

~~What is claimed is:~~ Claims

1. A method for cleaning semiconductor wafers, comprising:

transferring one or more wafers to at least one first tank containing a cleaning chemical, one or more second tanks containing a cleaning liquid successively for implementing a batch cleaning process; and

taking the one or more wafers out of the cleaning liquid in the one or more second tanks and transferring the one or more wafers to one or more single wafer cleaning modules for implementing single wafer cleaning and drying processes;

wherein control and keep a ~~certain~~ thickness of liquid film on the one or more wafers from the moment of the one or more wafers out of the cleaning chemical in the at least one first tank till the one or more wafers are immersed in the cleaning liquid of the one or more second tanks, and/or from the moment of the one or more wafers are out of the cleaning liquid in the one or more second tanks till the one or more wafers are transferred to the one or more single wafer cleaning modules, and

wherein the thickness of liquid film on the one or more wafers is determined by a diameter of a largest particle in the liquid film, a transfer acceleration of robots which transfer the one or more wafers, and a maximum thickness of liquid film held by liquid surface tension on the one or more wafers.

~~2. The method of claim 1, wherein the thickness of liquid film on the one or more wafers is determined by the diameter of the largest particle in the liquid film, the transfer acceleration of robots which transfer the one or more wafers, and the maximum thickness of liquid film held by the liquid surface tension on the one or more wafers.~~

~~32. The method of claim 21, wherein the thickness of liquid film on the one or more wafers is not less than the diameter of the largest particle in the liquid film.~~

43. The method of claim 21, wherein the transfer acceleration of robots is controlled to make the thickness of liquid film on the one or more wafers be not greater than the maximum thickness of liquid film held by the liquid surface tension.

54. The method of claim 1, further comprising:

spraying liquid on the one or more wafers from the moment of the one or more wafers out of the cleaning chemical in the at least one first tank till the one or more wafers are immersed in the cleaning liquid in the one or more second tanks;

spraying liquid on the one or more wafers from the moment of the one or more wafers out of the cleaning liquid in the one or more second tanks till the one or more wafers are transferred to the one or more single wafer cleaning modules.

65. The method of claim 1, further comprising:

spraying liquid on the one or more wafers from the moment of the one or more wafers out of the cleaning chemical in the at least one first tank till the one or more wafers are immersed in the cleaning liquid in the one or more second tanks;

taking the one or more wafers out of the cleaning liquid in the one or more second tanks and rotating the one or more wafers from vertical plane to horizontal plane, and then horizontally transferring the one or more wafers to the one or more single wafer cleaning modules.

76. The method of claim 1, further comprising:

taking the one or more wafers out of the cleaning chemical in the at least one first tank and rotating the one or more wafers from a vertical plane to a horizontal plane;

horizontally transferring the one or more wafers to the one or more second tanks;

rotating the one or more wafers from the horizontal plane to the vertical plane and putting the one or more wafers in the cleaning liquid in the one or more second tanks;

spraying liquid on the one or more wafers from the moment of the one or more wafers out of the cleaning liquid in the one or more second tanks till the one or more wafers are transferred to the one or more single wafer cleaning modules.

87. The method of claim 1, further comprising:

taking the one or more wafers out of the cleaning chemical in the at least one first tank and rotating the one or more wafers from a vertical plane to a horizontal plane;

horizontally transferring the one or more wafers to the one or more second tanks;

rotating the one or more wafers from the horizontal plane to the vertical plane and putting the one or more wafers in the cleaning liquid in the one or more second tanks;

taking the one or more wafers out of the cleaning liquid in the one or more second tanks and rotating the one or more wafers from the vertical plane to the horizontal plane; and then horizontally transferring the one or more wafers to the one or more single wafer cleaning modules.

98. The method of claim 1, further comprising:

transferring the one or more wafers to the one or more single wafer cleaning modules;

spraying liquid on the one or more wafers before rotating the one or more wafers in the one or more single wafer cleaning modules.

~~109~~. The method of claim 1, wherein ~~the~~a number of wafers that is taken out of the one or more second tanks every time is equal to or less than ~~the~~a number of the single wafer cleaning modules.

~~11~~10. The method of claim 1, wherein ~~the~~a number of wafers that is taken out of the one or more second tanks every time is one or two or less than ten.

