FLOWING LIQUID TYPE CLEANING APPARATUS

FIELD OF THE INVENTION

[0001] The present invention relates to a flowing liquid type cleaning apparatus for precision cleaning of workpieces which require a high degree of cleanliness, such as semiconductor wafers, magnetic disk substrates, electronic components, optical components and precision machine components.

BACKGROUND OF THE INVENTION

[0002] Various flowing liquid type cleaning apparatuses in which workpieces are dipped in a uniform flow of cleaning liquid for cleaning have been proposed. In this type of cleaning apparatus, a contaminant coming off a workpiece is prevented from flowing back with a swirl of cleaning liquid and adhering to the workpiece again. For this purpose, porous flow straightening plates are installed upstream and downstream in the flow path in a way to let the cleaning liquid pass through these plates to ensure that the flow of cleaning liquid is a uniform and turbulence-free flow (laminar flow).

[0003] In this case, the flow velocity of the cleaning liquid, which is very low, for example at 5-20 mm/sec or so, is primarily determined by the balance between the cleaning liquid feed and discharge rates. The optimum flow velocity depends on the type

of workpiece, the type of cleaning liquid and the required cleanliness.

[0004] The flow velocity is controlled by changing the positions of holes in a flow straightening plate, their diameter and the number of holes or by installing another flow straightening plate of nonwoven fabric or the like or by pressurization. Another effort is to make arrangements to let the cleaning liquid drop from the top of a flow straightening plate on the downstream side to generate a positive flow on the liquid surface, thereby creating a uniform stream without a velocity component which might cause a backward flow.

[0005] However, when a surfactant such as a detergent is used for a cleaning liquid, the liquid foams very easily and a problem which would not occur in the case of distilled water arises. Figs. 3(1) and 3(2) show an example of a conventional flowing liquid type cleaning apparatus as mentioned above. Fig. 3(1) illustrates an initial condition of the cleaning process in case that a surfactant is used for a cleaning liquid, and Fig. 3(2) illustrates the next condition in which a lot of bubbles are generated.

[0006] In a flowing liquid type cleaning apparatus 1, a cleaning liquid flows from a feed liquid tank portion 2 through a flow straightening plate 21 into a cleaning tank portion 3 from left as shown in the figure. At this time, the cleaning

liquid flows to the right as a uniform stream. The cleaning tank portion 3 and drain tank portion 4 are separated by a drain plate 41. The drain plate 41 has plural holes 42 through which the liquid passes. A workpiece W to be cleaned is kept dipped in the cleaning tank portion 3 and slowly moved in the direction opposite to the direction of the cleaning liquid flow, namely from downstream to upstream.

[0007] A uniform stream is created by adjusting the positions, diameter and number of the holes 42 in the flow straitening plate 21 or the liquid level of the drain tank portion 4. The liquid which has passed through the holes 42 or has overflowed from the top of the drain plate 41 drops on the liquid surface of the drain tank portion 4. This generates bubbles b on the liquid surface of the drain tank portion 4.

[0008] If the cleaning liquid includes a surfactant, bubbles rarely disappear by themselves but remain in the drain tank portion 4 as they are. Therefore, a large cluster of bubbles is generated over time and as shown in Fig. 3(2), some bubbles b are forced to move and reach an area above the cleaning tank portion 3. These bubbles b touch the liquid surface of the cleaning tank portion 3 and consequently bubbles or broken bubbles spread there.

[0009] Since these bubbles have resulted from foaming of a waste liquid containing much removed dirt, not only they contain

impurities but also there is a lot of dirt adhering to their surfaces. Therefore, if bubbles enter the cleaning liquid portion 3, the cleaning liquid itself would be contaminated, making it impossible to maintain the cleaning performance of the liquid type cleaning apparatus 1.

[0010] The patent documents related to the above prior art are as follows:

Japanese Unexamined Patent Publication No. 1993-253410,
Japanese Unexamined Patent Publication No. 1995-302777,
Japanese Unexamined Patent Publication No. 1997-090643,
Japanese Unexamined Patent Publication No. 1997-285767,
Japanese Unexamined Patent Publication No. 1999-076956,
Japanese Unexamined Patent Publication No. 2000-058499, and
Japanese Unexamined Patent Publication No. 2002-222790.

SUMMARY OF THE INVENTION

[0011] An object of the present invention is to provide a flowing liquid type cleaning apparatus which prevents foaming of a cleaning liquid (waste liquid) in the course of its drainage from the downstream side of a cleaning tank portion to eliminate the possibility of deterioration in the cleaning performance due to bubbles flowing back from a drain tank portion into the cleaning tank as seen in the conventional system. Another object of the invention is to provide a flowing liquid type

cleaning apparatus which virtually eliminates the need for a drain tank portion as needed in the conventional system and requires a smaller installation space or has a larger cleaning tank portion than the conventional type. A further object is to provide a flowing liquid type cleaning apparatus in which the cleaning liquid flow distribution in the cleaning tank portion can be controlled more easily.

