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I certify under penalty of perjury under the laws of the United States that the foregoing is true and correct.

Executed this 20th day of January, 2017.

Signature: Naoko Uno

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EXHIBIT 1004

(19) JAPAN PATENT OFFICE (JP)

(12) PATENT APPLICATION LAID-OPEN PUBLICATION (A)

(11) PUBLICATION NUMBER
JP 05-136095 A
(43) DATE OF PUBLICATION
1.06.1993

(51) Int.Cl[5]	IDENTIFICATION CODE:	JPO REFERENCE NUMBER	F1	TECHNICAL INDICATIONS
H01L 21/302	B	7353-4M		
	M	7343-4M		

Request for Examination: Not Filed
Number of Claims: 1 (4 pages total)

(21) Application Number: 03-326453

(22) Date of Filing: 14.11.1991

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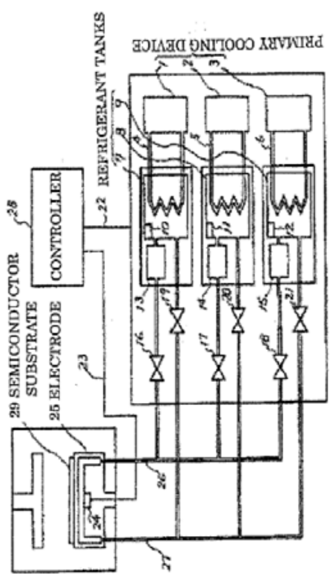
(54) [Title of the Invention] DRY ETCHING DEVICE

(57) [ABSTRACT]
[OBJECT] To improve responsiveness of a temperature control of a semiconductor substrate in dry etching.

[CONFIGURATION] Temperature of each of a plurality of refrigerant tanks 7, 8, and 9 which supply a refrigerant to an electrode 25, on which a semiconductor substrate 29 is arranged, is individually controlled.



[Claims]

[Claim 1] A dry etching device which makes process gas introduced into a vacuum processing chamber to be a plasma state by applying high-frequency power, and etches an etching target object on a semiconductor substrate using the plasma, comprising:

a plurality of refrigerant tanks that supply a refrigerant to an electrode on which the semiconductor substrate is arranged; and

a temperature control device that individually controls a temperature of each of the refrigerant tanks.

[Detailed Description of the Invention]

[0001]

[Industrial Applicability] The present invention relates to a semiconductor control device, and more particularly, to a temperature control system which controls a temperature of an electrode on which a semiconductor substrate is arranged in a dry etching device.

[0002]

[Background Art] Fig. 3 is a diagram illustrating a conventional temperature control system of a dry etching device. As illustrated in Fig. 3, a primary cooling device 1 controls a temperature of a refrigerant in a refrigerant tank 7 through a pipe 4 by the refrigerant in the primary cooling device 1, according to settings transmitted from a controller 28 through a signal cable 22.

[0003] The refrigerant tank 7 includes a temperature monitor 24, and outputs a monitoring temperature to the controller 28 through the signal cable 23. The refrigerant in the refrigerant tank 7 is transferred into the electrode 25 through a pipe 26 and a valve 16 by a pump 13, changes a temperature such that the monitoring temperature output from the temperature monitor 24 to the controller 28 through the signal cable 23 coincides with a set temperature of the controller 28, and comes back to the refrigerant tank 7 through the pipe 27 and the valve 19.

[0004] As described above, the temperature control system of such a kind of dry etching device includes only one refrigerant tank 7, and a temperature control of the electrode 25 on which the semiconductor substrate 29 is arranged depends on a temperature control of the primary cooling device 1.

[0005]

[Problem to be Solved by the Invention] In the conventional device, e.g., in the temperature control system of the primary cooling device 1, there is no problem in keeping a constant temperature, but responsiveness to the temperature change is not satisfactory, and generally, it takes about 10 minutes for the temperature to change from a normal temperature to 0℃ and takes about 20 to 30 minutes from 0℃ to -20℃.

[0006] In a single-wafer-type dry etching device, a process time of each semiconductor substrate is about 1 to 5 minutes, and when step etching is performed to continuously etch the same semiconductor substrate under different process conditions, a process time of each step etching is shorter. For this reason, in a case where the temperature of the electrode 25 is required to be changed for each step etching, the primary cooling device 1 does not respond to the temperature change satisfactorily, and it is not put into practical use.

[0007]

An object of the invention is to provide a dry etching device capable of realizing a sufficient responsiveness in a temperature control of an electrode.

[0008]

[Means for Solving the Problem] In order to achieve the above object, there is provided a dry etching device which makes process gas introduced into a vacuum processing chamber to be a plasma state by applying high-frequency power, and etches an etching target object on a semiconductor substrate using the plasma. The dry etching device includes a plurality of refrigerant tanks that supply a refrigerant to an electrode on which the semiconductor substrate is arranged and a temperature control device that individually controls a temperature of each of the refrigerant tanks.