~~12~~11. The method of claim 1, wherein the cleaning chemical in the at least one first tank is SPM which is a mixture of H_2SO_4 and H_2O_2 , and the temperature of SPM is 80 °C to 150 °C.

~~13~~12. The method of claim 1, wherein the cleaning chemical in the at least one first tank is SPM which is a mixture of H_2SO_4 and H_2O_2 , and the concentration ratio of H_2SO_4 and H_2O_2 is 3:1 to 50:1.

~~14~~13. The method of claim 1, wherein the one or more wafers are implemented a quickly dump rinse in the one or more second tanks.

~~15~~14. The method of claim ~~14~~13, wherein the cleaning liquid for the quickly dump rinse is deionized water.

~~16~~15. The method of claim 1, wherein the number of the second tanks is at least two, the cleaning chemical in the at least one first tank is HF solution, the cleaning liquid in at least one second tank is H_3PO_4 solution, the cleaning liquid in other second tank is deionized water for a quickly dump rinse.

~~17~~16. The method of claim ~~16~~15, wherein the temperature of H_3PO_4 solution is 150°C-200°C.

~~18~~17. A method for cleaning semiconductor wafers, comprising:

transferring one or more wafers to at least one tank filled with a cleaning solution for implementing a batch cleaning process, and

taking the one or more wafers out of the at least one tank and transferring the one or more wafers to one or more single wafer cleaning modules for implementing single wafer cleaning and drying processes;

wherein control and keep a ~~certain~~ thickness of liquid film on the one or more wafers from the moment of the one or more wafers out of the cleaning solution in the at least one tank till the one or more wafers are transferred to the one or more single wafer cleaning modules, and

wherein the thickness of liquid film on the one or more wafers is determined by a diameter of a largest particle in the liquid film, a transfer acceleration of robots which transfer the one or more wafers, and a maximum thickness of liquid film held by liquid surface tension on the one or more wafers.

~~19. The method of claim 18, wherein the thickness of liquid film on the one or more wafers is determined by the diameter of the largest particle in the liquid film, the transfer acceleration of robots which transfer the one or more wafers, and the maximum thickness of liquid film held by the liquid surface tension on the one or more wafers.~~

~~18~~20. The method of claim ~~19~~17, wherein the thickness of liquid film on the one or more wafers is not less than the diameter of the largest particle in the liquid film.

~~21~~19. The method of claim ~~19~~17, wherein the transfer acceleration of robots is controlled to make the thickness of liquid film on the one or more wafers be not greater than the maximum thickness of liquid film held by the liquid surface tension.

~~22~~20. An apparatus for cleaning semiconductor wafers, comprising:

at least one first tank, containing a cleaning chemical, configured to implement a batch cleaning process;

one or more second tanks, containing a cleaning liquid, configured to implement another batch cleaning process;

one or more single wafer cleaning modules, configured to implement single wafer cleaning and drying processes;

a plurality of robots, configured to transfer one or more wafers;

a controller, configured to control the plurality of robots to transfer the one or more wafers to the at least one first tank and the one or more second tanks successively, and then to the one or more single wafer cleaning modules;

wherein the controller is configured to keep a ~~certain~~ thickness of liquid film on the one or more wafers from the moment of the one or more wafers out of the cleaning chemical in the at least one first tank till the one or more wafers are immersed in the cleaning liquid of the one or more second tanks, and/or from the moment of the one or more wafers out of the cleaning liquid in the one or more second tanks till the one or more wafers are transferred to the one or more single wafer cleaning modules, and

wherein the controller is configured to determine the thickness of liquid film on the one or more wafers by a diameter of a largest particle in the liquid film, a transfer acceleration of robots which transfer the one or more wafers, and a maximum thickness of liquid film held by liquid surface tension on the one or more wafers.

~~23. The apparatus of claim 22, wherein the controller is configured to determine the thickness of liquid film on the one or more wafers by the diameter of the largest particle in the liquid film, the transfer acceleration of robots which transfer the one or more wafers, and the maximum thickness of liquid film held by the liquid surface tension on the one or more wafers.~~

2421. The apparatus of claim 2320, wherein the thickness of liquid film on the one or more wafers is not less than the diameter of the largest particle in the liquid film.

