

CLAIMS

What is claimed is:

1. A method of installing an annular seal in a fluid delivery module of a fluid supply line that extends from a fluid source to a process chamber, the method comprising:
 - a) coupling a seal insertion tool loaded with an annular seal to a first substrate block of the fluid delivery module so that the annular seal is positioned above and aligned with a first fluid port located on a first surface of the first substrate block; and
 - b) actuating the seal insertion tool so that the seal insertion tool lowers the annular seal and presses a lower portion of the annular seal into a first annular groove of the first fluid port that surrounds a first fluid opening of the first fluid port;wherein steps a) and b) are performed while the fluid delivery module remains in-situ within the fluid supply line.
2. The method according to claim 1 wherein, prior to step a) and while the fluid delivery module remains in-situ within the fluid supply line, the method further comprising:
 - decoupling a first active flow component from the first substrate block of the fluid delivery module to expose the first fluid port on the first surface of the first substrate block, the first substrate block comprising a first fluid passageway that extends from the first fluid opening of the first fluid port to a second fluid opening of a second fluid port on the first substrate block; and
 - removing an expired seal.
3. The method according to claim 2 wherein the active flow component comprises a component block having a bottom surface and a first component fluid port on the bottom surface; wherein when the active flow component is coupled to the first substrate block of the fluid delivery module, an areal portion of the bottom surface overlies and opposes a portion of the first surface of the first substrate block; and wherein the seal insertion tool has a footprint that fits within the areal portion of the bottom surface of the component block.
4. The method according to claim 2 further comprising:
 - d) decoupling the seal insertion tool from the first substrate block to expose the first fluid port, the annular seal remaining in place within the first annular groove; and

e) coupling the first active flow component to the first substrate block so that an upper portion of the annular seal is pressed into a component annular groove of a component fluid port located on a bottom surface of a component block of the first active flow component, the annular seal hermetically sealing the first fluid opening of the first fluid port to a component fluid opening of the component fluid port.

5. The method according to claim 4 wherein the fluid delivery module comprises a plurality of anchors, wherein the seal insertion tool is coupled to the first substrate block during step a) the anchors being the same anchors that are used to couple the first active flow component to the first substrate block in step e).

6. The method according to any one of claims 1 to 2 wherein when the seal insertion tool is coupled to the first substrate block of the fluid delivery module according to step a), a footprint of the seal insertion tool is contained within a footprint of the first substrate block.

7. The method according to any one of claims 1 to 6 further comprising:

the first substrate block comprising a second fluid port having a second fluid opening and a first fluid passageway extending between the first and second fluid openings;

the fluid delivery module comprising a second active flow component coupled to the first substrate block and fluidly coupled to the second fluid port; and

wherein during the performance of steps a) and b), the second active flow component remains fluidly coupled to the second fluid port.

8. The method according to claim 7 wherein the second fluid port is on the first surface.

9. The method according to any one of claims 1 to 8 further comprising:

the seal insertion tool comprising a pair of tool fasteners extending through fastener passageways in a body of the seal insertion tool;

wherein step a) comprises activating the pair of tool fasteners to engage a corresponding pair of anchors located in either the first substrate block or a support structure of the fluid delivery module to which the first substrate block is mounted.

10. The method according to claim 9 wherein the pair of tool fasteners are threaded tool fasteners and the pair of anchors are threaded anchors; and wherein step a) comprises rotating the pair of threaded tool fasteners to engage the pair of threaded anchors located in the support structure of the fluid delivery module to which the first substrate block is mounted, the pair of threaded tool fasteners extending through fastener passageways of the first substrate block.

11. The method according to any one of claims 1 to 10 wherein the first substrate block and additional components of the fluid delivery module remain mounted to a support structure of the fluid delivery module during steps a) and b).

12. The method according to any one of claims 1 to 11 wherein step b) further comprises:

b-1) rotating an actuator of the seal insertion tool, thereby causing an end effector of the seal insertion tool in which the annular seal is loaded to translate from a raised state to a lowered state.

