

DEVICE AND METHOD FOR CLEANING WAFER

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims a priority to the Chinese patent application No. 202311075026.8 filed on August 24, 2023, which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to the field of semiconductor wafer manufacturing, in particular to a device and a method for cleaning a wafer.

BACKGROUND

[0003] In currently-used methods for cleaning a wafer, one method includes immersing the wafer into a cleaning liquid. The wafer is etched by chemical components contained in the cleaning liquid, and contaminants on the surface of the wafer are removed from the wafer along with the etched-off material of the wafer itself.

[0004] Before the cleaning, the wafer is usually clamped so as to be transferred among various processing devices including the cleaning device. In specific terms, the clamping of the wafer is usually implemented by a clamping mechanism contacting a periphery of the wafer. As a result, the periphery of the wafer may carry a large number of contaminants, e.g., contamination particles and metallic substances.

[0005] In a conventional cleaning method, in order to clean the wafer, the wafer needs to be immersed into the cleaning liquid in a cleaning tank of the cleaning device. In this process, the contaminants carried at the periphery of the wafer move upward relative to the wafer due to the impact of the cleaning liquid. However, the wafer is usually immersed into the cleaning liquid while maintaining a vertical direction, so the contaminants carried at the periphery are transferred to a main surface of the wafer, resulting in a diminished cleaning efficacy for that surface, and a large number of localized light scatter (LLS) particles previously present at the periphery cannot be

cleaned off from the main surface. In addition, after the cleaning, the wafer needs to be retrieved from the cleaning liquid in the cleaning tank. In this process, contaminants which have been removed from the periphery of the wafer, but still gather in the cleaning liquid around the periphery of the wafer, move downward relative to the wafer. Since the wafer is usually retrieved from the cleaning liquid in a vertical direction in an upright manner, the contaminants will still be transferred to the main surface of the wafer, the effect of cleaning the main surface may be adversely affected, and a large number of LLS particles still exist on the main surface of the wafer. In usage of the wafer, the periphery of the wafer may be removed in some processes, but the other part of the wafer, except the periphery, is actually utilized. Hence, if the main surface has low cleanliness or there still exists the contaminants on the main surface, the performance of a product such as an electronic device obtained subsequently may be adversely affected.

SUMMARY

[0006] In order to solve the above-mentioned technical problems, the present disclosure intends to provide a device and a method for cleaning a wafer, so as to, in a process of immersing the wafer into a cleaning liquid and a process of moving the wafer out of the cleaning liquid after the cleaning is completed, prevent a large number of contaminants carried at a periphery of the wafer from being transferred to a main surface of the wafer, thereby improving a cleaning effect as well as the performance of a product manufactured from the wafer.

[0007] The present disclosure includes the following technical solutions.

[0008] In a first aspect, the present disclosure provides in some embodiments a device for cleaning a wafer, including: a cleaning tank; a first pump configured to pump an etching liquid at the bottom of the cleaning tank to a liquid surface of the etching liquid in the cleaning tank via outside the cleaning tank in a process of immersing the wafer into the etching liquid in the cleaning tank, so that the etching liquid in the cleaning tank moves downward to remain stationary relative to the wafer; and a second

pump configured to pump the etching liquid at the liquid surface to the bottom of the cleaning tank via outside the cleaning tank in a process of moving the wafer out of the etching liquid in the cleaning tank, so that the etching liquid in the cleaning tank moves upward to remain stationary relative to the wafer.

[0009] In the process of immersing the wafer into the etching liquid, because the etching liquid moves downward to remain stationary relative to the wafer or, in other words, there is no relative movement between the etching liquid and the wafer, no impact is applied by the etching liquid onto the wafer. Therefore, even if a large number of contaminants are carried at a periphery of the wafer, the contaminants will not be transferred onto a main surface of the wafer, so it is able to ensure a cleaning effect of the main surface, and prevent the occurrence of such a situation where a large number of LLS particles previously present at the periphery cannot be cleaned off from the main surface. In addition, in the process of moving the wafer out of the etching liquid, because the etching liquid moves upward in such a manner that the etching liquid is stationary relative to the wafer or, in other words, there is no relative movement between the etching liquid and the wafer, a large number of contaminants removed from the periphery of the wafer and existing in the etching liquid are stationary relative to the wafer like the etching liquid, i.e., the contaminants are not transferred onto the main surface of the wafer, so it is able to maintain the cleaned status of the main surface, and prevent the occurrence of such a situation where a large number of LLS particles exist on the main surface of the wafer. As a result, after the cleaning, it is able to ensure that the main surface of the wafer, or more specifically, a portion of the wafer to be actually utilized, achieve a high level of cleanliness, thereby ensuring the performance of a product manufactured from the cleaned wafer.