2522. The apparatus of claim 2320, wherein the transfer acceleration of robots is controlled to make the thickness of liquid film on the one or more wafers be not greater than the maximum thickness of liquid film held by the liquid surface tension.

2623. The apparatus of claim 2220, further comprising a liquid providing device, having a first nozzle and a second nozzle,

wherein the first nozzle sprays liquid on the one or more wafers from the moment of the one or more wafers out of the cleaning chemical in the at least one first tank till the one or more wafers are rotated from a vertical plane to a horizontal plane after the one or more wafers have been taken out of the at least one first tank, and the first nozzle stops spraying liquid after the one or more wafers are rotated to the horizontal plane for being horizontally transferred to the one or more second tanks,

wherein the second nozzle sprays liquid on the one or more wafers from the moment of the one or more wafers rotating from the horizontal plane above the one or more second tanks till the one or more wafers are vertically immersed into the cleaning liquid of the one or more second tanks.

2724. The apparatus of claim 2220, further comprising:

a first turnover device, configured to rotate the one or more wafers from a horizontal plane to a vertical plane for the one or more wafers being vertically transferred to the at least one first tank; and

a second turnover device, configured to rotate the one or more wafers from the vertical plane to the horizontal plane for the one or more wafers being horizontally transferred to the one or more single wafer cleaning modules.

2825. The apparatus of claim 2724, wherein the second turnover device comprises:

- a receiving chamber,
- a wafer holder, being set in the receiving chamber,
- a first driving mechanism, driving the wafer holder to rotate in the receiving chamber,
- a support bar, an end of the support bar extending to the receiving chamber,
- a support seat, fixed at the end of the support bar,
- a second driving mechanism, driving the support seat to ascend and descend via the support bar,
- a window, defined on the receiving chamber,
- a door, being set in the receiving chamber, and
- a third driving mechanism, driving the door to move up to close the window or move down to open the window.

2926. The apparatus of claim 2724, wherein the plurality of robots further comprises:

a first wafer transfer robot, configured to take the one or more wafers and transfer the one or more wafers to the at least one first tank and the one or more second tanks;

a second wafer transfer robot, configured to take a certain number of wafers out of the one or more second tanks every time and transfer the certain number of wafers to the second turnover device;

a process robot, configured to take the certain number of wafers out of the second turnover device and transfer the certain number of wafers to corresponding number of single wafer cleaning modules.

3027. The apparatus of claim 2926, wherein the second wafer transfer robot has a pair of clamp arms, an end of each clamp arm defines a plurality of clamp slots for holding a plurality of wafers.

3128. The apparatus of claim 2926, further comprising one or more nozzle devices, wherein every nozzle device is long strip shape and has a slit-shaped nozzle, at least one inlet connects to the slit-shaped nozzle for supplying liquid to the slit-shaped nozzle.

3229. The apparatus of claim 3128, wherein ~~the~~a number of the nozzle devices is matched with ~~the~~a number of the wafers clamped by the second wafer transfer robot so that one nozzle device is corresponding to one wafer and sprays liquid on the one wafer.

3330. The apparatus of claim 3128, wherein the one or more nozzle devices is capable of moving back and forth above the wafer and spraying liquid on the wafer while the wafer is held by the second turnover device.

3431. The apparatus of claim 2926, wherein the process robot is capable of rotating from the horizontal plane to an inclined plane and to the horizontal plane.

3532. The apparatus of claim 2629, wherein the certain number of wafers that is taken out of the one or more second tanks every time is equal to or less than ~~the~~ a number of the single wafer cleaning modules.

3633. The apparatus of claim 2629, further comprising a cleaning tank for cleaning the first wafer transfer robot while the first wafer transfer robot is idle.

3734. The apparatus of claim 2629, further comprising:

at least one load port,
at least one wafer cassette located at the at least one load port,
a buffer room, wherein the process robot takes the certain number of wafers out of the corresponding number of single wafer cleaning modules and transfers the certain number of wafers to the buffer room, and
an index robot, wherein the index robot takes one or more wafers from the at least one wafer cassette and transfers the one or more wafers to the first turnover device, and the index robot takes the certain number of wafers out of the buffer room and transfers the certain number of wafers to the at least one wafer cassette.