[0012] The above objects are achieved as follows. According to a first aspect of the present invention, a flowing liquid type cleaning apparatus comprises: a feed liquid tank portion for feeding cleaning liquid; a cleaning tank portion separated from the feed liquid tank portion by a flow straightening plate, a work piece being cleaned in a flow of cleaning liquid; a drain plate located at the end of the cleaning tank portion; a plurality of drain pipes attached to the drain plate and respectively opening to the cleaning tank portion; flow rate regulators for respectively regulating flow rate of cleaning liquid in the drain pipes; a pump for forcing cleaning liquid out of the drain pipes; and a cleaning liquid filter located between the discharging port of the pump and the feed liquid tank portion.

[0013] According to a second aspect of the invention, in the flowing liquid type cleaning apparatus according to the first aspect, the flow rate regulators is an adjustable flow regulating valve.

[0014] According to a third aspect of the invention, in the flowing liquid type cleaning apparatus according to the first aspect, the flow rate regulator is a replaceable orifice.

[0015] According to a fourth aspect of the invention, in the flowing liquid type cleaning apparatus according to the first, second or third aspect, the drain plate allows cleaning liquid to flow partially over the upper edge into a sluiceway formed on the top of the drain plate for leading cleaning liquid to the pump.

[0016] According to a fifth aspect of the invention, in the flowing liquid type cleaning apparatus according to the first, second or third aspect, the drain plate allows cleaning liquid to flow partially over the upper edge into a drain tank portion for leading cleaning liquid to the pump.

[0017] The flowing liquid type cleaning apparatus according to the present invention offers the following advantageous effects. Generation of bubbles in the course of drainage of a cleaning liquid (waste liquid) from the downstream side of the cleaning tank portion is prevented and it is unlikely that bubbles flow back from the drain tank portion, resulting in deterioration in the cleaning performance as seen in the conventional system. Furthermore, the need for a drain tank portion which is needed in the conventional system is virtually eliminated and the required installation space is smaller or

the cleaning tank portion can be larger. Moreover, the cleaning liquid flow distribution in the cleaning tank portion can be controlled more easily.

[0018] According to the second aspect of the invention, since the flow rate is controlled by the flow regulating valve located midway in a drain pipe, flow rate control is much easier than in the conventional method in which such control is done by adjusting the holes in the drain plate.

[0019] According to the third aspect, since the flow rate is controlled by replacing the orifice provided midway in a drain pipe, flow rate control is much easier than in the conventional method in which such control is done by adjusting the holes in the drain plate.

[0020] According to the fourth aspect, even when the cleaning liquid has to be drained from above the drain plate, the cleaning liquid on the liquid surface flows into the sluiceway formed on the top of the drain plate without a level difference, so it hardly foams and even if bubbles are generated, they are taken into drain pipes together with inflowing cleaning liquid and do not flow back into the cleaning tank portion.

[0021] According to the fifth aspect, since the liquid level of the drain tank portion does not affect the flow rate in the cleaning tank portion, the liquid level of the drain tank portion may be below that of the cleaning tank portion but very close

to it. In this case, when the cleaning liquid flows from the cleaning tank portion into the drain tank portion, it hardly foams. Even if bubbles are generated, they are easily taken into the opening of a drain pipe near the liquid surface and thus it is unlikely that the bubbles move to the cleaning tank portion and cause contamination.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The invention will be more particularly described with reference to the accompanying drawings, in which:

Fig. 1 illustrates a flowing liquid type cleaning apparatus according to an embodiment of the present invention;

Fig. 2 illustrates the panel surface of a flow rate regulator; and

Figs. 3(1) and 3(2) illustrate a flowing liquid type cleaning apparatus of the conventional type, wherein Fig. 3(1) shows an initial condition of the cleaning process and Fig. 3(2) shows the next condition of the process.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0023] Next, preferred embodiments of the present invention will be described referring to the accompanying drawings. Fig. 1 illustrates a flowing liquid type cleaning apparatus 1 according to a first embodiment of the present invention. In

Fig. 1, the same reference numerals as used in the description of the conventional type cleaning apparatus are used for members with similar functions in the present invention for the sake of convenience, but the members designated by the same reference numerals do not always perform the same functions.

[0024] The flowing liquid type cleaning apparatus 1 includes a feed liquid tank portion 2 for feeding a cleaning liquid and a cleaning tank portion 3 which is separated from the feed liquid tank portion 2 by a flow straitening plate 21. The cleaning liquid flows from the feed liquid tank portion 2 into the cleaning tank portion 3 through the flow straitening plate 21 and further runs from upstream to downstream in the cleaning tank portion 3 (from left to right in the figure). A workpiece W is dipped in the cleaning liquid and cleaned while being slowly moved in the cleaning liquid flow in the opposite direction, namely from downstream to upstream.

[0025] A drain plate 41 is located on the most downstream side of the cleaning tank portion 3. Plural drain pipes 45 which are open to the cleaning tank portion 3 at one end are fitted to the drain plate 41. The drain pipes 45 each run through a flow rate regulator 5 (stated later) and connect to the intake port of a pump P together. A cleaning liquid filter F is provided on the discharge port side of the pump P to remove contaminants in the cleaning liquid discharged from the pump P and send the

liquid back to the feed liquid tank portion for circulation.

