

CLEANING APPARATUS

Field of the Invention

The present invention relates to a cleaning apparatus which removes very fine particles or organic substances on the surface of a hard disk medium, a silicon wafer, or the like by cleaning.

Prior Art

The surfaces of a hard disk medium, a silicon wafer, a glass plate for machining a liquid crystal display, and so forth must be completely cleaned for minimization of irregularities and for micromachining so as to prevent very fine particles or organic substances from remaining.

An example of a cleaning apparatus which cleans the surface of a silicon wafer or the like as above has been disclosed in Japanese Laid-Open Patent Publication (Kokai) No. 2003-1208.

Fig. 5 is a view showing the construction of the cleaning apparatus disclosed in this publication. In Fig. 5, reference numeral 11 denotes a cylinder of CO₂ as a cleaning agent (hereinafter referred to as "solvent"); CO₂ within the cylinder 11 is divided into a liquid section 111 with a temperature T and a gas section 112 with a pressure P₀. Reference numeral 12 denotes a heater which keeps the cylinder 11 warm at a constant temperature.

Reference numeral 13 denotes a pipe which takes out the gas CO₂. Reference numeral 14 denotes a pressure gage disposed in the pipe 13, for measuring the temperature within the pipe 13. The pressure within the pipe 13 is equal to the pressure P₀ of the gas

section 112. Reference numeral 16 denotes a line filter, and reference numeral 17 denotes an air operate valve, and both of them are attached to the pipe 13. The CO₂ cylinder, the line filter 16, and the air operate valve 17 are arranged in this order as shown in Fig. 5.

Reference numeral 19 denotes a hard disk medium as an object to be cleaned, which is rotated by a spindle 20. Reference numeral 18 denotes a nozzle, which is disposed with a predetermined gap from the object to be cleaned 19. The nozzle 18 is a double pipe type, in which the gas CO₂ lead into the pipe 13 is passed through an inner pipe, and N₂ gas is passed through an outer pipe. Reference numeral 21 denotes an infrared heater, which heats the object to be cleaned 19. Reference numeral 22 denotes a purge pipe from which the N₂ gas is injected. In Fig. 5, the pressure gauge 14 measures the pressure within the pipe 13, and the heater 12 is controlled so that the pressure within the pipe 13 can be constant. Since the CO₂ liquid and the CO₂ gas coexist in the cylinder 11, the pressure P_0 of the gas section 112 corresponds to a saturation vapor pressure at the temperature T of the liquid section 111. The liquid temperature and the saturation vapor pressure have a one-on-one relationship, and hence if the heater 12 controls the temperature of the liquid section 111, the saturation vapor pressure i.e. the pressure within the pipe 13 can be controlled. For example, if the liquid temperature is controlled to 22°C, the saturation vapor pressure is 6.0 Mpa.

According to the above construction, particles such as dusts are removed by subjecting gas of the solvent (CO₂) to filtering by the line filter, injected from the nozzle to be changed into solid particles or droplets, which are then injected to the object

to be cleaned, so that particles or organic substances can be removed. Further, since the solvent can be changed into solid particles or droplets by controlling the gap between the nozzle and the object to be cleaned, it is possible to select the optimum state of the solvent according to the degree of dirt. Further, since particles such as dusts in the solvent can be easily removed by filtering, there is no necessity of using an expensive and pure solvent, and this reduces running cost.

Problems to be Solved by the Invention

The above described cleaning apparatus, however, has problems as follows.

1) Particles such as dusts are generated from the infrared heater 21 which heats the object to be cleaned 19 to a predetermined temperature.

2) The end of the nozzle 18 is rapidly cooled due to adiabatic expansion during the injection of CO₂, and liquefaction occurs within a CO₂ passage as the temperature decreases. As a result, the generation of dry ice cannot be controlled. To avoid this, the infrared heater 21 controls the temperature, but the generation of CO₂ may be unstable since the temperature of the nozzle 18 is not independently controlled.

It is therefore an object of the present invention to provide a cleaning apparatus which enables more satisfactory cleaning by reducing dust sources, and preventing dew condensation of an object to be cleaned due to CO₂ sprayed thereto, and the condensation of CO₂ within pipes.

Means for Solving the Problems

To attain the above object, according to the invention of claim 1, there is provided a cleaning apparatus that cleans an object to be cleaned by injecting a cleaning agent from a nozzle, comprising gas injecting means for injecting heated gas to a surface of the object to be cleaned, wherein the injecting means is configured to move on the object to be cleaned when cleaning is performed, and retract from the object to be cleaned when cleaning is not performed, and an injection quantity of the heated gas is controlled when cleaning is performed and when cleaning is not performed.

