execute when removing and reattaching a part.

[0005] Accordingly, there remains a need to make the replacement of parts in the vacuum environment of a processing system more practical.

Summary of the Invention

[0006] The invention provides an apparatus and method for replacing parts in a vacuum chamber of a substrate processing system without venting the vacuum. Such processing systems are those of the types used for processing substrates such as semiconductor wafers. These processing systems typically include one or more processing modules, for example, deposition, etch, cleaning, heat treating or other processing modules, and a transfer system having transfer ports at a number of locations that communicate with the processing modules, with loadlocks and other loading devices, and to other systems. The transfer system transfers substrates among and through the ports and the modules and systems connected to them.

[0007] In accordance with the invention, the transfer system of the processing system is used to transfer parts or components of the processing system to and from the processing module for service or replacement. The parts are moved without excessive motions or special actions being performed by the transfer arm and without the kind of manipulation of mounting structure and fastening elements that can cause particle generation that can contaminate the chamber. Rather, the parts to be replaced are configured to be picked up by the normal motions of a transfer arm that are used in the handling of wafers to be processed, and actuators necessary to release and present the parts in a condition to be picked up by the transfer arm are provided in the process module. In many embodiments, a generic transfer module and transfer mechanism, such as a standard fork type end effector, can be used. In other embodiments, a modified end effector can be used, or a transfer arm or transfer module with minimal modification. In alternative embodiments, a separate transfer arm may be used for maintenance items that require a different end effector than is on the wafer transfer arm or the transfer arm that is configured to transfer wafers and other maintenance items. In addition, more than one transfer arm can be used to increase throughput.

[0008] In one described embodiment of the invention, a lift pin system is provided to raise an upwardly facing focus ring or peripheral deposition shield from around the perimeter of a wafer on a wafer support in an etching module or a deposition module. In another embodiment, actuators lower and release a deposition shield in a deposition module from the sputtering cathode assembly. In both cases, the part is moved into a position where it can be engaged at a peripheral edge configured for pick up by a wafer transfer arm. The part release features are provided without requiring mechanical or structural modification of the tool beyond the modules that are being provided.

[0009] The parts being replaced are typically those that are consumed or coated during the operation of the processing module such that they may need service or replacement. Those parts that routinely must be replaced particularly benefit from the invention. A maintenance system or maintenance module may be connected to the processing system to supply replacement parts or receive parts that are to be replaced, with the transfer system being used to move the parts between the maintenance system and the processing module.

[0010] The component parts and other items that are replaced according to the invention are referred to herein as maintenance items. These items may include chamber components that have a tendency to degrade as processes are performed in the processing module. Typically, such items are etched or eroded away or accumulate coatings, requiring their occasional removal and replacement. Focus rings, chamber shields, dark space shields, insulators, deposition baffles and adaptors are some of the items requiring periodic replacement.

[0011] The items that are to be replaced by the invention are mounted in the process module on structure that permits their removal and replacement by a transfer arm or other transfer mechanism of the transfer system. Port sizes on the processing module and maintenance module are large enough to allow the maintenance items to be passed through them.

[0012] The invention is particularly advantageous for use in replacing annular focus rings and perimeter shields that surround upwardly facing wafer supports in etching systems, where these annular members tend to be eroded by the etching process, requiring periodic replacement. In such systems, these annular maintenance items can be removably mounted on or around a wafer holder, being held in position only by gravity, where they can be picked up by a wafer transfer arm adapted for that purpose. Lift pins or other delivery or release mechanisms may be provided to facilitate the removable mounting of the maintenance items by a transfer arm. Shields in deposition chambers, where they tend to accumulate deposits of coating material, can also be easily replaced in this manner.

[0013] In accordance with embodiments of the invention, a processing system is provided with a transfer system capable of transferring a maintenance item to and from a processing module without exposing the processing module to an outside environment. The transfer system may also be capable of transferring a substrate to and from the processing module, or may be separate from a transfer module of the processing system provided for transferring substrates. An isolation assembly can be coupled between the

processing module and the transfer system that is configured for the maintenance item to pass through. A maintenance system may be coupled to the transfer system structure to store maintenance items to be transferred to, or after being transferred from, the processing module.

[0014] The transfer system may have a transfer arm, and an end effector, and a drive system to move the transfer arm and the end effector so as to pick up a removably mounted maintenance item and transfer it to and from a transfer plate or other support in the transfer system, a substrate holder or item mounting structure in the processing module, or a storage assembly in the maintenance system.

[0015] A processing system controller that controls the processing module and transfer system may be configured to control the maintenance system and transfer system related thereto.

[0016] The processing modules that have maintenance items that can be replaced using the invention include etching and deposition modules, ALD modules, patterning and developing modules, metrology and thermal processing modules, cleaning and other modules used in vacuum processing systems, particularly for processing of semiconductor wafers.

[0017] The replacement process according to certain embodiments of the invention includes removing the maintenance item that is to be replaced from its mounting structure in the processing module with the transfer arm or with other mechanisms provided for that purpose. Then the removed item is transferred from the processing module to the transfer system.

Brief Description of the Drawings

[0018] FIG. 1 illustrates an exemplary block diagram of a processing system according to an embodiment of the invention.

[0019] FIG. 1A illustrates one embodiment of a processing system of FIG. 1 in the form of an etch module showing the positioning of a focus ring for replacement by a transfer arm.

[0020] FIG. 1B illustrates another embodiment of a processing system of FIG. 1 in the form of a sputter deposition module showing the positioning of a deposition shield for replacement by the transfer arm.

[0021] FIG. 2 illustrates an exemplary block diagram of a transfer system and a processing module according to an embodiment of the invention.

[0022] FIG. 3 illustrates an exemplary block diagram of a transfer system and a maintenance system according to an embodiment of the invention.

[0023] FIG. 4A illustrates an exemplary block diagram of a processing system according to an embodiment of the invention.

[0024] FIG. 4B illustrates an exemplary block diagram of a transfer system, an exchange system, and a processing system according to an embodiment of the invention.

[0025] FIG. 5A illustrates an exemplary block diagram of a processing system according to an embodiment of the invention.

[0026] FIG. 5B illustrates an exemplary block diagram of a transfer system, an exchange system, and a maintenance system according to an embodiment of the invention.

[0027] FIG. 6A illustrates an exemplary block diagram of a processing system according to an embodiment of the invention.

[0028] FIG. 6B illustrates an exemplary block diagram of a transfer system, a processing module, an exchange system, and a maintenance system according to an embodiment of the invention.

[0029] FIG. 7A illustrates an exemplary block diagram of a processing system according to an embodiment of the invention.

[0030] FIG. 7B illustrates an exemplary block diagram of a processing module and a maintenance system according to an embodiment of the invention.

[0031] FIG. 8 illustrates a flow diagram of a method of operating a processing system in accordance with an embodiment of the invention.

[0032] FIG. 9 illustrates a flow diagram for another method of operating a processing system in accordance with an embodiment of the invention.

Detailed Description of Several Embodiments

[0034] In semiconductor processing systems, a number of processes are executed at reduced pressures. In order to reduce the maintenance time for processing modules, a maintenance system has been developed to replace consumable parts and other maintenance items without venting the process chamber/module to the atmosphere. Such maintenance items include consumable chamber components such as sputtering targets and other electrodes as well as members within a processing chamber such as clips, latches, shields, focus rings and structures having surfaces that can be eroded by etching or damaged by plasmas, heat, chemical reactions or other

causes. Such maintenance items can also include chamber components that are susceptible to accumulations of deposits, such as shields, structural clamps and structural members, sensors, electrodes, clamps and latches, columnators, and other components exposed to deposition material, reactive gases, plasmas or other processing elements.

[0035] FIG. 1 illustrates an exemplary block diagram of a processing system according to an embodiment of the invention. In the illustrated embodiment, a processing system 100 for processing a substrate is shown. The processing system 100 includes a transfer system 140, a processing module 130 coupled to the transfer system 140, and a maintenance system 110 coupled to the transfer system 140. The transfer system 140 is coupled to the maintenance system 110 in order to transfer maintenance items into and out of the maintenance system 110. The transfer system 140 is coupled to the processing module 130 in order to transfer maintenance items into and out of the processing module 130. In addition, the processing module 130 can exchange substrates with the transfer system 140. For example, the transfer system 140 permits the transfer of substrates and/or maintenance items to and from processing module 130. The processing module 130 can be the processing module of an etch system, an ALD system, a deposition system, a coating system, a patterning system, a developing system, a metrology system, a thermal processing system, a cleaning system, and combinations thereof.

[0036] Processing system 100 also comprises an isolation assembly 10 that can be utilized to couple the transfer system 140 to the processing module 130 and to isolate the transfer system 140 from the processing module 130. For instance, the isolation assembly 10 can comprise at least one of a thermal insulation assembly to provide thermal isolation, and a gate valve assembly to provide vacuum isolation. The isolation assembly has an opening between the processing module 130 and the transfer system 140 that is large enough to allow maintenance items to pass through. The isolation assembly 10 can be used to transfer maintenance items into and out of the processing module 130 either when the processing module 130 is coupled to the transfer system 140 or when the processing module 130 is not coupled to the transfer system 140.

[0037] In addition, the isolation assembly 10 can be used to transfer substrates into and out of the processing module 130 both when the processing module 130 is coupled to the transfer system 140 and when the processing module 130 is not coupled to the transfer system 140. For example, in one embodiment, gate valve assembly 10 can comprise two gate valves 10A and 10B, one attached to the processing module 130,

and one attached to the transfer system 140, respectively. Alternately, a different number of gate valves can be used. The isolation assembly 10 can be the same gate or other port assembly that is used to transfer substrates to and from the processing module 110 for processing, or it may be a separate isolation assembly dedicated to the transfer of maintenance items.

[0038] Processing system 100 also comprises an isolation assembly 11 that can be utilized to couple the transfer system 140 to the maintenance system 110 and to isolate the transfer system 140 from the maintenance system 110. For instance, the isolation assembly 11 can comprise at least one of a thermal insulation assembly to provide thermal isolation, and a gate valve assembly to provide vacuum isolation. The isolation assembly opening is large enough to allow maintenance items to pass through.

[0039] The isolation assembly 11 can be used to transfer maintenance items into and out of the maintenance system 110 both when the maintenance system 110 is coupled to the transfer system 140 and when the maintenance system 110 is not coupled to the transfer system 140. In one embodiment, gate valve assembly 11 can comprise two gate valves 11A and 11B, one gate valve 11B is attached to the maintenance system 110, and one gate valve 11A is attached to the transfer system 140. Alternately, a different number of gate valves can be used. The gate valve openings can be large enough to allow substrates and/or maintenance items to pass through.

[0040] In one embodiment, the maintenance system 110 can comprise a storage subsystem (not shown) that can be used to store maintenance items such as consumable parts or chamber components that might need to be replaced, serviced or reconditioned. Maintenance system 110 can be removably coupled to transfer system 140. Alternately, the maintenance system 110 can be fixedly coupled to the transfer system 140. For example, the gate valve(s) between the transfer system 140 and the maintenance system 110 can be opened; a maintenance item can be transferred between the transfer system and the maintenance system; the gate valve(s) between the transfer system 140 and the maintenance system 110 can be closed; and since the maintenance system and transfer system remain in a vacuum (evacuated) state, an isolated state can be preserved in the processing system. In addition, the gate valve(s) between the transfer system 140 and the processing module 130 can be opened; a maintenance item and/or substrate can be transferred between the transfer system and the processing module; the gate valve(s) between the transfer system 140 and the processing module 130 can be closed; and since the maintenance system and transfer

system remain in a vacuum (evacuated) state an isolated state can be preserved in the processing system.