13. The method according to claim 12 wherein in the raised state, the annular seal is engaged and retained by the end effector; and wherein in the lowered state, the end effector has pressed the annular seal into the first annular groove and disengaged the annular seal.

14. The method according to claim 13 wherein in the lowered state an end face of a plunger of the end effector contacts the first surface of the first substrate block.

15. The method according to claim 12 to 13 wherein the end effector comprises a gripper slidably mounted to a plunger having a plunger shaft and a plunger head located at the distal end of the plunger shaft, the gripper comprising a plurality of grip fingers mounted to a collar slidably mounted about the plunger shaft.

16. The method according to claim 15 further comprising:

prior to step a), loading the annular seal into the end effector by inserting the annular seal between the plurality of grip fingers, the grip fingers exerting a radially inward force on the annular seal to engage and retain the annular seal in the end effector, the gripper being in a lowered position relative to the plunger;

wherein when the seal insertion tool is coupled to the first substrate block, the grip fingers contact or are above the first surface of the first substrate block; and

wherein step b) comprises rotating the actuator of the seal insertion tool, thereby lowering the plunger of the end effector, the plunger sliding relative to the gripper and pressing the lower portion of the annular seal into the first annular groove.

17. The method according to claim 16 wherein during step b), the gripping fingers are deflected radially outward by a cam action between the inner surface of the gripping fingers and at least one of the annular seal or the plunger.

18. The method according to any one of claims 1 to 17 wherein the annular seal comprises an outer upstanding ring wall, an inner upstanding ring wall, and a flange extending between the inner and outer upstanding ring walls; and wherein the seal insertion tool does not exert any vertical compression force on the inner upstanding ring wall during the performance of step b).

19. The method according to claim 18 wherein the seal insertion tool does not contact the inner upstanding ring wall during the performance of step b).

20. A method of replacing an annular seal in a fluid delivery module, the method comprising:

a) decoupling a first active flow component from a first substrate block of the fluid delivery module by releasing one or more component fasteners that respectively engage one or more anchors of the fluid delivery module, thereby exposing a first fluid port on a first surface of the first substrate block;

b) removing an expired seal;

c) coupling a seal insertion tool to the first substrate block by activating one or more tool fasteners to engage the one or more anchors of the fluid delivery module; and

d) actuating the seal insertion tool so that an annular seal that is aligned with the first fluid port is pressed into a first annular groove of the first fluid port that surrounds a first fluid opening of the first fluid port.

21. The method according to claim 20 further comprising:

e) decoupling the seal insertion tool from the first substrate block to expose the first fluid port, the annular seal remaining in place within the first annular groove; and

f) coupling the first active flow component to the first substrate block by activating the one or more component fasteners to engage the one or more anchors, thereby pressing an upper portion of the annular seal into a component annular groove of a component fluid port located on a bottom surface of a component block of the first active flow component, the annular seal hermetically sealing the first fluid opening of the first fluid port to a component fluid opening of the component fluid port.

22. The method according to claim 21 wherein the fluid delivery module remains in-situ within a fluid supply line that extends from a fluid source to a process chamber during the performance of steps a) to f).

23. The method according to any one of claims 20 to 21 wherein the fluid delivery module remains in-situ within a fluid supply line that extends from a fluid source to a process chamber during the performance of steps a) to d).

24. The method according to any one of claims 20 to 23 wherein, prior to step a), the liquid delivery module further comprises a support structure to which the first substrate block, the first active flow component, and a plurality of other fluid flow components are mounted and fluidly communicate with one another; and wherein upon completion of step a), the first substrate block remains mounted to the support structure.

25. The method according to any one of claims 20 to 24 wherein the first substrate block comprises a second fluid port on the first surface of the first substrate block, the second fluid port having a second fluid opening, and a first fluid passageway extending between the first and second fluid openings; the first and second fluid ports located on opposite sides of a central plane that is transverse to the first surface and divides a footprint of the first substrate block into a first footprint half and a second footprint half; and wherein a footprint of the seal insertion tool first within first footprint half.

