

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 CO_2 as a cleaning agent (hereinafter referred to as "solvent"); CO_2 within the cylinder 11 is divided into a liquid section 111 with a temperature T and a gas section 112 with a pressure P_0 . 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 CO_2 . 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 P_0 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 ejected. 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, ejected from the nozzle to be changed into solid particles or droplets, which are then ejected

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 for cleaning an object with a cleaning agent, comprising:

solvent ejecting means ejecting carbon dioxide as the cleaning agent for cleaning the object,

gas ejecting means for ejecting heated gas to a surface of the object, said ejecting means moving to a position above the object when cleaning is performed and retracting from the position above the object when cleaning is not performed, and

means for controlling a quantity of the heated gas when cleaning is performed and is not performed, said controlling means being connected to the gas ejecting means.

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

According to the invention of claim 3, in the cleaning apparatus according to claim 1, further comprising a supporting member for supporting end of the gas ejecting means and one end of the solvent ejecting means, to be disposed at a

predetermined interval on the surface of the object to be cleaned, such that gas is ejected toward the surface of the object to be cleaned.

According to the invention of claim 4, in the cleaning apparatus according to claim 2, wherein the jet holes of the gas ejecting 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 2, the gas ejecting 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 claim 1, there is provided a filter for cleaning the gas.

According to the invention of claim 7, in the cleaning apparatus according to claim 3, 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 claim 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 claim 3, at least two gas ejecting 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 ejecting means.

According to the invention of claim 11, in the cleaning apparatus according to claim 9, there is provided solvent ejecting means mounted in vicinity of a center of the at least two gas ejecting means supported by the supporting means, wherein the gas ejecting means and the solvent ejecting means are driven as an integral unit.

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

According to the invention of claim 14, in the cleaning apparatus according to claim 11, the solvent ejecting 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.

According to the invention of claim 15, in the cleaning apparatus according to claim 1, wherein said solvent ejecting means has a rod shape with a nozzle, and a relief part at one side of the nozzle.

According to the invention of claim 16, the cleaning apparatus according to claim 7, wherein said environmental chamber for retaining the heater, the filter, and the supporting member supporting the solvent ejecting means and the gas ejecting means is moved upon cleaning the object.

According to the invention of claim 17, in the cleaning apparatus according to claim 16, wherein said gas ejecting means includes two portions, and the solvent ejecting means is disposed between the two portions, which are supported by the supporting member to be disposed above the surface of the object with a center of the object therebetween.

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 ejecting means according to an embodiment of the present invention.

Fig. 3 is a view showing an example of solvent ejecting 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 ejecting 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 ejecting 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-ejection lead-in pipe 6b via an air operate valve 5 during cleaning.

Reference numeral 8 denotes a rod-shaped CO_2 ejecting 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 ejecting 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 ejecting 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 ejecting 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 ejecting means 8 in Fig. 3 differs from the CO₂ ejecting means 8 in Fig. 2 in that the N₂ passage

8d for N_2 gas ejection (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 CO_2 in the case where CO_2 is ejected using the CO_2 ejecting 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), CO_2 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 CO_2 ejecting 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, CO_2 is ejected from the nozzle 8b. In synchronism with timing of the CO_2 ejection, the air operate valve 5 is opened, so that a large quantity of N_2 gas jets from the in-ejection 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 N_2 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, N_2 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, N_2 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 N_2 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 CO_2 ejecting means; the CO_2 ejecting means in Fig. 2 emits a jet of CO_2 gas from the CO_2 passage 8c via the nozzle 8b, while the CO_2 ejecting means in Fig. 3 jets N_2 gas through holes formed in the periphery of the nozzle 8b.

The reason why N_2 gas is jetted from the periphery of the nozzle 8b is as follows.

CO_2 gas ejected 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 CO_2 gas ($22^\circ C$ when the jet pressure is 6 Mpa), and consequently, CO_2 gas liquefies in a pipe section of the nozzle block, and is ejected 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 ejecting means 8 omits ejection 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 ejecting 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 ejecting 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 ejecting means

is rectangular, and the pipes are used as the N₂ ejecting ejecting 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 ejecting a cleaning agent from a nozzle, comprising gas ejecting means for ejecting heated gas to a surface of the object to be cleaned, wherein the ejecting 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 ejection 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 ejecting means comprises a plurality of jet holes from which gas

heated to a predetermined temperature is ejected, 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 ejection 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 ejecting means.