[0041] In one embodiment, the gate valve 11B can be coupled to the maintenance system 110 and can be used to load maintenance items such as consumable parts. During processing, for example, the gate valve(s) between the transfer system 140 and the maintenance system 110 can be closed; the maintenance system can be decoupled from the transfer system; the gate valve 11B can be opened; a maintenance item can be transferred into or out of the maintenance system; the gate valve 11B can be can be closed; the maintenance system can be evacuated; the maintenance item can be stored in the maintenance system, and an isolated state can be preserved in the processing system.

[0042] In an alternate embodiment, the maintenance system 110 can comprise an additional opening (not shown) that can be used to load maintenance items such as consumable parts, either through a loadlock or otherwise from outside the vacuum environment or by docking with a cassette or transfer module. For example, the maintenance system 110 can merely be vented and opened into a controlled atmospheric pressure environment to exchange used parts with fresh ones. The maintenance system 110 can be removably coupled to transfer system 140. Alternately, maintenance system 110 can be fixedly coupled to the transfer system 140. During processing, for example, the gate valve(s) between the transfer system 140 and the maintenance system 110 can be closed; the additional opening (not shown) can be opened; a maintenance item can be positioned in the maintenance system; the additional opening (not shown) can be closed; the maintenance system can be evacuated; the gate valve(s) between the transfer system 140 and the maintenance system 110 can be opened; the maintenance item can be stored in the maintenance system and/or moved from the maintenance system to the transfer system, and an isolated state can be preserved in the processing system. In one embodiment, one maintenance system can be used for both new parts and used parts. Alternately, one maintenance system can be used for new parts and another maintenance system can be used for used parts.

[0043] In an alternate embodiment, maintenance system 110 can comprise a cleaning sub-system (not shown) that can clean a maintenance item and/or measuring subsystem for measuring a maintenance item.

[0044] In addition, a controller 160 can be coupled to the processing module 130, the maintenance system 110, and the transfer system 140. For example, controller 160

can be used to control the processing module 130, the maintenance system 110, the transfer system 140, and gate valve assemblies (10 and 11). Alternately, the controller 160 can be coupled to a controller (not shown) in the processing module 130, a controller (not shown) in the maintenance system 110, and a controller (not shown) in the transfer system 140. Also, the controller 160 can be coupled to a control element (not shown) in a multi-element manufacturing system (not shown).

[0045] FIG. 1A illustrates an embodiment of the system 100 of FIG. 1 wherein the processing module 130 is an etch module 130A having a vacuum processing chamber 131 with a plasma source 133 in the upper section 132 thereof with an upwardly facing wafer support 134 at the bottom. The plasma source energizes a plasma in the chamber 131 for etching a wafer 135 on the wafer support 134. A focus ring 136 is provided on the wafer support 134 to shape the electric fields so as to prevent an edge effect around the edge of the wafer 135 that undermines the etch uniformity. In the etching process, the focus ring 136 undergoes some etching, which necessitates its occasional replacement, making it a maintenance item in the context of the present invention. The focus ring 136 has a wafer shaped edge 137 that allows it to be easily handled by the wafer transfer arm 194 of a transfer mechanism 198 within a transfer module or transfer system 130. A set of lift pins 138 is provided in the wafer support 134 to lift the focus ring 136, on command from the controller 160, to present the focus ring 136 in position to be easily picked up and replaced by motion of the transfer arm 194.

[0046] Similarly, as illustrated in FIG. 1B, an embodiment of the system 100 of FIG. 1 is provided wherein the processing module 130 is a physical vapor deposition module 130B having a vacuum processing chamber 141 with a sputtering target 142 and a plasma source 143 in the upper section 132 thereof with an upwardly facing wafer support 134 at the bottom. The plasma source 142 energizes a high density plasma in the chamber 141 while a DC power source (not shown) energizes the sputtering target 142 for producing coating material for coating wafer 135 on the wafer support 134. A deposition shield 146 is provided at the plasma source 143 to protect a dielectric window 145 from deposition. In the deposition process, the deposition shield 146 accumulates deposition material, which necessitates its occasional replacement, making it a maintenance item in the context of the present invention. The deposition shield 146 has a wafer shaped edge 147 that allows it to be easily handled by the transfer arm 194 of a transfer mechanism 198 within a transfer module or transfer system 130. A set of lowering rods 148 is provided in the wafer support 134 to lower the deposition shield 146, on command from the controller 160, to present the deposition shield 146 in

position to be easily picked up and replaced by motion of the transfer arm 194. The lowering rods are configured to release the shield 146 by making a partial rotation.

[0047] FIG. 2 illustrates an exemplary block diagram of a transfer system and a processing module according to an embodiment of the invention. In the illustrated embodiment shown in FIG. 2, a processing module 130 is shown coupled to a transfer system 140. Alternately, a number of processing modules 130 can be coupled to a transfer system 140. In addition, a number of transfer systems 140 can be coupled to a processing module 130.

[0048] The transfer system 140 includes a transfer assembly 180, and transfer plate 184. The transfer assembly 180 can be used to move the transfer plate 184 in at least one direction in the transfer system 140. For example, the transfer plate 184 can be moved from one chamber to another, from one system to another, or from one position to another.

[0049] The transfer system 140 can also comprise an exchange system 190 for transferring substrates and/or maintenance items. Exchange system 190 can comprise a drive system 192, a transfer arm 194, and an end effector 196. The drive system 192 is used to move the transfer arm 194 and end effector horizontally, vertically, and rotationally in order to transfer substrates and/or maintenance items between the transfer system 140 and the processing module 130. Several transfer arms 194 and end effectors 196 are shown in FIG. 2 to illustrate some of the various positions for the transfer arm 194 and end effector 196. In one embodiment, one transfer arm 194 and one end effector 196 are used. Alternately, two transfer arms 194 and two end effectors 196 can be used to increase throughput. For example, one end effector can be used to transfer maintenance items and one end effector can be used to transfer substrates.

[0050] The exchange system 190 can be used to transfer a maintenance item 170A between the transfer plate 184 in the transfer system and the substrate holder 134 in the processing module. For example, the maintenance item 170A can be a ring, a shield, an insulator, an adapter, a plate or some other component that is removably mounted on or near the substrate holder. The exchange system 190 can also be used to transfer a substrate 170B between the transfer plate 184 in the transfer system and the substrate holder 134 in the processing module. For example, substrate 170B can be at least one of a production substrate, a dummy substrate, a test substrate, and a test device.

[0051] The exchange system 190 can be used to transfer a maintenance item 170C between the transfer plate 184 in the transfer system and the upper assembly 132

in the processing module. For example, maintenance item 170C can be a shield, an insulator, an adapter, an electrode, an antenna, or some other component of the processing chamber remote from the substrate holder.

[0052] Maintenance items that can be most easily replaced without breaking the vacuum of the system are those that are secured in place in simple ways, particularly those that are merely set in place and do not require complex fasteners or complicated securing structure. Such simply secured items can thus be removed and replaced with a transfer arm or otherwise robotically through the isolation assemblies. Other items can be redesigned to facilitate their easy removal and replacement with transfer arms.

[0053] FIG. 3 illustrates an exemplary block diagram of a transfer system and a maintenance system according to an embodiment of the invention. In the illustrated embodiment shown in FIG. 3, a maintenance system 110 is shown coupled to a transfer system 140. Alternately, a number of maintenance systems 110 can be coupled to a transfer system 140. In addition, a number of transfer systems 140 can be coupled to a maintenance system 110.

[0054] Transfer system 140 can comprise a transfer assembly 180 and transfer plate 184. The transfer assembly 180 can be used to move the transfer plate in at least one direction in the transfer system. For example, the transfer plate can be moved from one chamber to another, from one system to another, or from one position to another.

[0055] The transfer system 140 can also comprise an exchange system 190 for transferring substrates and/or maintenance items. The exchange system 190 can comprise a drive system 192, a transfer arm 194, and an end effector 196. The drive system 192 is used to move the transfer arm 194 and end effector horizontally, vertically, and rotationally in order to transfer substrates and/or maintenance items between the transfer system 140 and the maintenance system 110. Two transfer arms 194 and end effectors 196 are shown in FIG. 3 to illustrate some of the various positions for the transfer arm 194 and end effector 196. In one embodiment, one transfer arm 194 and one end effector 196 are used. Alternately, two transfer arms 194 and two end effectors 196 can be used to increase throughput. For example, one end effector can be used to transfer a new maintenance item and one end effector can be used to transfer a used maintenance item.

[0056] The exchange system 190 can be used to transfer a maintenance item 170A between the transfer plate 184 in the transfer system and the storage assembly 112 in the maintenance system. For example, maintenance item 170A can be at least one of a ring, a shield, an insulator, an adapter, and a plate. Exchange system 190 can

also be used to transfer a substrate 170B between the transfer plate 184 in the transfer system and the storage assembly 112 in the maintenance system. For example, substrate 170B can be at least one of a production substrate, a dummy substrate, a test substrate, and a test device.

[0057] FIG. 4A illustrates an exemplary block diagram of a processing system according to an embodiment of the invention. In the illustrated embodiment shown in FIG. 4A, a processing system 400 for processing a substrate is shown. Processing system 400 can comprise a transfer system 440, an exchange system 490 coupled to the transfer system 440, and a processing module 430 coupled to the exchange system 490. An exchange system 490 can be coupled to the processing module 430 in order to transfer maintenance items into and out of the processing module 430. In addition, an exchange system 490 can be coupled to the processing module 430 in order to transfer substrates into and out of the processing module 430. For example, the exchange system 490 can permit the transfer of substrates and/or maintenance items between the transfer system 440 and the processing module 430, and the processing module 430 can be associated with an etch system, ALD system, deposition system, coating system, patterning system, developing system, metrology system, thermal processing system, cleaning system, and combinations thereof.

[0058] The processing system 400 also comprises an isolation assembly 413 that can be utilized to couple the transfer system 440 to the exchange system 490 and to isolate the transfer system 440 from the exchange system 490. For instance, the isolation assembly 413 can comprise at least one of a thermal insulation assembly to provide thermal isolation, and a gate valve assembly to provide vacuum isolation. The isolation assembly opening is large enough to allow maintenance items to pass through. Isolation assembly 413 can be used to transfer maintenance items into and out of the exchange system 490 when the exchange system 490 is coupled to the transfer system 440 and when the exchange system 490 is not coupled to the transfer system 440. In addition, the isolation assembly 413 can be used to transfer substrates into and out of the exchange system 490 when the exchange system 490 is coupled to the transfer system 440.

[0059] In one embodiment, the gate valve assembly 413 can comprise two gate valves (413A and 413B), one (413B) attached to the exchange system 490, and one (413A) attached to the transfer system 440. Alternately, a different number of gate valves can be used.

[0060] The processing system 400 also comprises an isolation assembly 414 that can be utilized to couple the processing module 430 to the exchange system 490 and to isolate the processing module 430 from the exchange system 490. For instance, the isolation assembly 414 can comprise at least one of a thermal insulation assembly to provide thermal isolation, and a gate valve assembly to provide vacuum isolation. The isolation assembly opening is large enough to allow maintenance items to pass through. The isolation assembly 414 can be used to transfer maintenance items and/or substrates between the processing module 430 and the exchange system 490 when the exchange system 490 is coupled to the processing module 430. In addition, the exchange system 490 can be used to transfer maintenance items and/or substrates between the transfer system 440 and the processing system 430 when the exchange system 490 is coupled to the transfer system 440 and the processing system 430.

[0061] In one embodiment, the gate valve assembly 414 can comprise two gate valves (414A and 414B), one (414A) attached to the exchange system 490, and one (414B) attached to the processing system 430. Alternately, a different number of gate valves can be used.