26. The method according to claim 25 wherein the fluid delivery module comprising a second active flow component coupled to the first substrate block and fluidly coupled to the second fluid port; and wherein during the performance of steps a) and d), the second active flow component remains fluidly coupled to the second fluid port.

27. A method of installing an annular seal in a fluid delivery module comprising a support structure, a first substrate block mounted to the support structure, and a plurality of flow components mounted to the support structure, the method comprising:

a) coupling a seal insertion tool loaded with an annular seal to the first substrate block, the annular seal positioned above and aligned with a first fluid port located on a first surface of the first substrate block; and

b) actuating the seal insertion tool so that the seal insertion tool presses a lower portion of the annular seal into a first annular groove of the first fluid port that surrounds a first fluid opening of the first fluid port;

wherein steps a) and b) are performed while the first substrate block remains mounted to the support structure of the fluid delivery module.

28. A method of manufacturing semiconductors or integrated circuits comprising:

installing or replacing an annular seal of a fluid delivery module according to the method of any one of claims 1 to 27 to complete a fluid supply line that extends from a fluid source to a process chamber; and

flowing fluid from the fluid source to the process chamber to contact one or more semiconductor or integrated circuit wafers in the process chamber.

29. A seal insertion tool comprising:

a body;

a pair of fasteners for coupling the body to a fluid delivery module;

an end effector slidably mounted to the body, the end effector configured to receive and retain an annular seal; and

an actuator operably coupled to the end effector and configured to alter the end effector from a raised state to a lowered state upon a user actuating the actuator.

30. The seal insertion tool according to claim 29 wherein the actuator comprises:
- a user-engagement component;
 - a threaded drive shaft non-rotatably coupled to the user-engagement component such that rotation of the user-engagement component causes corresponding rotation of the threaded drive shaft; and
 - a threaded collar mounted to and fixed relative to the body, the threaded drive shaft in threaded engagement with the threaded collar such that rotation of the threaded drive shaft causes the threaded drive shaft to axially translate relative to the body and the threaded collar.
31. The seal insertion tool according to claim 30 wherein the threaded collar comprises a ball nut and the threaded drive shaft comprises a ball screw.
32. The seal insertion tool according to any one of claims 30 to 31 wherein the end effector comprises a plunger shaft and a plunger head, the plunger shaft in axial alignment and operable cooperation with the threaded drive shaft such that the axial translation of the threaded drive shaft moves the end effector from the raised state to the lowered state.
33. The seal insertion tool according to claim 32 further comprising a friction-reducing component located between a distal end of the threaded drive shaft and a proximal end of the plunger shaft.
34. The seal insertion tool according to claim 33 wherein the friction-reducing component comprises a ball bearing.
35. The seal insertion tool according to claim 34 wherein the proximal end of the plunger shaft comprises a depression in which the ball bearing nests.
36. The seal insertion tool according to any one of claims 29 to 35 wherein the end effector is non-rotatable relative to the body.
37. The seal insertion tool according to any one of claims 29 to 35 wherein the end effector comprises a plunger head having an annular wall surrounding a central depression having a floor,

the annular wall terminating in a work surface, the work surface and floor being axially offset from one another.

38. The seal insertion tool according to claim 37 further comprising the annular seal loaded into the end effector, the annular seal comprising an outer upstanding ring wall, an inner upstanding ring wall, and a flange extending between the inner and outer upstanding ring walls; and wherein a top surface of the outer upstanding ring wall is in contact with the work surface and an upper portion of the inner upstanding ring wall protrudes into the central depression, a gap existing between the floor and a top surface of the inner upstanding ring wall.

39. The seal insertion tool according to any one of claims 29 to 38 wherein the end effector comprises a gripper slidably mounted to a plunger having a plunger shaft and a plunger head located at the distal end of the plunger shaft, the gripper comprising a plurality of radially deflectable grip fingers mounted to a collar slidably mounted about the plunger shaft.

40. The seal insertion tool according to claim 39 wherein upon the actuator being actuated, the plunger of the end effector is lowered and slides relative to the gripper.