According to the invention of claim 2, in the cleaning apparatus according to claim 1, the gas injecting means comprises a plurality of jet holes, and gas heated to a predetermined temperature is injected from the plurality of jet holes.

According to the invention of claim 3, in the cleaning apparatus according to claim 1 or 2, the gas injecting means has one end thereof supported by a supporting member and is disposed at a predetermined interval on the surface of the object to be cleaned, such that gas is injected toward the surface of the object to be cleaned.

According to the invention of claim 4, in the cleaning apparatus according to any of claims 1 to 3, wherein the jet holes of the gas injecting means are at a predetermined angle with respect to the surface of the object to be cleaned.

According to the invention of claim 5, in the cleaning

apparatus according to claim 4, the gas injecting means is disposed between a center and a circumference of the object to be cleaned, and the jet holes are formed in at least two directions: a direction vertical to the surface of the object to be cleaned and an inner circumferential direction or an outer circumferential direction.

According to the invention of claim 6, in the cleaning apparatus according to any of claims 1 to 5, there is provided a filter for cleaning the gas.

According to the invention of claim 7, in the cleaning apparatus according to any of claims 3 to 6, the supporting member and the filter as well as a heater for heating the gas are disposed within a keep-warm chamber.

According to the invention of claim 8, in the cleaning apparatus according to any of claims 3 to 7, at least one of the supporting member or the filter comprises a temperature control mechanism.

According to the invention of claim 9, in the cleaning apparatus according to any of claims 3 to 8, at least two gas injecting means supported by the supporting member are disposed on the surface of the object to be cleaned across the center thereof.

According to the invention of claim 10, in the cleaning apparatus according to claim 9, gas from one gas source is flown into the at least two gas injecting means.

According to the invention of claim 11, in the cleaning apparatus according to any of claims 2 to 10, there is provided solvent injecting means mounted in vicinity of a center of the at least two gas injecting means supported by the supporting means, wherein the gas injecting means and the solvent injecting means are driven as an integral unit.

According to the invention of claim 12, in the cleaning apparatus according to any of claims 1 to 11, the solvent injecting means comprises temperature control means for controlling a solvent to a temperature equal to or higher than a dew point.

According to the invention of claim 13, in the cleaning apparatus according to any of claims 1 to 12, gas jetting holes through which gas is jetted are formed on an outer circumference of a nozzle provided in the solvent injecting means.

According to the invention of claim 14, in the cleaning apparatus according to any of claims 1 to 13, the solvent injecting means is rod-shaped, and is formed with a wedge-shaped gradient in a longitudinal direction thereof and in opposed relation to the surface of the object to be cleaned.

Brief Description of the Drawings

Fig. 1 is a view showing the construction of essential parts of an example of a cleaning apparatus according to an embodiment of the present invention.

Fig. 2 is a view showing an example of a solvent injecting means according to an embodiment of the present invention.

Fig. 3 is a view showing an example of solvent injecting means according to another embodiment of the present invention.

Fig. 4 is a view showing the flow of dry ice (CO_2) using the solvent injecting means according to the present invention.

Fig. 5 is a view showing the construction of a cleaning apparatus according to a prior art.

Embodiments of the Invention

The present invention will now be described in detail with reference to the accompanying drawings showing preferred embodiments thereof.

Fig. 1 is a view showing the construction of essential parts of a cleaning apparatus according to an embodiment of the present invention. In Fig. 1, an area A enclosed by a chain double-dashed line is a keep-warm chamber, which prevent exchange of heat with the outside using a heat insulating material, not shown. The keep-warm chamber A contains a heater block 4, a filter 3, and a supporting member 2. Reference numeral 1 denotes pipes as gas injecting means, which have one ends thereof closed and the other ends thereof fixed to the supporting member (manifold) 2. Although in Fig. 1, each of the pipes 1 is disposed between the center and the periphery of an object to be cleaned 19, it is preferred that four pipes 1 are provided on both sides of the object to be cleaned 19 since they are intended to mainly prevent dew condensation of the object to be cleaned 19. However, at least one pipe 1 suffices insofar as dew condensation can be prevented.

Each of the pipes 1 is formed with holes 1a and 1b in two

series in the longitudinal direction thereof. These holes 1a and 1b are formed at regular intervals and at a predetermined angle with respect to the surface of the object to be cleaned 19.