[0062] In one embodiment, the exchange system 490 is used to transfer maintenance items such as consumable parts. Alternately, the exchange system 490 can comprise a storage means (not shown) that can be used to store maintenance items such as consumable parts. The exchange system 490 can be removably coupled to the transfer system 440. In an alternate embodiment, the exchange system 490 can be fixedly coupled to the transfer system 440.

[0063] During processing, for example, the gate valve(s) between the transfer system 440 and the exchange system 490 can be opened; a maintenance item can be transferred between the transfer system and the exchange system; the gate valve(s) between the transfer system 440 and the exchange system 490 can be closed; and since the exchange system and transfer system remain in a vacuum (evacuated) state, an isolated state can be preserved in the processing system. In addition, the gate valve(s) between the exchange system 490 and the processing module 430 can be opened; a maintenance item and/or substrate can be transferred between the transfer system and the processing module; the gate valve(s) between the exchange system 490 and the processing module 430 can be closed; and since the exchange system and transfer system remain in a vacuum (evacuated) state, an isolated state can be preserved in the processing system.

[0064] In an alternate embodiment, the exchange system 490 can comprise means for cleaning a maintenance item and/or measuring a maintenance item.

[0065] In addition, a controller 460 can be coupled to the processing module 430, the exchange system 490, and the transfer system 440. For example, the controller 460 can be used to control the processing module 430, the exchange system 490, and the transfer system 440. Alternately, the controller 460 can be coupled to a controller (not shown) in the processing module 430, a controller (not shown) in the exchange system 490, and a controller (not shown) in the transfer system 440. Also, the controller 460 can be coupled to a control element (not shown) in a multi-element manufacturing system (not shown).

[0066] FIG. 4B illustrates an exemplary block diagram of a transfer system, an exchange system, and a processing system according to an embodiment of the invention. In the illustrated embodiment shown in FIG. 4B, an exchange system 490 is shown coupled to a processing module 430 and to a transfer system 440. Alternately, a number of processing modules 430 can be coupled to an exchange system 490. In addition, a number of transfer systems 440 can be coupled to an exchange system 490.

[0067] The transfer system 440 can comprise a transfer assembly 480 and transfer plate 484. The transfer assembly 480 can be used to move transfer plate in at least one direction in the transfer system. For example, the transfer plate can be moved from one chamber to another, from one system to another, or from one position to another. The transfer plate 484 can be used to hold a substrate and/or maintenance item.

[0068] Transfer system 440 can be coupled to an exchange system 490 for transferring substrates and/or maintenance items. The exchange system 490 can comprise a drive system 492, a transfer arm 494, and an end effector 496. The drive system 492 is used to move the transfer arm 494 and end effector horizontally, vertically, and rotationally in order to transfer substrates and/or maintenance items between the transfer system 440 and the processing module 430. Several transfer arms 494 and end effectors 496 are shown in FIG. 4B to illustrate some of the various positions for the transfer arm 494 and end effector 496. In one embodiment, one transfer arm 494 and one end effector 496 are used. Alternately, two transfer arms 494 and two end effectors 496 can be used to increase throughput.

[0069] The exchange system 490 can be used to transfer a maintenance item 470A between the transfer plate 484 in the transfer system and the substrate holder 434 in the processing module. For example, maintenance item 470A can be at least one of a

ring, a shield, an insulator, an adapter, and a plate. The exchange system 490 can also be used to transfer a substrate 470B between the transfer plate 484 in the transfer system and the substrate holder 434 in the processing module. For example, substrate 470B can be at least one of a production substrate, a dummy substrate, a test substrate, and a test device.

[0070] The exchange system 490 can be used to transfer a maintenance item 470C between the transfer plate 484 in the transfer system and the upper assembly 432 in the processing module. For example, maintenance item 470C can be at least one of a ring, a shield, an insulator, an adapter, and a plate.

[0071] FIG. 5A illustrates an exemplary block diagram of a processing system according to an embodiment of the invention. In the illustrated embodiment shown in FIG. 5A, a processing system 500 for processing a substrate is shown. The processing system 500 can comprise a transfer system 540, an exchange system 590 coupled to the transfer system 540, and a maintenance system 510 coupled to the exchange system 590. The maintenance system 510 can be used for storing and/or transporting substrates and/or maintenance items. In an alternate embodiment, the maintenance system 510 can comprise means for cleaning and/or measuring a maintenance item. An exchange system 590 can be coupled to the maintenance system 510 in order to transfer substrates and/or maintenance items into and out of the maintenance system 510.

[0072] The processing system 500 also comprises an isolation assembly 515 that can be utilized to couple the transfer system 540 to the exchange system 590 and to isolate the transfer system 540 from the exchange system 590. For instance, the isolation assembly 515 can comprise at least one of a thermal insulation assembly to provide thermal isolation, and a gate valve assembly to provide vacuum isolation. The isolation assembly opening is large enough to allow maintenance items to pass through. Isolation assembly 515 can be used to transfer maintenance items into and out of the exchange system 590 when the exchange system 590 is coupled to the transfer system 540 and when the exchange system 590 is not coupled to the transfer system 540. In addition, the isolation assembly 515 can be used to transfer substrates into and out of the exchange system 590 when the exchange system 590 is coupled to the transfer system 540.

[0073] In one embodiment, gate valve assembly 515 can comprise two gate valves (515A and 515B), one (515B) attached to the exchange system 590, and one

(515A) attached to the transfer system 540. Alternately, a different number of gate valves can be used.

[0074] The processing system 500 also comprises an isolation assembly 516 that can be utilized to couple the maintenance system 510 to the exchange system 590 and to isolate the maintenance system 510 from the exchange system 590. For instance, the isolation assembly 516 can comprise at least one of a thermal insulation assembly to provide thermal isolation, and a gate valve assembly to provide vacuum isolation. The isolation assembly opening is large enough to allow maintenance items to pass through. Isolation assembly 516 can be used to transfer maintenance items and/or substrates between the maintenance system 510 and the exchange system 590 when the exchange system 590 is coupled to the maintenance system 510. In addition, the exchange system 590 can be used to transfer maintenance items and/or substrates between the transfer system 540 and the maintenance system 510 when the exchange system 590 is coupled to the transfer system 540 and the maintenance system 510.

[0075] In one embodiment, gate valve assembly 516 can comprise two gate valves (516A and 516B), one (516A) attached to the exchange system 590, and one (516B) attached to the maintenance system 510. Alternately, a different number of gate valves can be used.

[0076] In one embodiment, the exchange system 590 is used to transfer maintenance items such as consumable parts. Alternately, the exchange system 590 can comprise a storage means (not shown) that can be used to store maintenance items such as consumable parts. The exchange system 590 can be removably coupled to the transfer system 540. In an alternate embodiment, the exchange system 590 can be fixedly coupled to the transfer system 540.

[0077] During processing, for example, the gate valve(s) between the transfer system 540 and the exchange system 590 can be opened; a maintenance item can be transferred between the transfer system and the exchange system; the gate valve(s) between the transfer system 540 and the exchange system 590 can be closed; and since the exchange system and transfer system remain in a vacuum (evacuated) state, an isolated state can be preserved in the processing system. In addition, the gate valve(s) between the exchange system 590 and the maintenance system 510 can be opened; a maintenance item and/or substrate can be transferred between the exchange system and the maintenance system; the gate valve(s) between the exchange system 590 and the maintenance system 510 can be closed; and since the exchange system

and maintenance system remain in a vacuum (evacuated) state, an isolated state can be preserved in the processing system.

[0078] In addition, a controller 560 can be coupled to the maintenance system 510, the exchange system 590, and the transfer system 540. For example, the controller 560 can be used to control the maintenance system 510, the exchange system 590, and the transfer system 540. Alternately, the controller 560 can be coupled to a controller (not shown) in the maintenance system 510, a controller (not shown) in the exchange system 590, and a controller (not shown) in the transfer system 540. Also, the controller 560 can be coupled to a control element (not shown) in a multi-element manufacturing system (not shown).

[0079] FIG. 5B illustrates an exemplary block diagram of a transfer system, an exchange system, and a maintenance system according to an embodiment of the invention. In the illustrated embodiment shown in FIG. 5B, an exchange system 590 is shown coupled to a maintenance system 510 and to a transfer system 540. Alternately, a number of exchange systems 590 can be coupled to a transfer system 540. In addition, a number of exchange systems 590 can be coupled to a maintenance system 510. In addition, a number of maintenance systems 510 can be coupled to an exchange system 590.

[0080] The transfer system 540 can comprise a transfer assembly 580 and transfer plate 584. The transfer assembly 580 can be used to move the transfer plate in at least one direction in the transfer system. For example, the transfer plate can be moved from one chamber to another, from one system to another, or from one position to another. The transfer plate 584 can be used to hold a substrate and/or maintenance item.

[0081] The transfer system 540 can be coupled to an exchange system 590 for transferring substrates and/or maintenance items. The exchange system 590 can comprise a drive system 592, a transfer arm 594, and an end effector 596. The drive system 592 is used to move the transfer arm 594 and end effector horizontally, vertically, and rotationally in order to transfer substrates and/or maintenance items between the transfer system 540 and the maintenance system 510. Two transfer arms 594 and end effectors 596 are shown in FIG. 5B to illustrate some of the various positions for the transfer arm 594 and end effector 596. In one embodiment, one transfer arm 594 and one end effector 596 are used. Alternately, two transfer arms 594 and two end effectors 596 can be used to increase throughput.

[0082] The exchange system 590 can be used to transfer a maintenance item 570A between the transfer plate 584 in the transfer system and the storage assembly 512 in the maintenance system. For example, maintenance item 570A can be at least one of a ring, a shield, an insulator, an adapter, and a plate. The exchange system 590 can also be used to transfer a substrate 570B between the transfer plate 584 in the transfer system and the storage assembly 512 in the maintenance system. For example, substrate 570B can be at least one of a production substrate, a dummy substrate, a test substrate, and a test device.

[0083] FIG. 6A illustrates an exemplary block diagram of a processing system according to an embodiment of the invention. In the illustrated embodiment shown in FIG. 6A, a processing system 600 for processing a substrate is shown. The processing system 600 can comprise a transfer system 640, a processing module 630 coupled to the transfer system 640, an exchange system 690 coupled to the processing module 630, and a maintenance system 610 coupled to the exchange system 690.

[0084] A maintenance system 610 can be used for storing and/or transporting substrates and/or maintenance items. The maintenance system 610 can be coupled to additional systems that can include processing modules, transfer systems, and exchange systems. In an alternate embodiment, the maintenance system 610 can comprise means for measuring and/or cleaning a maintenance item.

[0085] The exchange system 690 can be coupled to the processing module 630 and the maintenance system 610 in order to transfer substrates and/or maintenance items between the maintenance system 610 and the processing module 630. The exchange system 690 can be coupled to additional systems that can include processing modules, transfer systems, and maintenance systems.

[0086] In addition, the transfer system 640 can permit the transfer of substrates between the transfer system 640 and the processing module 630. Alternately, the transfer system 640 can permit the transfer of maintenance items between the transfer system 640 and the processing module 630. The transfer system 640 can be coupled to additional systems that can include processing modules, exchange systems, and maintenance systems.

[0087] The processing system 600 can comprise at least one of an etch system, a deposition system, coating system, patterning system, developing system, metrology system, thermal processing system, and lithography system. The processing system 600 can be coupled to additional systems that can include transfer systems, exchange systems, and maintenance systems.

[0088] Processing system 600 also comprises an isolation assembly 617 that can be utilized to couple the transfer system 640 to the processing module 630 and to isolate the transfer system 640 from the processing module 630. For instance, the isolation assembly 617 can comprise at least one of a thermal insulation assembly to provide thermal isolation, and a gate valve assembly to provide vacuum isolation. The isolation assembly opening is large enough to allow maintenance items and/or substrates to pass through. Isolation assembly 617 can be used to transfer substrates into and out of processing module 630 when processing module 630 is coupled to transfer system 640. In an alternate embodiment, isolation assembly 617 can be used to transfer maintenance items into and out of the processing module 630 when the processing module 630 is coupled to the transfer system 640 and when the processing module 630 is not coupled to the transfer system 640.