[0010] In an optional embodiment of the present disclosure, the device further includes a first pipeline, the first pump is arranged in the first pipeline, a first port of the first pipeline leads into the cleaning tank at the bottom of the cleaning tank, and a second port of the first pipeline is arranged at the top of the cleaning tank.

[0011] In this way, when the etching liquid is pumped by the first pump, because the first port of the first pipeline leads into the cleaning tank at the bottom of the cleaning tank, the etching liquid at the bottom of the cleaning tank leaves the cleaning tank. In addition, because the second port of the first pipeline is arranged at the top of the cleaning tank, the etching liquid leaves the first pipeline at the top of the cleaning tank and reaches the liquid surface of the etching liquid in the cleaning tank.

[0012] In an optional embodiment of the present disclosure, the device further includes a second pipeline, the second pump is arranged in the second pipeline, a first port of the second pipeline leads into the cleaning tank at the bottom of the cleaning tank, and a second port of the second pipeline is arranged below the liquid surface of the etching liquid in the cleaning tank and at a position adjacent the liquid surface.

[0013] In this way, when the etching liquid is pumped by the second pump, because the second port of the second pipeline is arranged below the liquid surface of the etching liquid in the cleaning tank and at a position adjacent the liquid surface, the etching liquid at the liquid surface leaves the cleaning tank. In addition, because the first port of the second pipeline leads into the cleaning tank at the bottom of the cleaning tank, the etching liquid leaves the second pipeline at the bottom of the cleaning tank and reaches the bottom of the cleaning tank.

[0014] In an optional embodiment of the present disclosure, the device further includes an overflow tank. When additional etching liquid is added into the cleaning tank, the etching liquid at the liquid surface overflows from the cleaning tank into the overflow tank, and the second pump is configured to pump the etching liquid in the overflow tank.

[0015] Due to the existence of the overflow tank, it is able to pump the etching liquid at the liquid surface in an easier manner, because it is unnecessary to consider whether the etching liquid being pumped is at the liquid surface.

[0016] In an optional embodiment of the present disclosure, the device further includes an overflow pipeline, the second pump is arranged in the overflow pipeline, a

first port of the overflow pipeline leads into the overflow tank, and a second port of the overflow pipeline leads into the cleaning tank at the bottom of the cleaning tank.

[0017] In this way, when the etching liquid is pumped by the second pump, because the first port of the overflow pipeline leads into the overflow tank, it is able to pump the etching liquid in the overflow tank. In addition, because the second port of the overflow pipeline leads into the cleaning tank at the bottom of the cleaning tank, the etching liquid leaves the overflow pipeline at the bottom of the cleaning tank and reaches the bottom of the cleaning tank.

[0018] In an optional embodiment of the present disclosure, the device further includes a first filter, and the first filter is configured to filter the etching liquid flowing in a pumping path of the first pump.

[0019] In this way, in a case that impurities or contaminants from the wafer enter the pumping path of the first pump, it is able to filter out the impurities or contaminants and prevent the impurities or contaminants from returning to the cleaning tank.

[0020] In an optional embodiment of the present disclosure, the device further includes a second filter, and the second filter is configured to filter the etching liquid flowing in a pumping path of the second pump.

[0021] In this way, in a case that the impurities or contaminants from the wafer enter the pumping path of the second pump, it is able to filter out the impurities or contaminants and prevent the impurities or contaminants from returning to the cleaning tank.

[0022] In an optional embodiment of the present disclosure, the etching liquid is used for removing an oxidation film on a surface of the wafer.

[0023] In an optional embodiment of the present disclosure, the etching liquid is a hydrofluoric acid solution.