Specifically, the holes 1a are formed in a direction vertical to the surface of the object to be cleaned 19, and the holes 2a are formed at an angle of 45° in a direction toward the center of the object to be cleaned 19.

The supporting member 2 is formed with a branched hole 2a, and the other ends of the two pipes 1 are air tightly fixed to both ends of the branched hole 2a. A pipe 3a, which is connected to the outlet of the filter 3, is connected to a predetermined location of the branched hole 2a. A pipe 4a, which leads N_2 gas, is connected to the inlet of the heater block 4, and a pipe 4b, which is connected to the inlet of the filter 3, is connected to the outlet of the heater block 4.

The pipe 4a which leads N_2 gas is configured such that N_2 gas flows in from two directions; a small quantity of N_2 gas is constantly flown into the pipe 4a from the inlet of a constant lead-in pipe 6a, while a relatively large quantity of N_2 gas flows into the pipe 4a from an in-injection lead-in pipe 6b via an air operate valve 5 during cleaning.

Reference numeral 8 denotes a rod-shaped CO_2 injecting means, which is formed of a high thermal capacity metal block 8a which is e.g. 50 mm in length and 15 mm on a side. The CO_2 injecting means has one end thereof fixed to the supporting member 2, and has the other end thereof formed with a nozzle 8b which is provided with a jet hole of about 0.3 mm, for example.

Figs. 2(a) to 2(c) illustrate an example of the CO₂ injecting means 8 according to an embodiment, in which Fig. 2(a) is a sectional view, Fig. 2(b) is a side view, and Fig. 2(c) is an enlarged sectional view of Fig. 2(b).

In Figs. 2(a) to 2(c), reference numeral 8c denotes a CO₂ passage in which CO₂ as a solvent flows, and reference numeral 8d denotes an N₂ passage in which N₂ gas flows. It is configured such that N₂ gas led into the N₂ passage 8d jets from the periphery of the nozzle 8b.

The nozzle 8b is fabricated as a separate part, and is fixed to an end of the metal block 8a by press-fitting, welding, or the like. Reference numeral 8e denotes a temperature control means which has a temperature sensor and a temperature control circuit incorporated therein although they are not illustrated.

Figs. 3(a) to 3(c) illustrate an example of the injecting means 8 according to another embodiment, in which Fig. 3(a) is a sectional view, Fig. 3(b) is a side view, and Fig. 3(c) is an enlarged sectional view of Fig. 3(b). In Figs. 3(a) to 3(c), reference numeral 8f denotes a CO₂ passage in which CO₂ as a solvent flows, and reference numeral 8e denotes a temperature control means which has a temperature sensor and a temperature control circuit incorporated therein although they are not illustrated.

The CO₂ injecting means 8 in Fig. 3 differs from the CO₂ injecting means 8 in Fig. 2 in that the N₂ passage 8d for N₂ gas injection (refer to Fig. 2) is not provided, and a wedge-shaped part 9 and a relief part 10 are provided on a surface opposed to

the surface of the object to be cleaned 19.

Fig. 4(a) to 4(c) illustrate the flow of CO₂ in the case where CO₂ is injected using the CO₂ injecting means 8 (metal block 8a) in Fig. 3. Fig. 4(a) is a front view, Fig. 4(b) is a side view, and a Fig. 4(c) is a perspective view. As is apparent from Figs. 4(a) to 4(c), CO₂ jetted from the nozzle 8b smoothly flows without rebounding between the nozzle 8b and the metal block 8a.

Referring again to Fig. 1, the supporting member 2, the filter 3, the heater block 4, the CO₂ injecting means 8, and the pipes 1, all of which are provided in the keep-warm chamber A enclosed by the chain double-dashed line, are driven integrally with each other. In cleaning the object to be cleaned 19, the keep-warm chamber A moves in a direction indicated by an arrow B so as to seek the object to be cleaned 19. As the object to be cleaned 19 is sought, CO₂ is injected from the nozzle 8b. In synchronism with timing of the CO₂ injection, the air operate valve 5 is opened, so that a large quantity of N₂ gas jets from the in-injection lead-in pipe 6b.

When cleaning is completed, the keep-warm chamber A retracts in a direction indicated by an arrow C so as to attach/remove the object to be cleaned 19. Even when the keep-warm chamber A retracts, a small quantity of N₂ gas which has been heated to a predetermined temperature via the constant lead-in pipe 6a, the heater block 4, the filter 3, and the supporting member 2 in this order is jetted into the pipes 1 so that the pipes 1 can be kept at a predetermined temperature.