[0089] In one embodiment, gate valve assembly 617 can comprise two gate valves (617A and 617B), one (617B) attached to the processing module 630, and one (617A) attached to the transfer system 640. Alternately, a different number of gate valves can be used.

[0090] Processing system 600 also comprises an isolation assembly 618 that can be utilized to couple the processing module 630 to the exchange system 690 and to isolate the processing module 630 from the exchange system 690. For instance, the isolation assembly 618 can comprise at least one of a thermal insulation assembly to provide thermal isolation, and a gate valve assembly to provide vacuum isolation. The isolation assembly opening is large enough to allow maintenance items to pass through. The isolation assembly 618 can be used to transfer maintenance items between the processing module 630 and the exchange system 690 when the exchange system 690 is coupled to the processing module 630.

[0091] In one embodiment, the gate valve assembly 618 can comprise two gate valves (618A and 618B), one (618A) attached to the exchange system 690, and one (618B) attached to the maintenance system 610. Alternately, a different number of gate valves can be used.

[0092] The processing system 600 also comprises an isolation assembly 619 that can be utilized to couple the maintenance system 610 to the exchange system 690 and to isolate the maintenance system 610 from the exchange system 690. For instance, the isolation assembly 619 can comprise at least one of a thermal insulation assembly to provide thermal isolation, and a gate valve assembly to provide vacuum isolation. The isolation assembly opening is large enough to allow maintenance items to

pass through. The isolation assembly 619 can be used to transfer maintenance items between the maintenance system 610 and the exchange system 690 when the exchange system 690 is coupled to the maintenance system 610.

[0093] In addition, the exchange system 690 can be used to transfer maintenance items between the processing module 630 and the maintenance system 610 when the exchange system 690 is coupled to the processing module 630 and the maintenance system 610.

[0094] In one embodiment, gate valve assembly 619 can comprise two gate valves (619A and 619B), one (619A) attached to the exchange system 690, and one (619B) attached to the maintenance system 610. Alternately, a different number of gate valves can be used.

[0095] In one embodiment, the exchange system 690 is used to transfer maintenance items such as consumable parts. Alternately, the exchange system 690 can comprise a storage means (not shown) that can be used to store maintenance items such as consumable parts. The exchange system 690 can be removably coupled to the processing module 630. In an alternate embodiment, the exchange system 690 can be fixedly coupled to the processing module 630. The exchange system 690 can be removably coupled to the maintenance system 610. In an alternate embodiment, the exchange system 690 can be fixedly coupled to the maintenance system 610.

[0096] During processing, for example, the gate valve(s) between the processing module 630 and the exchange system 690 can be opened; a maintenance item can be transferred between the processing module and the exchange system; the gate valve(s) between the processing module 630 and the exchange system 690 can be closed; and since the exchange system and processing module remain in a vacuum (evacuated) state, an isolated state can be preserved in the processing system. In addition, the gate valve(s) between the exchange system 690 and the maintenance system 610 can be opened; a maintenance item and/or substrate can be transferred between the exchange system and the maintenance system; the gate valve(s) between the exchange system 690 and the maintenance system 610 can be closed; and since the exchange system and maintenance system remain in a vacuum (evacuated) state, an isolated state can be preserved in the processing system.

[0097] In addition, a controller 660 can be coupled to the maintenance system 610, the processing module 630, the exchange system 690, and the transfer system 640. For example, the controller 660 can be used to control the maintenance system 610, the processing module 630, the exchange system 690, and the transfer system

640. Alternately, the controller 660 can be coupled to a controller (not shown) in the processing module 630, a controller (not shown) in the exchange system 690, and a controller (not shown) in the transfer system 640. In addition, the controller 660 can be coupled to a control element (not shown) in a multi-element manufacturing system (not shown).

[0098] FIG. 6B illustrates an exemplary block diagram of a transfer system, a processing module, an exchange system, and a maintenance system according to an embodiment of the invention. In the illustrated embodiment shown in FIG. 6B, a processing module 630 is shown coupled to an exchange system 690 and to a transfer system 640. In addition, a maintenance system 610 is coupled to the exchange system 690.

[0099] The exchange system 690 is coupled between the maintenance system 610 and the processing module 630, and can be used for transferring substrates and/or maintenance items between the maintenance system 610 and the processing module 630. The exchange system 690 can comprise a drive system 692, a transfer arm 694, and an end effector 696. The drive system 692 is used to move the transfer arm 694 and end effector horizontally, vertically, and rotationally in order to transfer substrates and/or maintenance items between the transfer system 640 and the maintenance system 610. Several transfer arms 694 and end effectors 696 are shown in FIG. 6B to illustrate some of the various positions for the transfer arm 694 and end effector 696. In one embodiment, one transfer arm 694 and one end effector 696 are used. Alternately, two transfer arms 694 and two end effectors 696 can be used to increase throughput.

[00100] The exchange system 690 can be used to transfer a maintenance item 670A between the storage assembly 612 in the maintenance system and the substrate holder 634 in the processing module. For example, maintenance item 670A can be at least one of a ring, a shield, an insulator, an adapter, and a plate. The exchange system 690 can also be used to transfer a substrate 670B between the storage assembly 612 in the maintenance system and the substrate holder 634 in the processing module. For example, substrate 670B can be at least one of a production substrate, a dummy substrate, a test substrate, and a test device.

[00101] The exchange system 690 can be used to transfer a maintenance item 670C between the storage assembly 612 in the maintenance system and the upper assembly 632 in the processing module 630. For example, maintenance item 670C can be at least one of a ring, a shield, an insulator, an adapter, and a plate.

[00102] FIG. 7A illustrates an exemplary block diagram of a processing system according to an embodiment of the invention. In the illustrated embodiment shown in FIG. 7A, a processing system 700 for processing a substrate is shown. The processing system 700 can comprise a transfer system 740, a processing module 730 coupled to the transfer system 740, and a maintenance system 795 coupled to the processing module 730.

[00103] A maintenance system 795 can be used for storing and/or transporting substrates and/or maintenance items. The maintenance system 795 can be coupled to additional systems that can include processing modules, transfer systems, and exchange systems. In an alternate embodiment, the maintenance system 795 can comprise means for measuring and/or cleaning a maintenance item.

[00104] In addition, the transfer system 740 can permit the transfer of substrates between the transfer system 740 and the processing module 730. Alternately, the transfer system 740 can permit the transfer of maintenance items between the transfer system 740 and the processing module 730. The transfer system 740 can be coupled to additional systems that can include processing modules, exchange systems, and maintenance systems.

[00105] The processing system 700 can comprise at least one of an etch system, a deposition system, coating system, patterning system, developing system, metrology system, thermal processing system, and lithography system. The processing system 700 can be coupled to additional systems that can include transfer systems, exchange systems, and maintenance systems.

[00106] Processing system 700 also comprises an isolation assembly 721 that can be utilized to couple the transfer system 740 to the processing module 730 and to isolate the transfer system 740 from the processing module 730. For instance, the isolation assembly 721 can comprise at least one of a thermal insulation assembly to provide thermal isolation, and a gate valve assembly to provide vacuum isolation. The isolation assembly opening is large enough to allow substrates to pass through. The isolation assembly 721 can be used to transfer substrates into and out of processing module 730 when the processing module 630 is coupled to the transfer system 640. In an alternate embodiment, the isolation assembly 721 can be used to transfer maintenance items into and out of the processing module 730 when the processing module 730 is coupled to the transfer system 740 and when the processing module 730 is not coupled to the transfer system 740.

[00107] In one embodiment, gate valve assembly 617 can comprise two gate valves (721A and 721B), one (721B) attached to the processing module 730, and one (721A) attached to the transfer system 740. Alternately, a different number of gate valves can be used.

[00108] Processing system 700 also comprises an isolation assembly 722 that can be utilized to couple the maintenance system 795 to the processing module 730 and to isolate the maintenance system 795 from the processing module 730. For instance, the isolation assembly 722 can comprise at least one of a thermal insulation assembly to provide thermal isolation, and a gate valve assembly to provide vacuum isolation. The isolation assembly opening is large enough to allow maintenance items to pass through. The isolation assembly 722 can be used to transfer maintenance items between the maintenance system 795 and the processing module 730 when the processing module 730 is coupled to the maintenance system 795.

[00109] In one embodiment, gate valve assembly 722 can comprise two gate valves (722A and 722B), one (722A) attached to the processing module 730, and one (722B) attached to the maintenance system 795. Alternately, a different number of gate valves can be used.

[00110] In one embodiment, maintenance system 795 is used to transfer maintenance items such as consumable parts. In addition, maintenance system 795 can comprise a storage means (not shown) that can be used to store maintenance items such as consumable parts. The maintenance system 795 can be removably coupled to the processing module 730. In an alternate embodiment, the maintenance system 795 can be fixedly coupled to the processing module 730.

[00111] During processing, for example, the gate valve(s) between the processing module 730 and the maintenance system 795 can be opened; a maintenance item can be transferred between the processing module and the maintenance system; the gate valve(s) between the processing module 630 and the maintenance system 795 can be closed; and since the maintenance system and processing module remain in a vacuum (evacuated) state, an isolated state can be preserved in the processing system.

[00112] In one embodiment, gate valve 722B can be coupled to the maintenance system 795 and can be used to load maintenance items such as consumable parts. After processing, for example, the gate valve(s) between the processing module 730 and the maintenance system 795 can be closed; the maintenance system can be decoupled from the processing module; gate valve 722B can be opened; a maintenance item can be transferred into or out of the maintenance system; gate valve 722B can be can be

closed; the maintenance system can be evacuated; the maintenance item can be stored in the maintenance system, and an isolated state can be preserved in the processing system. Subsequently, the maintenance system can be coupled to the processing module and a maintenance item can be transferred between the processing module and the maintenance system.

[00113] In an alternate embodiment, maintenance system 795 can comprise an additional opening (not shown) that can be used to load maintenance items such as consumable parts. The maintenance system 795 can be removably coupled to the processing module 730. Alternately, the maintenance system 110 can be fixedly coupled to the processing module 730. After processing, for example, the gate valve(s) between the processing module 730 and the maintenance system 795 can be closed; the additional opening (not shown) can be opened; a maintenance item can be positioned in the maintenance system; the additional opening (not shown) can be closed; the maintenance system can be evacuated; the gate valve(s) between the processing module 730 and the maintenance system 795 can be opened; the maintenance item can be stored in the maintenance system and/or moved from the maintenance system to the processing module, and an isolated state can be preserved in the processing system. In one embodiment, one maintenance system can be used for new and used parts. Alternately, one maintenance system can be used for new parts and another maintenance system can be used for used parts.

[00114] In addition, a controller 760 can be coupled to the maintenance system 795, the processing module 730, and the transfer system 740. For example, controller 760 can be used to control the maintenance system 795, the processing module 730, and the transfer system 740. Alternately, controller 760 can be coupled to a controller in the processing module 730, a controller in the maintenance system 795, and a controller in the transfer system 740. In addition, controller 760 can be coupled to a control element (not shown) in a multi-element manufacturing system (not shown).

[00115] FIG. 7B illustrates an exemplary block diagram of a processing module and a maintenance system according to an embodiment of the invention. In the illustrated embodiment shown in FIG. 7B, a processing module 730 is shown coupled to a maintenance system 795.