[0024] In a second aspect, the present disclosure provides in some embodiments a method for cleaning a wafer, including: pumping an etching liquid at the bottom of a cleaning tank to a liquid surface of the etching liquid in the cleaning tank via outside the cleaning tank in a process of immersing the wafer into the etching liquid in the

cleaning tank, so that the etching liquid in the cleaning tank moves downward to remain stationary relative to the wafer; and pumping the etching liquid at the liquid surface to the bottom of the cleaning tank via outside the cleaning tank in a case of moving the wafer out of the etching liquid in the cleaning tank, so that the etching liquid in the cleaning tank moves upward to remain stationary relative to the wafer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] Fig. 1 is a schematic view showing a device for cleaning a wafer according to an embodiment of the present disclosure;

[0026] Fig. 2 is another schematic view showing a device for cleaning the wafer according to an embodiment of the present disclosure;

[0027] Fig. 3 is yet another schematic view showing a device for cleaning the wafer according to an embodiment of the present disclosure;

[0028] Fig. 4 is still another schematic view showing a device for cleaning the wafer according to an embodiment of the present disclosure;

[0029] Fig. 5 is still yet another schematic view showing a device for cleaning the wafer according to an embodiment of the present disclosure; and

[0030] Fig. 6 is a flow chart of a method for cleaning a wafer according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0031] The technical solutions of the present disclosure will be described hereinafter in a clear and complete manner in conjunction with the drawings.

[0032] Referring to Fig. 1, the present disclosure provides in some embodiments a device 1 for cleaning a wafer W, which includes a cleaning tank 10, a first pump 11 and a second pump 12.

[0033] The first pump 11 is configured to pump an etching liquid EL at the bottom 10B of the cleaning tank 10 to an area of a liquid surface LS of the etching liquid EL in the cleaning tank 10 via outside the cleaning tank 10 in a process of

immersing the wafer W into the etching liquid EL in the cleaning tank 10, e.g., moving the wafer W from a position indicated by a dotted line to a position indicated by a solid line in a direction indicated by a hollowed arrow A1 as shown in Fig. 1, so that the etching liquid EL in the cleaning tank 10 moves downward as a whole to remain stationary relative to the wafer W. Here, the etching liquid EL at the bottom 10B refers to the etching liquid EL in a region between a dotted line BL1 and the bottom 10B shown in Fig. 1. In addition, the area of the liquid surface LS of the etching liquid EL may refer to, e.g., a region between a dotted line BL2 and the liquid surface LS in Fig. 1. In Fig. 1, a solid line with hollowed double-head arrows illustratively shows a flow path and a flow direction of the etching liquid EL pumped by the first pump 11. It is easily understood, by referring to Fig. 1, that when the etching liquid EL at the bottom 10B leaves the cleaning tank 10 and is supplemented to the liquid surface LS, the etching liquid EL in the cleaning tank 10 moves downward as a whole. As to how to enable the etching liquid EL to be stationary relative to the wafer W which is currently being immersed or how to make a movement speed of the etching liquid EL to be equal to a movement speed of the immersed wafer W, because the movement speed of the etching liquid EL depends on a sectional area of the cleaning tank 10 and a pumping flow rate of the first pump 11, the pumping flow rate of the first pump 11 may be calculated based on a movement speed of the immersed wafer W and the sectional area of the cleaning tank 10. The movement speed of the etching liquid EL is equal to the movement speed of the wafer W, as long as the etching liquid EL is pumped by the first pump 11 at the pumping flow rate.

[0034] The second pump 12 is configured to pump the etching liquid EL at the liquid surface LS to an area of the bottom 10B of the cleaning tank 10 via outside the cleaning tank 10 in a process of moving the wafer W out of the etching liquid EL in the cleaning tank 10, e.g., moving the wafer W from a position indicated by a solid line to a position indicated by a dotted line in a direction indicated by a hollowed arrow A2 as shown in Fig. 1, so that the etching liquid EL in the cleaning tank 10 moves upward as a whole in such a manner that the etching liquid EL is stationary relative to the wafer