[0026] The flow rate regulator 5 is capable of controlling the flow rate of the liquid running in each of the drain pipes 45. Fig. 2 shows a panel surface 50 of the flow rate regulator 5. The regulator shown here uses flow regulating valves 51 with flow meters 52. Each of the flow regulating valves 51 is installed midway in one of the drain pipes 45, which means that as many flow regulating valves as the drain pipes 45 are provided.

[0027] The aperture size of the flow regulating valve 51 is controlled by adjusting the needle position by a dial 53. The liquid flow from the cleaning tank portion 3 is introduced into the flow regulating valve 51 from behind the dial 53 at the bottom of the flow regulating valve 51 and narrowed and passed through the flow meter 52, exiting the valve at its top from behind. The flows which have exited the flow regulating valves 51 join together and reach the pump P.

[0028] The flow meter 52 measures the flow rate on the following principle: when a fluid is introduced from below into a tapered graduated glass tube with its upper end diameter larger than its lower end diameter, the position of a marker ball 521 as a pointer varies depending on the flow rate. Since the flow rate regulator 5 is integrated in the form of a panel as shown in Fig. 2, it is easy to control the flow rate distribution

in the cleaning tank portion 3. However, it does not always have to be integrated in the form of a panel like this.

[0029] It is also possible to make arrangements that allow the cleaning liquid to flow out from above the drain plate 41 as in the conventional system. In that case, a sluiceway 6 with an inclined surface is provided on the top of the drain plate 41 and the cleaning liquid which has reached the sluiceway 6 is introduced into the pump through one of the drain pipes 45. Needless to say, this drain pipe 45 runs through the flow rate regulator 5 in the same way as the other drain pipes 45.

[0030] The cleaning liquid hardly foams in the sluiceway 6 because there is almost no level difference and the surface is inclined, and even if bubbles are generated, the bubbles are forced out through the drain pipes 45 and it is unlikely that stagnant bubbles in the sluiceway 6 flow back into the cleaning tank portion 3.

[0031] It is also possible that the drain tank portion 4 is located behind the drain plate 41 (on the right of the drain plate 41 in Fig. 1) as in the conventional type; however, in that case, the drain tank portion 4 is not connected with the cleaning tank portion 3 through the holes 42 as in the conventional system. In other words, the flow rate need not be controlled by a pressure difference in the holes 42 between the cleaning tank portion 3 and the drain tank portion 4 as

in the conventional system. Therefore, the liquid level of the drain tank portion 4 may be freely set.

[0032] Therefore, the liquid level of the drain tank portion 4 can be as close to that of the cleaning tank portion 3 as possible, which means that the level difference from the top of the drain plate 41 to the liquid surface of the drain tank portion 4 can be minimized to the extent that bubbles are not generated as the liquid falls. Since the level difference can be almost eliminated, the liquid hardly foams and even if bubbles are generated, they are forced out by the drain pipes 45 located in the upper portion of the drain tank portion 4 and thus it is unlikely that stagnant bubbles flow back into the cleaning tank portion 3.

[0033] Although the above explanation assumes that the flow rate regulator 5 uses flow regulating valves, orifices may be inserted into the pipes in a replaceable manner instead of the regulating valves. An orifice itself cannot control the flow rate but the flow rate can be controlled by replacement of the orifice when many types of orifices are available on hand. When many flowing liquid type cleaning units of the same type are manufactured, a combination of orifices may be shared among the units, contributing to cost reduction.

What is claimed is:

1. A flowing liquid type cleaning apparatus comprising:

a feed liquid tank portion for feeding cleaning liquid;

a cleaning tank portion separated from the feed liquid tank portion by a flow straightening plate, a work piece being cleaned in a flow of cleaning liquid;

a drain plate located at the end of the cleaning tank portion;

a plurality of drain pipes attached to the drain plate and respectively opening to the cleaning tank portion;

flow rate regulators for respectively regulating flow rate of cleaning liquid in the drain pipes;

a pump for forcing cleaning liquid out of the drain pipes; and

a cleaning liquid filter located between the discharging port of the pump and the feed liquid tank portion.

2. A flowing liquid type cleaning apparatus according to Claim 1, wherein the flow rate regulators is an adjustable flow regulating valve.

3. A flowing liquid type cleaning apparatus according to Claim 1, wherein the flow rate regulator is a replaceable orifice.

4. A flowing liquid type cleaning apparatus according to any of Claims 1 to 3, wherein the drain plate allows cleaning liquid to flow partially over the upper edge into a sluiceway formed on the top of the drain plate for leading cleaning liquid to the pump.

5. A flowing liquid type cleaning apparatus according to any of Claims 1 to 3, wherein the drain plate allows cleaning liquid to flow partially over the upper edge into a drain tank portion for leading cleaning liquid to the pump.