[00116] The maintenance system 795 comprises an exchange system 790 that can be used for transferring substrates and/or maintenance items between the maintenance system 795 and the processing module 730. The exchange system 790 can comprise a drive system 792, a transfer arm 794, and an end effector 796. The

drive system 792 is used to move the transfer arm 794 and end effector horizontally, vertically, and rotationally in order to transfer substrates and/or maintenance items between the transfer system 740 and the maintenance system 710. Several transfer arms 794 and end effectors 796 are shown in FIG. 7B to illustrate some of the various positions for the transfer arm 794 and end effector 796. In one embodiment, one transfer arm 794 and one end effector 796 are used. Alternately, two transfer arms 794 and two end effectors 796 can be used to increase throughput.

[00117] The exchange system 790 can be used to transfer a maintenance item 770A between the storage assembly 712 in the maintenance system and the substrate holder 734 in the maintenance system. For example, maintenance item 770A can be at least one of a ring, a shield, an insulator, an adapter, and a plate. The exchange system 790 can also be used to transfer a substrate 770B between the storage assembly 712 in the maintenance system and the substrate holder 734 in the maintenance system. For example, substrate 770B can be at least one of a production substrate, a dummy substrate, a test substrate, and a test device.

[00118] The exchange system 790 can be used to transfer a maintenance item 770C between the storage assembly 712 in the maintenance system and the upper assembly 732 in the processing module 730. For example, maintenance item 770C can be at least one of a ring, a shield, an insulator, an adapter, and a plate.

[00119] FIG. 8 illustrates a flow diagram of a method of operating a processing system in accordance with an embodiment of the invention. Procedure 800 starts in 810.

[00120] In 820, an exchange system removes a first removably mounted maintenance item or a substrate out of a processing module in a processing system.

[00121] In one case, the exchange system can be a part of a transfer system and can transfer the first removably mounted maintenance item or a substrate to a transfer plate in the transfer system. For example, a transfer system can comprise a first transfer plate for transferring maintenance items and a second transfer plate for transferring substrates. In addition, the transfer system can comprise a transfer plate configured for transferring maintenance items and/or substrates.

[00122] In another case, the exchange system can be a part of a transfer system and can transfer the first removably mounted maintenance item or a substrate to a holding plate in the transfer system. For example, a transfer system can comprise a first holding plate for holding maintenance items and a second holding plate for holding substrates. Also, the transfer system can comprise a holding plate configured for holding maintenance items and/or substrates

[00123] In another case, the exchange system can be coupled to a transfer system and a processing system and can transfer the first removably mounted maintenance item or a substrate to a transfer plate in the transfer system. For example, a transfer system can comprise a first transfer plate for transferring maintenance items and a second transfer plate for transferring substrates. In addition, the transfer system can comprise a transfer plate configured for transferring maintenance items and/or substrates.

[00124] In another case, the exchange system can be coupled to a transfer system and a processing system and can transfer the first removably mounted maintenance item or a substrate to a holding plate in the exchange system. For example, an exchange system can comprise a first holding plate for holding maintenance items and a second transfer plate for holding substrates. In addition, the exchange system can comprise a holding plate configured for holding maintenance items and/or substrates.

[00125] In another case, the exchange system can be coupled to a maintenance system and a processing system and can transfer the first removably mounted maintenance item or a substrate to a storage assembly in the transfer system. For example, a maintenance system can comprise a first storage assembly for holding maintenance items and a second storage assembly for holding substrates. In addition, the maintenance system can comprise a storage assembly configured for holding maintenance items and/or substrates.

[00126] In another case, the exchange system can be coupled to a maintenance system and a processing system and can transfer the first removably mounted maintenance item or a substrate to a holding plate in the exchange system. For example, an exchange system can comprise a first holding plate for holding maintenance items and a second transfer plate for holding substrates. In addition, the exchange system can comprise a holding plate configured for holding maintenance items and/or substrates.

[00127] In another case, the exchange system can be part of a maintenance system that is coupled to a processing system and can transfer the first removably mounted maintenance item or a substrate to a storage assembly in the maintenance system. For example, a maintenance system can comprise a first storage assembly for holding maintenance items and a second storage assembly for holding substrates. In addition, the maintenance system can comprise a storage assembly configured for holding maintenance items and/or substrates.

[00128] In another case, the exchange system can be part of a maintenance system that is coupled to a processing system and can transfer the first removably mounted maintenance item or a substrate to a holding plate in the maintenance system. For example, a maintenance system can comprise a first holding plate for holding maintenance items and a second transfer plate for holding substrates. In addition, the maintenance system can comprise a holding plate configured for holding maintenance items and/or substrates.

[00129] In 830, the exchange system can transfer a second removably mounted maintenance item or a wafer into the processing module.

[00130] In one case, the exchange system can be a part of a transfer system and can transfer the second removably mounted maintenance item or a substrate from a transfer plate in the transfer system. For example, a transfer system can comprise a first transfer plate for transferring maintenance items and a second transfer plate for transferring substrates. In addition, the transfer system can comprise a transfer plate configured for transferring maintenance items and/or substrates.

[00131] In another case, the exchange system can be a part of a transfer system and can transfer the second removably mounted maintenance item or a substrate from a holding plate in the transfer system. For example, a transfer system can comprise a first holding plate for holding maintenance items and a second holding plate for holding substrates. Also, the transfer system can comprise a holding plate configured for holding maintenance items and/or substrates.

[00132] In another case, the exchange system can be coupled to a transfer system and a processing system and can transfer the second removably mounted maintenance item or a substrate from a transfer plate in the transfer system. For example, a transfer system can comprise a first transfer plate for transferring maintenance items and a second transfer plate for transferring substrates. In addition, the transfer system can comprise a transfer plate configured for transferring maintenance items and/or substrates.

[00133] In another case, the exchange system can be coupled to a transfer system and a processing system and can transfer the second removably mounted maintenance item or a substrate from a holding plate in the exchange system. For example, an exchange system can comprise a first holding plate for holding maintenance items and a second transfer plate for holding substrates. In addition, the exchange system can comprise a holding plate configured for holding maintenance items and/or substrates.

[00134] In another case, the exchange system can be coupled to a maintenance system and a processing system and can transfer the second removably mounted maintenance item or a substrate from a storage assembly in the transfer system. For example, a maintenance system can comprise a first storage assembly for holding maintenance items and a second storage assembly for holding substrates. In addition, the maintenance system can comprise a storage assembly configured for holding maintenance items and/or substrates.

[00135] In another case, the exchange system can be coupled to a maintenance system and a processing system and can transfer the second removably mounted maintenance item or a substrate from a holding plate in the exchange system. For example, an exchange system can comprise a first holding plate for holding maintenance items and a second transfer plate for holding substrates. In addition, the exchange system can comprise a holding plate configured for holding maintenance items and/or substrates.

[00136] In another case, the exchange system can be part of a maintenance system that is coupled to a processing system and can transfer the second removably mounted maintenance item or a substrate from a storage assembly in the maintenance system. For example, a maintenance system can comprise a first storage assembly for holding maintenance items and a second storage assembly for holding substrates. In addition, the maintenance system can comprise a storage assembly configured for holding maintenance items and/or substrates.

[00137] In another case, the exchange system can be part of a maintenance system that is coupled to a processing system and can transfer the second removably mounted maintenance item or a substrate from a holding plate in the maintenance system. For example, a maintenance system can comprise a first holding plate for holding maintenance items and a second transfer plate for holding substrates. In addition, the maintenance system can comprise a holding plate configured for holding maintenance items and/or substrates.

[00138] Procedure 800 ends in 840.

[00139] In an alternate embodiment, the exchange system can comprise two transfer means; the first transfer means can be used to transfer the first removably mounted maintenance item or substrate; and the second transfer means can be used to transfer the second removably mounted maintenance item or substrate.

[00140] FIG. 9 illustrates a flow diagram for another method of operating a processing system in accordance with an embodiment of the invention. Procedure 900 starts in 910.

[00141] In 915, a processing module is coupled to a first position in a transfer system using a first isolation assembly. The processing module can comprise a first maintenance item, and the first maintenance item can be removably mounted in the process module. For example, the processing module can be an etching module and can comprise a maintenance item for an etching module, and the maintenance item can be removably mounted in the etching module.

[00142] In 920, the first maintenance item can be detached from the processing module. For example, a maintenance item can be lifted off a substrate holder or can be decoupled from an upper assembly.

[00143] In 925, the first maintenance item can be transferred from the processing module to the transfer system. The transfer system can comprise a first exchange system for transferring the first maintenance item between the transfer system and the processing module through the first isolation assembly without exposing the processing module to an outside environment.

[00144] In 930, a maintenance system can be coupled to a second position in the transfer system using a second isolation assembly. The maintenance system can comprise a second maintenance item, and the second maintenance item can be removably mounted in the process module.

[00145] In 935, the second maintenance item can be transferred from the maintenance system to the transfer system. The transfer system can comprise a second exchange system for transferring the maintenance item between the maintenance system and the transfer system through the second isolation assembly without exposing the system to an outside environment.

[00146] In 940, the second maintenance item can be transferred from the transfer system to the processing module. The first exchange system can comprise means for transferring the second maintenance item between the transfer system and the processing module through the first isolation assembly without exposing the system to an outside environment.

[00147] In 945, the second maintenance item can be removably coupled to the processing module. Procedure 900 ends in 950.

[00148] After replacing one or more maintenance items in one or more processing modules, additional substrates can be processed.

[00149] In one embodiment, a transfer plate and a transfer assembly in a transfer system can be used to move a maintenance item and/or a substrate from one position to another position in the transfer system.

[00150] Alternately, the processing system components can be configured differently. For example, a stacked arrangement or a side-by-side arrangement can be used.

[00151] A maintenance system, an exchange system, and/or a transfer system can comprise at least one of a thermal control system, a pressure control system, a gas supply system, an end effector exchange system, a clamping system, a lifting system, an aligning system, a monitoring system

[00152] Although only certain embodiments of this invention have been described in detail above, those skilled in the art will readily appreciate that many modifications are possible in the embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention.

[00153] What is claimed is:

1. A processing system having a vacuum environment therein and comprising:

a processing module having mounting structure therein configured to removably mount a maintenance item in the vacuum environment in the processing module and to present the maintenance item for pick up by a wafer transfer mechanism;

the processing module having a maintenance item removably mounted on the mounting structure;

a transfer system having a transfer mechanism therein configured to transfer a maintenance item within the vacuum environment between the mounting structure in the processing module and the transfer system without exposing the processing module to an outside environment.

2. The processing system as claimed in claim 1, further comprising:

an isolation assembly coupled between the processing module and the transfer system, the isolation assembly comprising a gate valve assembly.

3. The processing system as claimed in claim 1, further comprising:

a maintenance system comprising a storage assembly storing at least one maintenance item and an exchange system for transferring a maintenance item between the transfer system and the maintenance system without exposing the vacuum environment to an outside environment.

4. The processing system as claimed in claim 3, further comprising:

an isolation assembly coupled between the maintenance system and the transfer system, the isolation assembly comprising a gate valve assembly.

5. The processing system as claimed in claim 3, wherein the exchange system comprises a drive system, a transfer arm coupled to the drive system, and an end effector coupled to the transfer arm, the drive system being used to move the transfer arm and the end effector in at least one direction in order to transfer the removably mounted maintenance item between the maintenance system and the processing module.

6. The processing system as claimed in claim 3, wherein the exchange system comprises a drive system, a transfer arm coupled to the drive system, and an end effector coupled to the transfer arm, the drive system being used to move the transfer

arm and the end effector to transfer the substrate between a transfer plate in the transfer system and a substrate holder in the processing module.

7. The processing system as claimed in claim 3, wherein the exchange system comprises a drive system, a transfer arm coupled to the drive system, and an end effector coupled to the transfer arm, the drive system being used to move the transfer arm and the end effector to transfer the removably mounted maintenance item between the transfer system and a storage assembly in the maintenance system.