3835. The apparatus of claim 2220, wherein the one or more wafers are transferred to the one or more single wafer cleaning modules and sprayed liquid thereon before the one or more wafers are rotated in the one or more single wafer cleaning modules.

3936. The apparatus of claim 2220, wherein the cleaning chemical in the at least one first tank is SPM which is a mixture of H_2SO_4 and H_2O_2 , and the temperature of SPM is 80 °C to 150 °C.

4037. The apparatus of claim 2220, wherein the cleaning chemical in the at least one first tank is SPM which is a mixture of H_2SO_4 and H_2O_2 , and the concentration ratio of H_2SO_4 and H_2O_2 is 3:1 to 50:1.

4138. The apparatus of claim 2220, wherein the one or more wafers are implemented a quickly dump rinse in the one or more second tanks.

4239. The apparatus of claim 4138, wherein the cleaning liquid for the quickly dump rinse is deionized water.

4340. The apparatus of claim 2220, wherein the number of the second tanks is at least two, the cleaning chemical in the at least one first tank is HF solution, the cleaning liquid in at least one second tank is H_3PO_4 solution, the cleaning liquid in other second tank is deionized water for a quickly dump rinse.

4441. The apparatus of claim 4340, wherein the temperature of H_3PO_4 solution is 150°C - 200°C .

4542. An apparatus for cleaning semiconductor wafers, comprising:
a plurality of load ports;
at least one first tank, containing a cleaning chemical, configured to implement a batch cleaning process;
one or more second tanks, containing a cleaning liquid, configured to implement another batch cleaning process;
one or more single wafer cleaning modules, configured to implement single wafer cleaning and drying processes;
a plurality of robots, configured to transfer one or more wafers;
a controller, configured to control the plurality of robots to transfer the one or more wafers to the at least one first tank and the one or more second tanks successively, and then to the one or more single wafer cleaning modules;

wherein the plurality of load ports is transversely arranged, the at least one first tank and the one or more second tanks are lengthways arranged at one side, and the one or more single wafer cleaning modules are lengthways arranged at the other side and opposing the at least one first tank and the one or more second tanks,

wherein the controller is configured to keep a thickness of liquid film on the one or more wafers from the moment of the one or more wafers out of the cleaning chemical in the at least one first tank till the one or more wafers are immersed in the cleaning liquid of the one or more second tanks, and/or from the moment of the one or

more wafers out of the cleaning liquid in the one or more second tanks till the one or more wafers are transferred to the one or more single wafer cleaning modules, and wherein the controller is configured to determine the thickness of liquid film on the one or more wafers by a diameter of a largest particle in the liquid film, a transfer acceleration of robots which transfer the one or more wafers, and a maximum thickness of liquid film held by liquid surface tension on the one or more wafers.

4643. The apparatus of claim 4542, further comprising a space formed between the one or more single wafer cleaning modules and the at least one first tank and the one or more second tanks, a process robot being arranged in the space.

4744. An apparatus for cleaning semiconductor wafers, comprising:
at least one tank, containing a cleaning solution, configured to implement a batch cleaning process;

one or more single wafer cleaning modules, configured to implement single wafer cleaning and drying processes;

one or more robots, configured to transfer one or more wafers to the at least one tank and the one or more single wafer cleaning modules;

a controller, configured to control the one or more robots;

wherein the controller is configured to keep a ~~certain~~ thickness of liquid film on the one or more wafers from the moment of the one or more wafers out of the cleaning solution in the at least one tank till the one or more wafers are transferred to the one or more single wafer cleaning modules, and

wherein the controller is configured to determine the thickness of liquid film on the one or more wafers by a diameter of a largest particle in the liquid film, a transfer acceleration of robots which transfer the one or more wafers, and a maximum thickness of liquid film held by liquid surface tension on the one or more wafers.

~~48. The apparatus of claim 47, wherein the controller is configured to determine the thickness of liquid film on the one or more wafers by the diameter of the largest particle in the liquid film, the transfer acceleration of robots which transfer the one or more wafers, and the maximum thickness of liquid film held by the liquid surface tension on the one or more wafers.~~