During cleaning, N₂ gas from the jet holes 1a vertical to

the object to be cleaned 19 is intended to mainly heat the surface of the object to be cleaned 19. Similarly, N₂ gas from the jet holes 1b formed inward at an angle of 45° is intended to evenly heat the whole area of the object to be cleaned 19. It should be noted that N₂ gas is controlled to a predetermined temperature by temperature control means provided in the heater block 4 and the filter 3.

As described previously, those illustrated in Figs. 2 and 3 are used as CO₂ injecting means; the CO₂ injecting means in Fig. 2 emits a jet of CO₂ gas from the CO₂ passage 8c via the nozzle 8b, while the CO₂ injecting means in Fig. 3 jets N₂ gas through holes formed in the periphery of the nozzle 8b.

The reason why N₂ gas is jetted from the periphery of the nozzle 8b is as follows.

CO₂ gas injected from the nozzle 8b is cooled by adiabatic expansion to lower the temperature around the periphery of the nozzle 8b. Therefore, the temperature of the entire nozzle block becomes lower than the liquefying temperature of CO₂ gas (22°C when the jet pressure is 6 Mpa), and consequently, CO₂ gas liquefies in a pipe section of the nozzle block, and is injected as liquid. As a result, the amount of generation of dry ice is unstable, or it is impossible to control the generation of dry ice.

To prevent this phenomenon, the temperature control means 8e controls the temperatures of CO₂ and N₂ gas.

According to the embodiment in Fig. 3, the CO₂ injecting means 8 omits injection of N₂ gas, and has the nozzle 8b simplified

in construction. The temperature control means 8e heats the entire high thermal capacity metal block 8a so that it can be kept at a temperature equal to or higher than the liquefying temperature of CO₂.

According to this arrangement, N₂ gas for purging as shown in Fig. 2 is unnecessary, and hence filters and valves used for it can be omitted, so that the entire system can be reduced in size and weight. Further, it is unnecessary to form a joint by the nozzle 8b, and therefore it is possible to fabricate the nozzle 8b in a simpler and easier way.

Further, in the present embodiment, the surface of the CO₂ injecting means, which is opposed to the object to be cleaned 19, is wedge-shaped. As a result, dry ice jetted from the nozzle 8b never rebounds between the nozzle 8b and the metal block 8a, so that the object to be cleaned 19 can be smoothly cleaned. It should be noted that the wedge-shaped part 9 may also be formed in the CO₂ injecting means 8 in Fig. 2.

Although the present invention has been described in some detail by way of specific preferred embodiments for purposes of explanation and illustration, it will be apparent to a person skilled in the art that certain changes and modifications may be practiced within the scope of the claims. For example, in the above described embodiments, the CO₂ injecting means is rectangular, and the pipes are used as the N₂ injecting means, but they may be arbitrarily shaped.

Further, in the above described embodiments, the temperature control means for heating is provided in both the

filter 3 and the heater block 4, but may be provided in one of them. Further, in the above described embodiments, N₂ gas is used for heating, but dry air or the like may be used.

The scope of the present invention defined by the scope of claims for patent encompasses modifications and variations within the scope of the present invention.

Advantageous Effects of the Invention

As is apparent from the above description, the following effects can be obtained according to the present invention.

According to the invention of claim 1, there is provided a cleaning apparatus that cleans an object to be cleaned by injecting a cleaning agent from a nozzle, comprising gas injecting means for injecting heated gas to a surface of the object to be cleaned, wherein the injecting means is configured to move on the object to be cleaned when cleaning is performed, and retract from the object to be cleaned when cleaning is not performed, and an injection quantity of the heated gas is controlled when cleaning is performed and when cleaning is not performed. Therefore, the cleaning apparatus can perform more satisfactory cleaning by reducing dust sources and preventing dew condensation caused by CO₂ jetted onto the object to be cleaned.

According to the invention of claims 2 to 5, the gas injecting means comprises a plurality of jet holes from which gas heated to a predetermined temperature is injected, and is disposed at a predetermined interval on the surface of the object to be cleaned, and the jet holes are formed in at least two directions: a direction vertical to the surface of the object to be cleaned

and an inner circumferential direction or an outer circumferential direction. Therefore, it is possible to enable thermal cleaning of the surface of the object to be cleaned while preventing temperature irregularities.