W. Here, the etching liquid EL at the liquid surface LS refers to the etching liquid EL in a region between the dotted line BL2 and the liquid surface LS in Fig. 1. In addition, the area of the bottom 10B of the cleaning tank 10 may refer to, e.g., a region between the dotted line BL1 and the bottom 10B in Fig. 1. In Fig. 1, a solid line with black double-head arrows illustratively shows a flow path and a flow direction of the etching liquid EL pumped by the second pump 12. It is easily understood, by referring to Fig. 1, that when the etching liquid EL at the liquid surface LS leaves the cleaning tank 10 and is supplemented to the area of the bottom 10B, the etching liquid EL in the cleaning tank 10 moves upward as a whole. As to how to enable the etching liquid EL to be stationary relative to the wafer W which is currently being moved out of the cleaning tank or how to make a movement speed of the etching liquid EL to be equal to a movement speed of the wafer W, because the movement speed of the etching liquid EL depends on the sectional area of the cleaning tank 10 and a pumping flow rate of the second pump 12, the pumping flow rate of the second pump 12 is calculated based on a movement speed of the wafer W and the sectional area of the cleaning tank 10. The movement speed of the etching liquid EL is equal to the movement speed of the wafer W, as long as the etching liquid EL is pumped by the second pump 12 at the pumping flow rate.

[0035] In the device 1 according to the embodiments of the present disclosure, in the process of immersing the wafer W into the etching liquid EL, because the etching liquid EL moves downward as a whole in such a manner that the etching liquid EL is stationary relative to the wafer W or there is no relative movement between the etching liquid EL and the wafer W, no impact is applied by the etching liquid EL onto the wafer W. Thus, even if a large number of contaminants are carried at a periphery of the wafer W, the contaminants will not be transferred onto a main surface of the wafer W, so it is able to ensure a cleaning effect of the main surface, and prevent the occurrence of such a situation where a large number of LLS particles previously present at the periphery cannot be cleaned off from the main surface. In addition, in the process of moving the wafer W out of the etching liquid EL, because the etching liquid EL moves upward as

a whole in such a manner that the etching liquid EL is stationary relative to the wafer W or there is no relative movement between the etching liquid EL and the wafer W, a large number of contaminants removed from the periphery of the wafer W and existing in the etching liquid EL are stationary relative to the wafer W like the etching liquid EL, i.e., the contaminants are not transferred onto the main surface of the wafer W, thus it is able to maintain the cleaned status of the main surface, and prevent the occurrence of such a situation where a large number of LLS particles exist on the main surface of the wafer W. As a result, after the cleaning is completed, the main surface of the wafer W, i.e., a portion of the wafer W to be actually utilized, has high cleanliness, thereby ensuring the performance of a product manufactured from the cleaned wafer W.

[0036] As to the specific implementation of pumping the etching liquid EL by the first pump 11 as mentioned hereinabove, in an optional embodiment of the present disclosure, as shown in Fig. 2, the device 1 may further include a first pipeline 13, the first pump 11 may be arranged in the first pipeline 13, a first port 131 of the first pipeline 13 may lead into the cleaning tank 10 at the bottom 10B of the cleaning tank 10, and a second port 132 of the first pipeline 13 is arranged at the top 10T of the cleaning tank 10. In this way, in a case that the etching liquid EL is pumped by the first pump 11, because the first port 131 of the first pipeline 13 leads into the cleaning tank 10 at the bottom 10B of the cleaning tank 10, the etching liquid EL at the bottom 10B of the cleaning tank 10 leaves the cleaning tank 10. In addition, the second port 132 of the first pipeline 13 is arranged at the top 10T of the cleaning tank 10, so the etching liquid EL leaves the first pipeline 13 at the top 10T of the cleaning tank 10 and reaches the liquid surface LS of the etching liquid E in the cleaning tank 10.

[0037] As to the specific implementation of pumping the etching liquid EL by the second pump 12 as mentioned hereinabove, in an optional embodiment of the present disclosure, as shown in Fig. 3, the device 1 may further include a second pipeline 14, the second pump 12 may be arranged in the second pipeline 14, a first port 141 of the second pipeline 14 may lead into the cleaning tank 10 at the bottom 10B of the cleaning tank 10, and a second port 142 of the second pipeline 14 may be arranged

below the liquid surface LS of the etching liquid EL in the cleaning tank 10 and at a position adjacent the liquid surface LS. In this way, in a case that the etching liquid EL is pumped by the second pump 12, because the second port 142 of the second pipeline 14 is arranged below the liquid surface LS of the etching liquid EL in the cleaning tank 10 and at a position adjacent the liquid surface LS, the etching liquid EL at the liquid surface LS leaves the cleaning tank 10. In addition, because the first port 141 of the second pipeline 14 leads into the cleaning tank 10 at the bottom 10B of the cleaning tank 10, the etching liquid EL leaves the second pipeline 14 at the bottom 10B of the cleaning tank 10 and reaches the bottom 10B of the cleaning tank 10.