8. The processing system as claimed in claim 1, wherein the transfer system comprises a transfer plate and a transfer assembly for moving the transfer plate from the one position to another position.

9. The processing system as claimed in claim 1, wherein the maintenance item comprises at least one of a ring, a shield, an insulator, an adapter, a baffle, and a plate.

10. The processing system as claimed in claim 1, further comprising:

a controller coupled to the processing module and the transfer system, the controller being programmed to control the processing module and the transfer system to replace the maintenance item on the mounting structure without exposing the processing module to an outside environment.

11. The processing system of claim 1 wherein:

the processing module is an etching module having an upwardly facing wafer support in a vacuum environment therein;

the maintenance item is an annular member in a mounting position in the etching module surrounding a wafer support area of the wafer support where the maintenance item is prone to being etched by an etching process being performed on a wafer in the etching module; and

the maintenance item is mounted in its mounting position in the etching module so as to be removable from the processing module in part by a lifting of the maintenance item from the mounting position.

12. The processing system of claim 1 wherein:

the processing module includes a deposition module having an upwardly facing wafer support in a vacuum environment therein;

the maintenance item is an annular member in a mounting position in the deposition module surrounding a wafer support area of the wafer support where the maintenance item is prone to collecting deposits of material thereon when a deposition process is performed on a wafer on the support in the deposition module; and

the maintenance item is mounted in its mounting position in the deposition module so as to be removable from the processing module in part by a lifting of the maintenance item from the mounting position.

13. The processing system of claim 1 wherein:

the mounting structure is configured to move the maintenance item into position for pick up by the transfer mechanism.

14. The processing system of claim 13 wherein:

the maintenance item is an annular ring configured to surround a wafer on a wafer support;

the mounting structure includes a set of lift pins operable to lift the ring into position for pick up by a wafer transfer arm.

15. The processing system of claim 13 wherein:

the maintenance item is supported within the processing module from the top of the processing module;

the mounting structure includes a set of elements for releaseably holding the maintenance item and operable to lower the maintenance item into position for pick up by a wafer transfer arm.

16. The processing system of claim 13 wherein:

the transfer mechanism includes a wafer transfer arm and a separate transfer arm configured to pick up a maintenance item.

17. The processing system as claimed in claim 1, wherein the processing module comprises at least one of an ALD module, a deposition module, a coating

module, a patterning module, a developing module, a metrology module, a thermal processing module, and a cleaning module.

18. A method of operating a processing system, the method comprising:

coupling a processing module to a transfer system having a wafer transfer arm therein, the processing module having a first maintenance item removably mounted therein;

presenting the first maintenance item within the processing module for pick up by a transfer arm of the transfer system; and

picking up the maintenance item with the wafer transfer arm and transferring the first maintenance item from the processing module to the transfer system without exposing the processing module to an outside environment.

19. The method of claim 18 wherein:

the maintenance item is an annular member in a mounting position in the processing module that surrounds a wafer support area on an upwardly facing wafer support where the maintenance item is prone to being etched or coated by a process performed on the wafer in the processing module; and

the maintenance item is removable from the processing module in part by lifting the maintenance item from the mounting position.

20. The method of operating a processing system as claimed in claim 18, the method further comprising:

coupling a maintenance system to the transfer system, the maintenance system having a second maintenance item therein;

transferring the second maintenance item from the maintenance system to the transfer system;

transferring the second maintenance item from the transfer system to the processing module without exposing the processing module to an outside environment; and

removably mounting the second maintenance to the module.

21. The method of operating a processing system as claimed in claim 18, the method further comprising:

transferring the first maintenance item to a transfer plate; and

moving the transfer plate from a first position to a second position.

22. The method of operating a processing system as claimed in claim 18, the method further comprising:

transferring the second maintenance item to a transfer plate; and

moving the transfer plate from a second position to a first position.

23. The method of operating a processing system as claimed in claim 18, the method further comprising:

transferring the first maintenance item to a storage assembly in a maintenance system without exposing the processing module to an outside environment.

24. The method of operating a processing system as claimed in claim 20, the method further comprising:

transferring a substrate from the transfer system to the processing module without exposing the processing module to an outside environment;

processing the substrate in the processing module; and

transferring the processed substrate from the processing module to the transfer system.

25. The method of operating a processing system as claimed in claim 18, the method further comprising:

monitoring the first maintenance item without exposing the processing module to an outside environment;

determining when to replace the first etching maintenance item; and

performing the detaching and the transferring in response to the determination.

26. The method of operating a processing system as claimed in claim 18, the method further comprising:

monitoring a processing recipe for the processing module; and

determining when to exchange the first maintenance item with a second maintenance item, wherein the process recipe specifies a different maintenance item.

27. The method of claim 18 further comprising:

coupling a processing module having a first maintenance item removably mounted therein to a first exchange system;

coupling the first exchange system to a transfer system;

detaching the first maintenance item from the processing module; and

transferring the first maintenance item from the processing module to the transfer system without exposing the processing module to an outside environment.

28. The method of operating a processing system as claimed in claim 27, the method further comprising:

coupling a maintenance system to a second exchange system, the maintenance system comprising a second etching maintenance item, wherein the second etching maintenance item can be removably mounted in the etching module;

coupling the second exchange system to a second position in the transfer system;

transferring the second etching maintenance item from the maintenance system to the transfer system, wherein the second exchange system comprises means for transferring the maintenance item between the maintenance system and the transfer system without exposing the etching module to an outside environment;

transferring the second etching maintenance item from the transfer system to the processing module, wherein the first exchange system comprises means for transferring the second etching maintenance item between the transfer system and the processing module without exposing the etching module to an outside environment; and

removably coupling the second etching maintenance item to the etching module.

29. A method of operating a processing system comprising:

coupling a processing module having a first maintenance item removably mounted therein to an exchange system using a first isolation assembly;

coupling the exchange system to a maintenance system using a second isolation assembly;

vertically moving the maintenance item into position within the processing module for pick up of the first maintenance item from the processing module by the wafer transfer arm;

transferring the first maintenance item from the processing module to the maintenance system through the first and second isolation assemblies without exposing the processing module and the first maintenance item to an outside environment;

transferring a second maintenance item from the maintenance system to the processing module through the first and second isolation assemblies without exposing the processing module and the second maintenance item to an outside environment; and

removably mounting the second maintenance item to the processing module.