According to the invention of claim 6, there is provided a filter for cleans the gas. Therefore, it is possible to improve the object to be cleaned from becoming unclean due to injection of heated gas.

According to the invention of claims 7 and 8, the supporting member and the filter as well as a heater for heating the gas are disposed within a keep-warm chamber, and at least one of the supporting member or the filter comprises a temperature control mechanism. Therefore, it is possible to accurately control the temperature of N_2 gas which is sent to the gas injecting means.

According to the invention of claims 9, 10, and 11, at least two gas injecting means supported by the supporting member are disposed on the surface of the object to be cleaned across the center thereof, gas from one gas source is flown into the at least two gas injecting means, and solvent injecting means is mounted in vicinity of a center of the at least two gas injecting means supported by the supporting means, and is driven integrally with the gas injecting means. Therefore, it is possible to simplify the entire construction of the cleaning apparatus.

According to the invention of claim 12, the solvent injecting means for injecting a solvent comprises temperature control means for controlling the solvent to a temperature equal to or higher than a dew point. It is therefore possible to more

accurately control the temperature of CO₂.

According to the invention of claim 13, gas jetting holes through which gas is jetted are formed on an outer circumference of a nozzle provided in the solvent injecting means. It is therefore possible to more accurately control the temperature of CO₂.

According to the invention of claim 14, the solvent injecting means is rod-shaped, and is formed with a wedge-shaped gradient in a longitudinal direction thereof and in opposed relation to the surface of the object to be cleaned. It is therefore possible to smoothly clean the object to be cleaned since injected dry ice never rebounds between the nozzle and a metal block.

Claims

1. A cleaning apparatus that cleans an object to be cleaned by injecting a cleaning agent from a nozzle, comprising gas injecting means for injecting heated gas to a surface of the object to be cleaned, wherein said injecting means is configured to move on the object to be cleaned when cleaning is performed, and retract from the object to be cleaned when cleaning is not performed, and an injection quantity of the heated gas is controlled when cleaning is performed and when cleaning is not performed.

2. A cleaning apparatus according to claim 1, wherein said gas injecting means comprises a plurality of jet holes, and gas heated to a predetermined temperature is injected from said plurality of jet holes.

3. A cleaning apparatus according to claim 1 or 2, wherein said gas injecting means has one end thereof supported by a supporting member and is disposed at a predetermined interval on the surface of the object to be cleaned, such that gas is injected toward the surface of the object to be cleaned.

4. A cleaning apparatus according to any of claims 1 to 3, wherein said jet holes of said gas injecting means are at a predetermined angle with respect to the surface of the object to be cleaned.

5. A cleaning apparatus according to claim 4, wherein said gas injecting means is disposed between a center and a circumference of the object to be cleaned, and the jet holes are formed in at least two directions: a direction vertical to the

surface of the object to be cleaned and an inner circumferential direction or an outer circumferential direction.

6. A cleaning apparatus according to any of claims 1 to 5, comprising a filter for cleaning the gas.

7. A cleaning apparatus according to any of claims 1 to 6, wherein said supporting member and said filter as well as a heater for heating the gas are disposed within a keep-warm chamber.

8. A cleaning apparatus according to any of claims 3 to 7, wherein at least one of said supporting member or said filter comprises a temperature control mechanism.

9. A cleaning apparatus according to any of claims 3 to 8, wherein at least two gas injecting means supported by said supporting member are disposed on the surface of the object to be cleaned across the center thereof.

10. A cleaning apparatus according to claim 9, wherein gas from one gas source is flown into said at least two gas injecting means.

11. A cleaning apparatus according to any of claims 2 to 10, comprising solvent injecting means mounted in vicinity of a center of said at least two gas injecting means supported by said supporting means, wherein said solvent injecting means is driven integrally with said gas injecting means.

12. A cleaning apparatus according to any of claims 1 to 11, wherein said solvent injecting means comprises temperature

control means for controlling a solvent to a temperature equal to or higher than a dew point.

13. A cleaning apparatus according to any of claims 1 to 12, wherein gas jetting holes through which gas is jetted are formed on an outer circumference of a nozzle provided in said solvent injecting means.

14. A cleaning apparatus according to any of claims 1 to 13, wherein said solvent injecting means is rod-shaped, and is formed with a wedge-shaped gradient in a longitudinal direction thereof and in opposed relation to the surface of the object to be cleaned.