[0038] In an optional embodiment of the present disclosure, as shown in Fig. 4, the device 1 may further include an overflow tank 15. When additional etching liquid EL is added into the cleaning tank 10, the etching liquid EL at the liquid surface LS may overflow from the cleaning tank 10 into the overflow tank 15, and the second pump 12 is configured to pump the etching liquid EL in the overflow tank 15. Firstly, when the etching liquid EL overflows from the cleaning tank 10, the etching liquid EL leaving the cleaning tank 10 must be the etching liquid EL at the liquid surface LS. Secondly, the etching liquid EL overflows into the overflow tank 15, so when the etching liquid EL in the overflow tank 15 is pumped by the second pump 12, it is equivalent to that the etching liquid EL at the liquid surface LS is pumped. In the embodiments of the present disclosure, due to the existence of the overflow tank 15, it is able to pump the etching liquid EL at the liquid surface LS in an easier manner, because it is unnecessary to consider whether the etching liquid being pumped is at the liquid surface.

[0039] As to the specific implementation of pumping the etching liquid EL by the second pump 12 as mentioned hereinabove, as shown in Fig. 5, the device 1 may further include an overflow pipeline 16, the second pump 12 may be arranged in the overflow pipeline 16, a first port 161 of the overflow pipeline 16 may lead into the overflow tank 15, and a second port 162 of the overflow pipeline 16 may lead into the cleaning tank 10 at the bottom 10B of the cleaning tank 10. In this way, in a case that the etching liquid EL is pumped by the second pump 12, because the first port 161 of

the overflow pipeline 16 leads into the overflow tank 15, it is able to pump the etching liquid EL in the overflow tank 15. In addition, because the second port 162 of the overflow pipeline 16 leads into the cleaning tank 10 at the bottom 10B of the cleaning tank 10, the etching liquid EL leaves the overflow pipeline 16 at the bottom 10B of the cleaning tank 10 and reaches the bottom 10 B of the cleaning tank 10.

[0040] In an optional embodiment of the present disclosure, as shown in Fig. 1, the device 1 further includes a first filter 17, and the first filter 17 is configured to filter the etching liquid EL flowing in a pumping path of the first pump 11. As specifically shown in Fig. 1, the first filter 17 may be arranged downstream of the first pump 11 in a flowing direction of the etching liquid EL. In this way, in a case that impurities or contaminants from the wafer W enter the pumping path of the first pump 11, it is able to filter out the impurities or contaminants and prevent the impurities or contaminants from returning to the cleaning tank 10.

[0041] In an optional embodiment of the preset disclosure, as shown in Fig. 1, the device 1 further includes a second filter 18, and the second filter 18 is configured to filter the etching liquid EL flowing in a pumping path of the second pump 12. As specifically shown in Fig. 1, the second filter 18 may be arranged downstream of the second pump 12 in the flowing direction of the etching liquid EL. In this way, in a case that the impurities or contaminants from the wafer W enter the pumping path of the second pump 12, it is able to filter out the impurities or contaminants and prevent the impurities or contaminants from returning to the cleaning tank 10.

[0042] Optionally, the etching liquid EL is used for removing an oxidation film on a surface of the wafer W, so as to remove the contaminant particles or other impurities in the oxidation film. Optionally, the etching liquid is a hydrofluoric acid solution.

[0043] As shown in Fig. 6 in conjunction with Fig. 1, the present disclosure further provides in some embodiments a method for cleaning a wafer W, which includes: Step S601 of pumping an etching liquid EL at a bottom 10B of a cleaning tank 10 to a liquid surface LS of the etching liquid EL in the cleaning tank 10 via outside the

cleaning tank 10 in a process of immersing the wafer W into the etching liquid EL in the cleaning tank 10, so that the etching liquid EL in the cleaning tank 10 moves downward as a whole in such a manner that the etching liquid EL is stationary relative to the wafer W; and Step S602 of pumping the etching liquid EL at the liquid surface LS to the bottom 10B of the cleaning tank 10 via outside the cleaning tank 10 in a case of moving the wafer W out of the etching liquid EL in the cleaning tank 10, so that the etching liquid EL in the cleaning tank 10 moves upward as a whole in such a manner that the etching liquid EL is stationary relative to the wafer W.