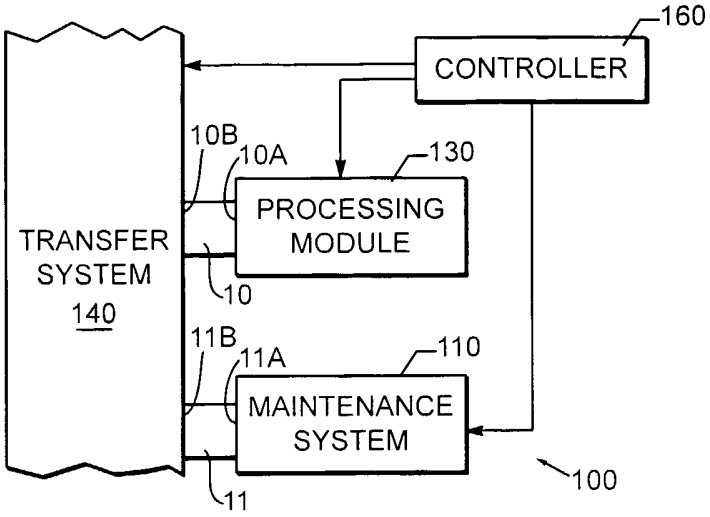


FIG. 1

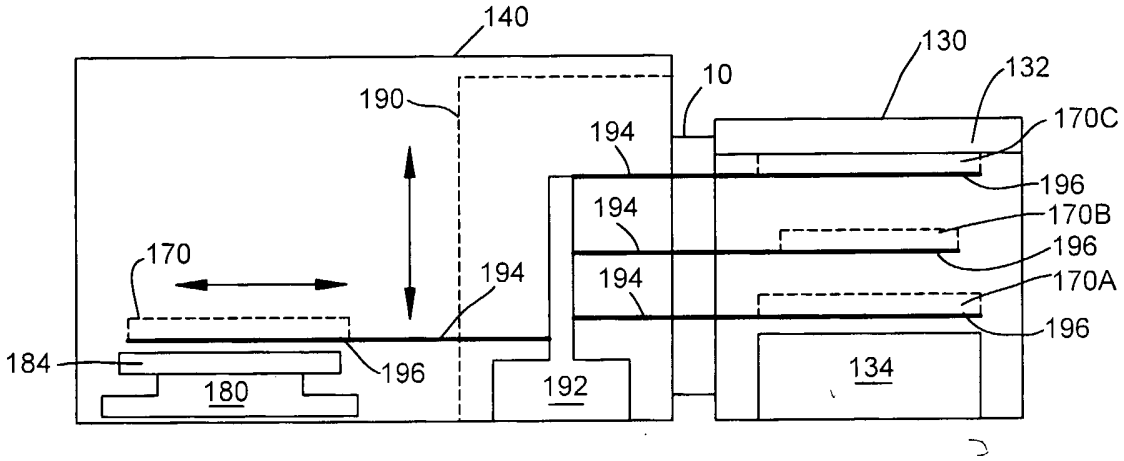


FIG. 2

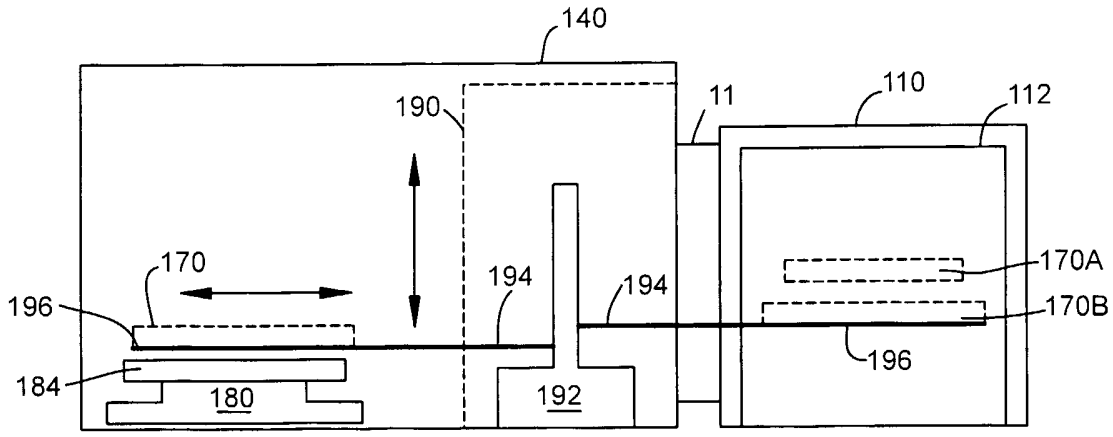


FIG. 3

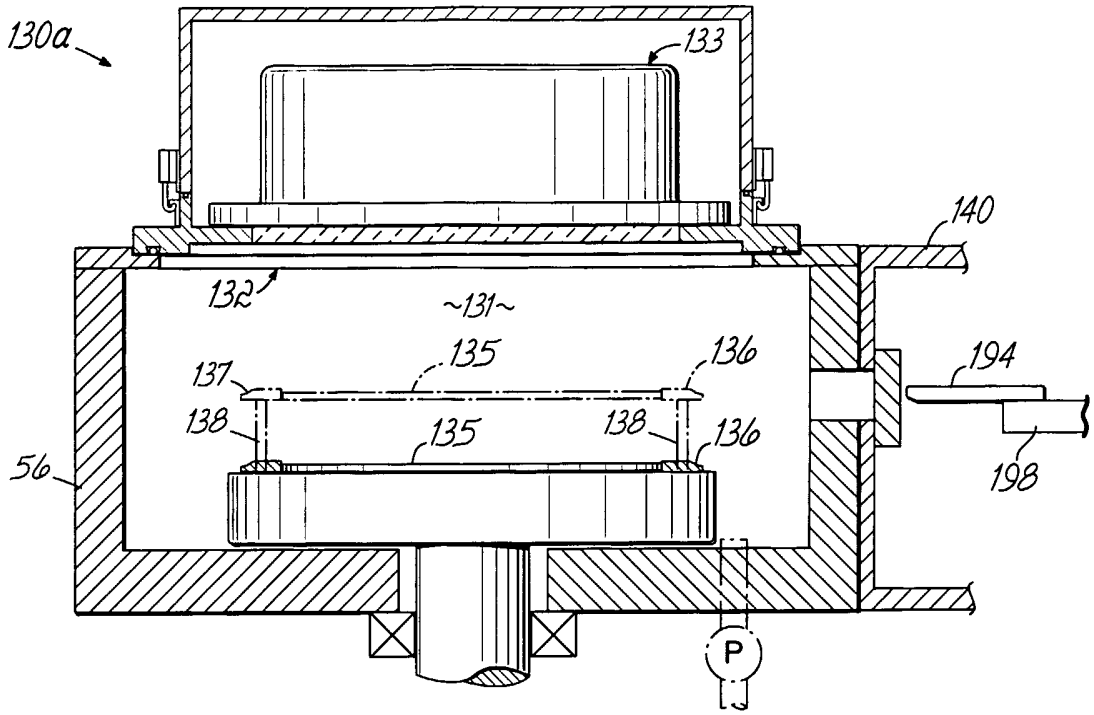

130a
133
140
132
~131~
135
136
137
138
135
138
136
194
56
198
P

FIG. 1A

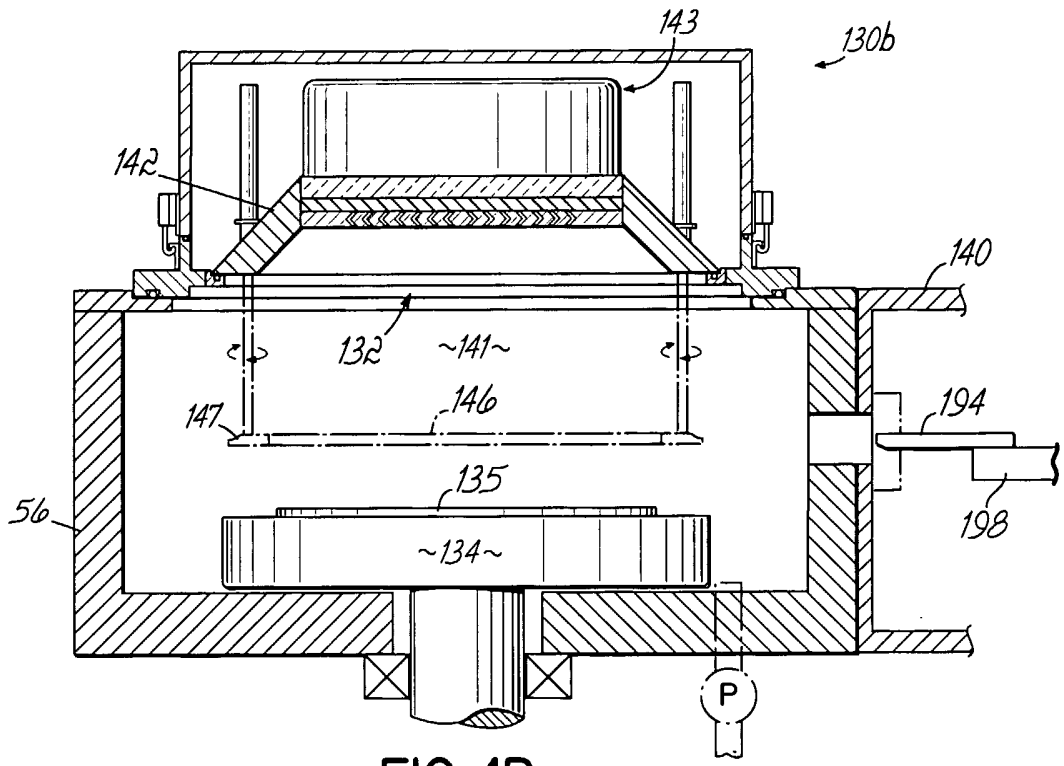

143
130b
142
140
132
~141~
147
146
194
135
56
198
~134~
P

FIG. 1B

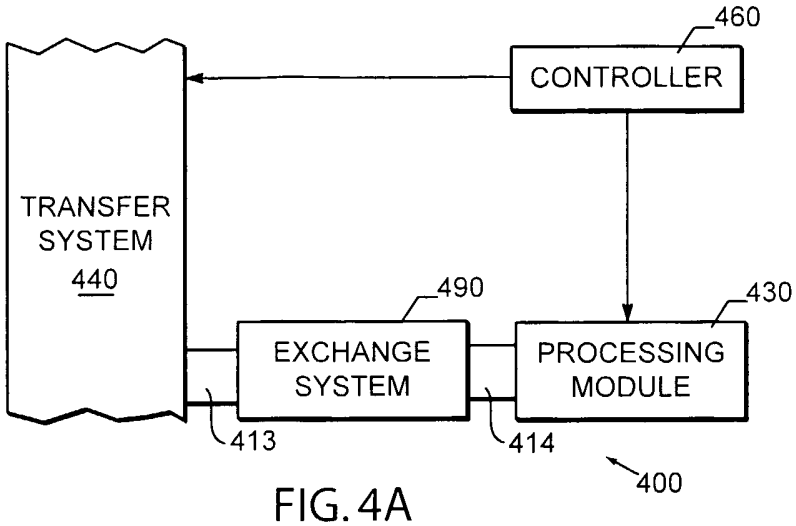

460
CONTROLLER
TRANSFER SYSTEM
440
490
EXCHANGE SYSTEM
430
PROCESSING MODULE
413
414
400

FIG. 4A

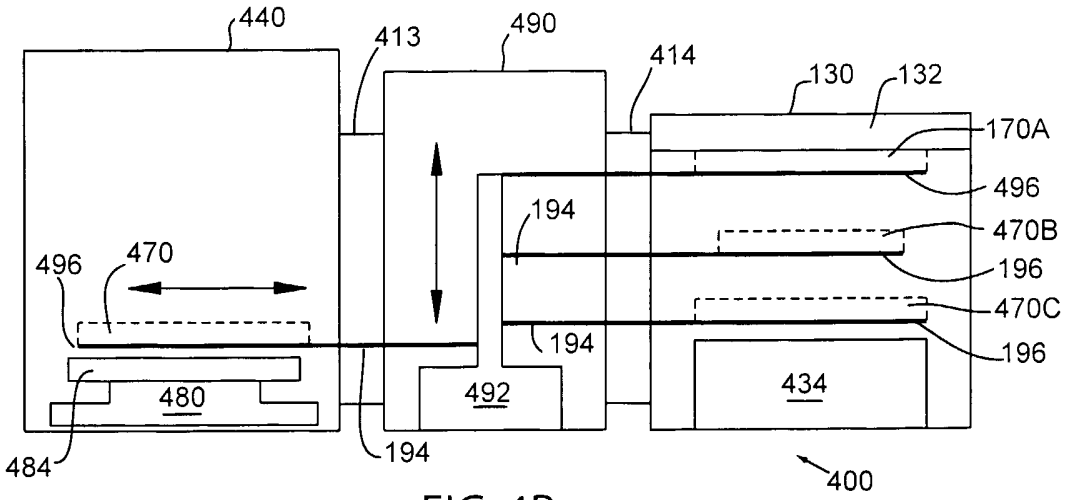

440
413
490
414
130
132
170A
496
194
470B
196
470C
496
470
194
196
480
492
434
484
194
400

FIG. 4B

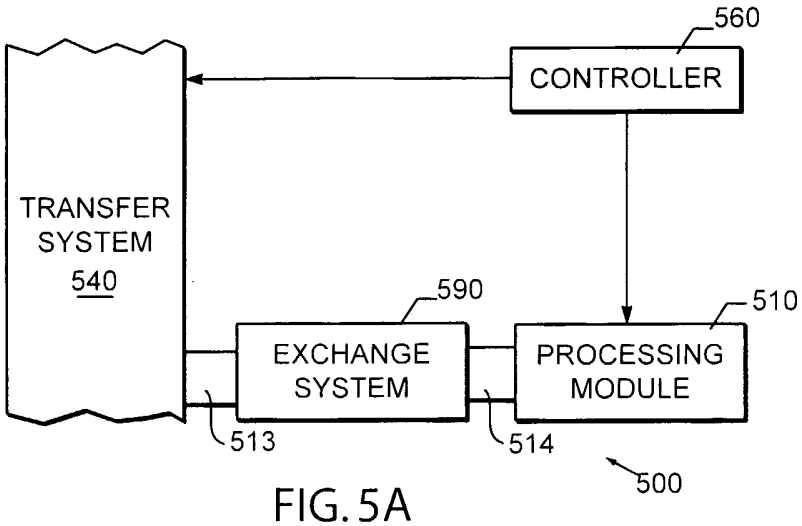

560
CONTROLLER
TRANSFER SYSTEM
540
590
EXCHANGE SYSTEM
510
PROCESSING MODULE
513
514
500

FIG. 5A

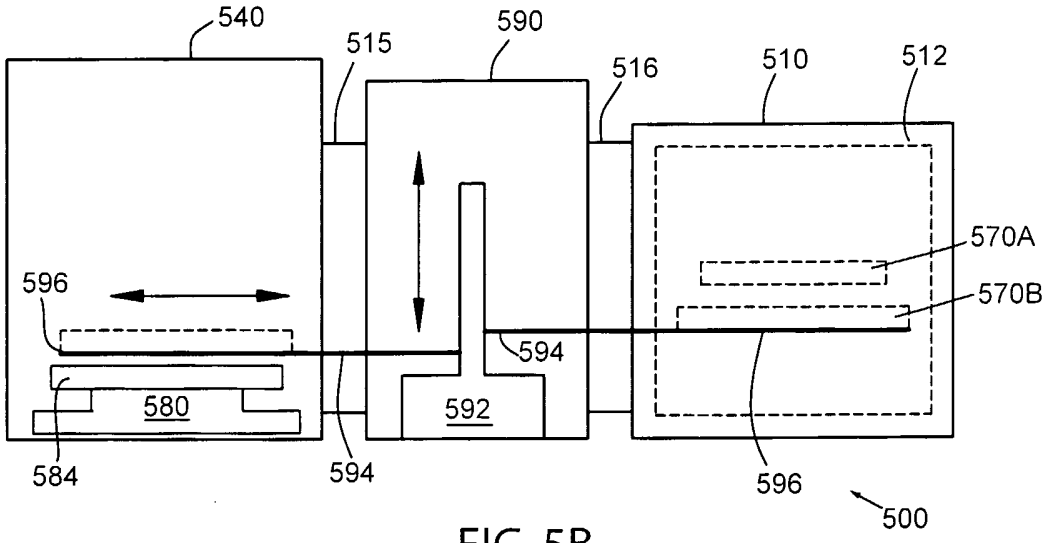

540
515
590
516
510
512
570A
570B
596
594
580
592
584
594
596
500

FIG. 5B

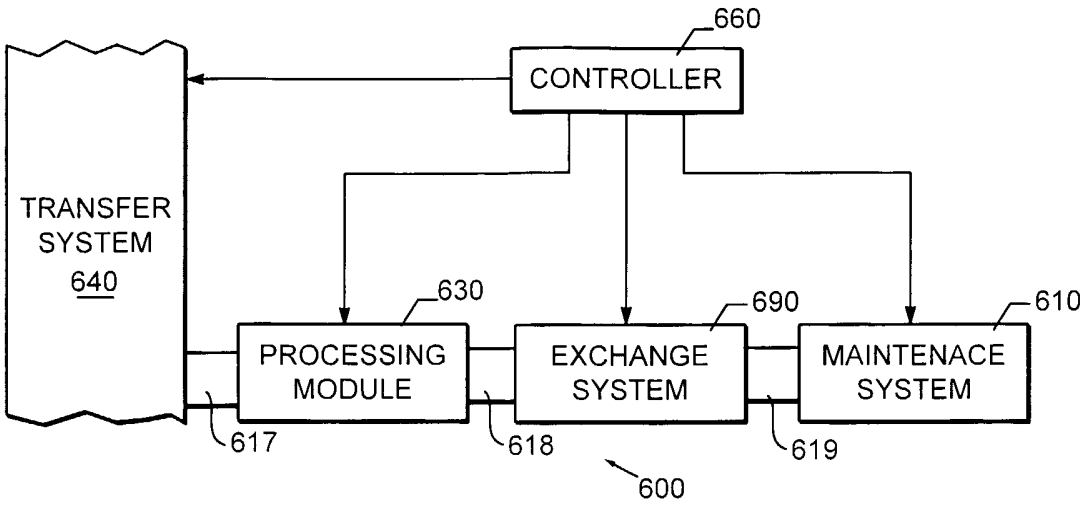

660
CONTROLLER
TRANSFER SYSTEM
640
630
690
610
PROCESSING MODULE
EXCHANGE SYSTEM
MAINTENACE SYSTEM
617
618
619
600

FIG. 6A