According to the invention of claims 9, 10, and 11, at least two gas ejecting 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 means, and solvent ejecting means is mounted in vicinity of a center of the at least two gas ejecting means supported by the supporting means, and is driven integrally with the gas ejecting means. Therefore, it is possible to simplify the entire construction of

the cleaning apparatus.

According to the invention of claim 12, the solvent ejecting means for ejecting 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 ejecting means. It is therefore possible to more accurately control the temperature of CO₂.

According to the invention of claim 14, the solvent ejecting 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 ejected dry ice never rebounds between the nozzle and a metal block.

Claims

1. A cleaning apparatus for cleaning an object with a cleaning agent, comprising:

solvent ejecting means ejecting carbon dioxide as the cleaning agent for cleaning the object,

gas ejecting means for ejecting heated gas to a surface of the object, said ejecting means moving to a position above the object when cleaning is performed and retracting from the position above the object when cleaning is not performed, and

means for controlling a quantity of the heated gas when cleaning is performed and is not performed, said controlling means being connected to the gas ejecting means.

2. A cleaning apparatus according to claim 1, wherein said gas ejecting means has a plurality of jet holes, and ejects the heated gas with a predetermined temperature through the plurality of the jet holes.

3. A cleaning apparatus according to claim 1 further comprising a supporting member for supporting one end of the gas ejecting means and one end of the solvent ejecting means, to be disposed at a position with a predetermined distance from the surface of the object so that the heated gas is ejected toward the surface of the object.

4. A cleaning apparatus according to claim 2, wherein said jet holes of the gas ejecting means are arranged with a predetermined angle relative to the surface of the object.

5. A cleaning apparatus according to claim 2, wherein said jet holes are arranged with at least two directions including a direction perpendicular to the surface of the object and an inner circumferential direction or an outer circumferential direction of the object.

6. A cleaning apparatus according to claim 1, further comprising a filter for cleaning the heated gas.

7. A cleaning apparatus according to claim 3, further comprising a heater for heating the heated gas, a filter for cleaning the heated gas and an environmental chamber for retaining the heater, the filter and the supporting member.

8. A cleaning apparatus according to claim 7, wherein at least one of said supporting member or said filter includes a temperature control mechanism.

9. A cleaning apparatus according to claim 3, wherein said gas ejecting means includes at least two portions supported by the supporting member to be disposed above the surface of the object with a center of the object therebetween.

10. A cleaning apparatus according to claim 9, further comprising one gas source for supplying the heated gas into the at least two portions.

11. A cleaning apparatus according to claim 9, wherein said solvent ejecting means is disposed between the two portions, said solvent ejecting means being driven together

with the gas ejecting means.

12. A cleaning apparatus according to claim 1, wherein said solvent ejecting means includes temperature control means for maintaining solvent at a temperature equal to or higher than a dew point thereof.

13. A cleaning apparatus according to claim 1, wherein said solvent ejecting means includes a nozzle having a gas jetting hole at an outer circumference thereof for ejecting gas.

14. A cleaning apparatus according to claim 1, wherein said solvent ejecting means has a rod shape and a wedge-shaped surface inclined in a longitudinal direction thereof to face the surface of the object.

15. A cleaning apparatus according to claim 1, wherein said solvent ejecting means has a rod shape with a nozzle, and a relief part at one side of the nozzle.

16. A cleaning apparatus according to claim 7, wherein said environmental chamber for retaining the heater, the filter, and the supporting member supporting the solvent ejecting means and the gas ejecting means is moved upon cleaning the object.

17. A cleaning apparatus according to claim 16, wherein said gas ejecting means includes two portions, and the solvent ejecting means is disposed between the two portions, which are supported by the supporting member to be disposed above the surface of the object with a center of the object therebetween.