[0044] Unless otherwise defined, any technical or scientific term used herein shall have the common meaning understood by a person of ordinary skills. Such words as “first” and “second” used in the specification and claims are merely used to differentiate different components rather than to represent any order, number or importance. Similarly, such words as “one” or “one of” are merely used to represent the existence of at least one member, rather than to limit the number thereof. Such words as “include” or “including” intends to indicate that an element or object before the word contains an element or object or equivalents thereof listed after the word, without excluding any other element or object. Such words as “connect/connected to” or “couple/coupled to” may include electrical connection, direct or indirect, rather than to be limited to physical or mechanical connection. Such words as “on”, “under”, “left” and “right” are merely used to represent relative position relationship, and when an absolute position of the object is changed, the relative position relationship will be changed too.

[0045] It should be appreciated that, the technical solutions in the embodiments of the present disclosure may be combined randomly in a case of no conflict.

[0046] The above are merely specific implementations of the present disclosure, and shall not be construed as limiting the scope of the present disclosure. Any person skilled in the art may make modifications and substitutions without departing from the spirit of the present disclosure, and these modifications and substitutions shall also fall

within the scope of the present disclosure. Hence, the scope of the present disclosure shall be subject to the scope defined by the appended claims.

What is claimed is:

1. A device for cleaning a wafer, comprising:

a cleaning tank;

a first pump, configured to pump an etching liquid at the bottom of the cleaning tank to a liquid surface of the etching liquid in the cleaning tank via outside the cleaning tank in a process of immersing the wafer into the etching liquid in the cleaning tank, so that the etching liquid in the cleaning tank moves downward to remain stationary relative to the wafer; and

a second pump, configured to pump the etching liquid at the liquid surface to the bottom of the cleaning tank via outside the cleaning tank in a process of moving the wafer out of the etching liquid in the cleaning tank, so that the etching liquid in the cleaning tank moves upward to remain stationary relative to the wafer.

2. The device according to claim 1, further comprising a first pipeline, wherein the first pump is arranged in the first pipeline, a first port of the first pipeline leads into the cleaning tank at the bottom of the cleaning tank, and a second port of the first pipeline is arranged at the top of the cleaning tank.

3. The device according to claim 1, further comprising a second pipeline, wherein the second pump is arranged in the second pipeline, a first port of the second pipeline leads into the cleaning tank at the bottom of the cleaning tank, and a second port of the second pipeline is arranged below the liquid surface of the etching liquid in the cleaning tank and at a position adjacent the liquid surface.

4. The device according to claim 1, further comprising an overflow tank, wherein when additional etching liquid is added into the cleaning tank, the etching liquid at the liquid surface overflows from the cleaning tank into the overflow tank, and the second pump is configured to pump the etching liquid in the overflow tank.

5. The device according to claim 4, further comprising an overflow pipeline, wherein the second pump is arranged in the overflow pipeline, a first port of the overflow pipeline leads into the overflow tank, and a second port of the overflow pipeline leads into the cleaning tank at the bottom of the cleaning tank.

6. The device according to claim 1, further comprising a first filter, wherein the first filter is configured to filter the etching liquid flowing in a pumping path of the first pump.

7. The device according to claim 1, further comprising a second filter, wherein the second filter is configured to filter the etching liquid flowing in a pumping path of the second pump.

8. The device according to any one of claims 1 to 7, wherein the etching liquid is used for removing an oxidation film on a surface of the wafer.

9. The device according to claim 8, wherein the etching liquid is a hydrofluoric acid solution.

10. A method for cleaning a wafer, comprising:

pumping an etching liquid at the bottom of a cleaning tank to a liquid surface of the etching liquid in the cleaning tank via outside the cleaning tank in a process of immersing the wafer into the etching liquid in the cleaning tank, so that the etching liquid in the cleaning tank moves downward to remain stationary relative to the wafer; and

pumping the etching liquid at the liquid surface to the bottom of the cleaning tank via outside the cleaning tank in a process of moving the wafer out of the etching

liquid in the cleaning tank, so that the etching liquid in the cleaning tank moves upward to remain stationary relative to the wafer.