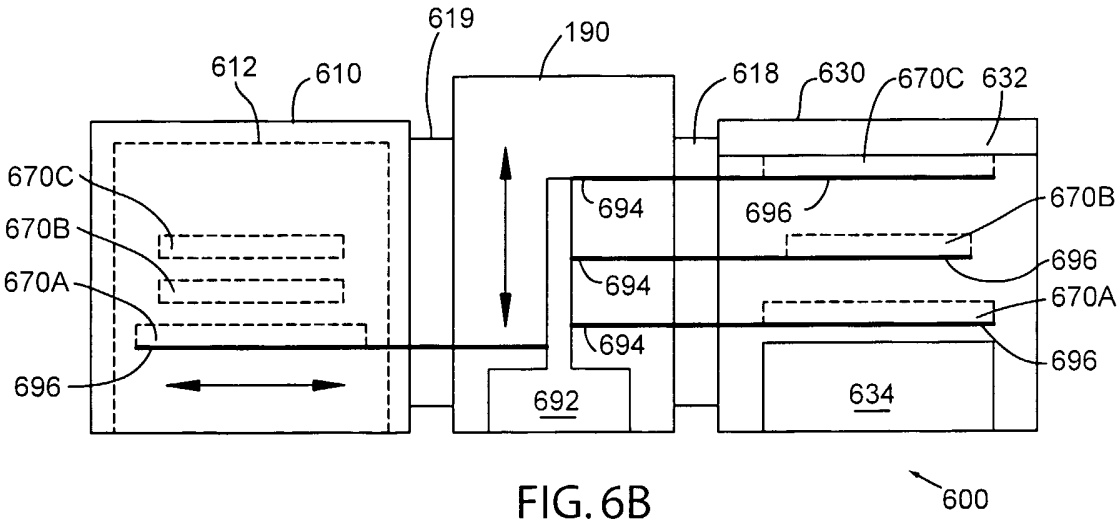

619
190
612
610
618
630
670C
632
670C
670B
670A
696
694
696
694
694
692
634
670B
696
670A
696
600

FIG. 6B

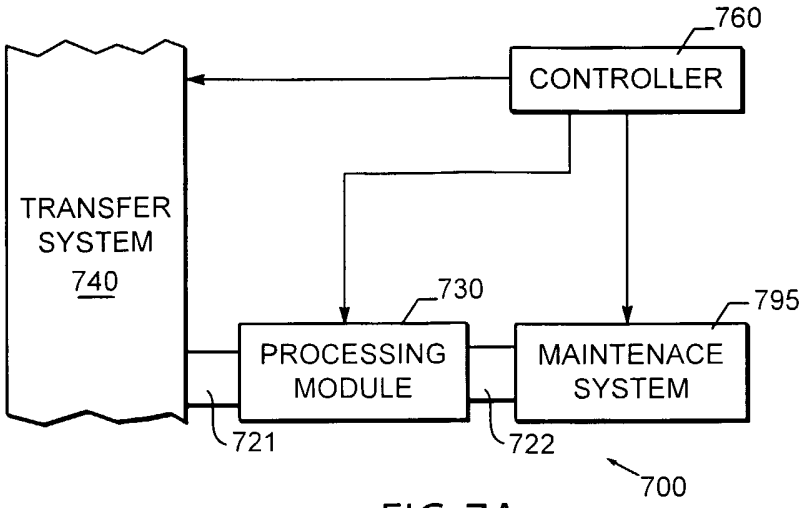

760
CONTROLLER
TRANSFER SYSTEM 740
730
795
PROCESSING MODULE
MAINTENACE SYSTEM
721
722
700

FIG. 7A

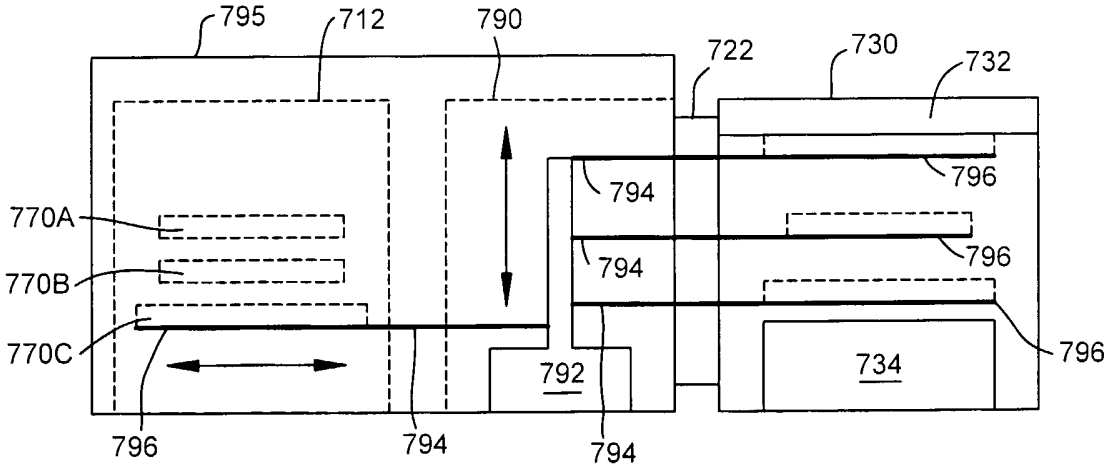

795
712
790
722
730
732
770A
770B
770C
794
796
792
734

FIG. 7B

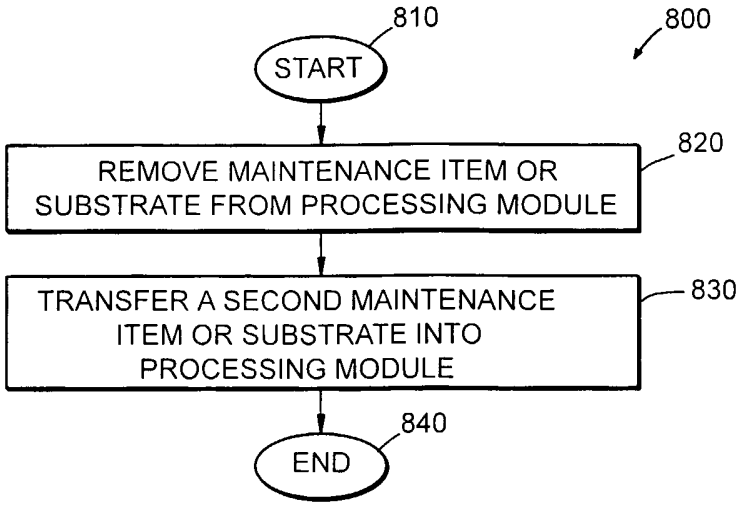

800
810
START
820
REMOVE MAINTENANCE ITEM OR SUBSTRATE FROM PROCESSING MODULE
830
TRANSFER A SECOND MAINTENANCE ITEM OR SUBSTRATE INTO PROCESSING MODULE
840
END

FIG. 8

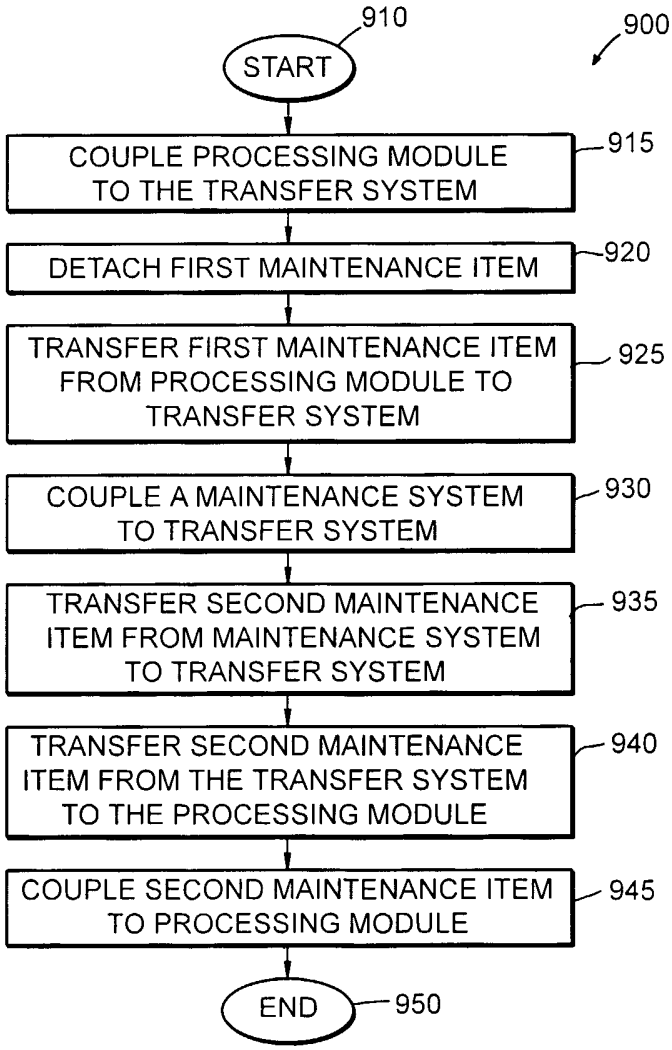

900
910
START
915
COUPLE PROCESSING MODULE TO THE TRANSFER SYSTEM
920
DETACH FIRST MAINTENANCE ITEM
925
TRANSFER FIRST MAINTENANCE ITEM FROM PROCESSING MODULE TO TRANSFER SYSTEM
930
COUPLE A MAINTENANCE SYSTEM TO TRANSFER SYSTEM
935
TRANSFER SECOND MAINTENANCE ITEM FROM MAINTENANCE SYSTEM TO TRANSFER SYSTEM
940
TRANSFER SECOND MAINTENANCE ITEM FROM THE TRANSFER SYSTEM TO THE PROCESSING MODULE
945
COUPLE SECOND MAINTENANCE ITEM TO PROCESSING MODULE
950
END

FIG. 9