[0009]

[Operation] A plurality of refrigerant tanks that supply a refrigerant to an electrode are provided, and a temperature of each of the refrigerant tanks is individually controlled to improve responsiveness of the temperature control of the electrode and to efficiently change the substrate temperature.

[0010]

[Embodiment] Hereinafter, an embodiment of the invention will be described with reference to the drawings. Fig. 1 is a diagram illustrating a configuration according to an embodiment of the invention.

[0011] In Fig. 1, in the embodiment, a plurality of refrigerant tanks 7, 8, and 9 that supply a refrigerant to an electrode 25, on which a semiconductor substrate 29 is arranged, are provided, and the temperatures of the refrigerant tanks 7, 8, and 9 are individually controlled using a plurality of primary cooling devices 1, 2, and 3.

[0012] The primary cooling device 1 controls the temperature of a refrigerant in the refrigerant tank 7 through a pipe 4 by a refrigerant in the primary cooling device 1 according to settings transmitted from a controller 28 through a signal cable 22. The refrigerant tank 7 includes a temperature monitor 10, and outputs a monitoring temperature to the controller 28 through the signal cable 22. The refrigerant in the refrigerant tank 7 is transferred into the electrode 25 through a pipe 26 and a valve 16 by a pump 13, changes a temperature such that the monitoring temperature output from the temperature monitor 24 to the controller 28 through the signal cable 23 coincides with a set temperature of the controller 28, and comes back to the refrigerant tank 7 through the pipe 27 and the valve 19.

[0013] The temperature control is similarly performed using the primary cooling devices 2 and 3 with respect to the other refrigerant tanks 8 and 9. Pipes 5 and 6, temperature monitors 11 and 12, pumps 14 and 15, and valves 17, 18, 20, and 21 have the same functions as those of the refrigerant tank 7.

[0014] The temperatures of the refrigerants in the refrigerant tanks 7, 8, and 9 are controlled by the primary cooling devices 1, 2, and 3 to be temperatures A, B, and C set in advance by the controller 28.

[0015] In a case where the electrode 25 needs the temperature A, the valves 16 and 19 are opened, and the refrigerant in the refrigerant tank 7 kept at the temperature A is transferred into the electrode 25 by the pump 13. In this case, the valves 17, 18, 20, and 21 are closed, and the refrigerants in the refrigerant tanks 8 and 9 are not transferred into the electrode 25.

[0016] In a case where the electrode 25 needs the temperature B, the valves 16 and 19 are instantly closed. Simultaneously, the valves 17 and 20 are opened, the refrigerant in the refrigerant tank 8 kept at the temperature B is transferred into the electrode 25 by the pump 14. In this case, the valves 18 and 21 are closed, and the refrigerant in the refrigerant tank 9 is not transferred into the electrode 25. The time taken for changing the electrode 25 from the temperature A to the temperature B is 2 to 10 seconds.

[0017] Fig. 2 is a cross-sectional view illustrating an oxide film on a semiconductor substrate etched using a temperature control system of the invention.

[0018] In Fig. 1, the refrigerants of the refrigerant tanks 7, 8, and 9 are set to, for example, -50°C, -30°C, and 0°C, respectively. In the first step etching, the refrigerant of the refrigerant tank 7 is transferred to the electrode 25, the electrode 25 is kept at -50°C, and etching is performed.

[0019] Similarly, etching is performed at -30℃ in the second step etching, and performed at 0℃ in the third step etching.

[0020] As a result, an etching angle with respect to the surface of a semiconductor substrate 31 of an Si oxide film 30 can be controlled as illustrated in Fig. 2. The etching angles based on the first, second, and third step etching are about 60°, 80°, and 90°, respectively.

[0021]

[Advantageous Effect of the Invention] As described above, in the invention, the plurality of refrigerant tanks that supply the refrigerant to the electrode, on which the semiconductor substrate is arranged, are provided, and the temperature control device that individually controls the temperature of each of the refrigerant tanks is provided. With this configuration, responsiveness to the temperature control of the electrode can be improved, and the temperature of the semiconductor substrate can be efficiently changed. Therefore, it is possible to arbitrarily control the etching angle of the etching target object on the semiconductor substrate with respect to the surface of the semiconductor substrate in the step etching, where the same semiconductor substrate is continuously etched based on different process conditions.

[0022] In particular, a contact hole such as the contact hole of a super-LSI is effectively formed in a part with a small margin.

[Brief Description of the Drawings]

[Fig. 1] Fig. 1 is a diagram illustrating a configuration according to an embodiment of the invention.

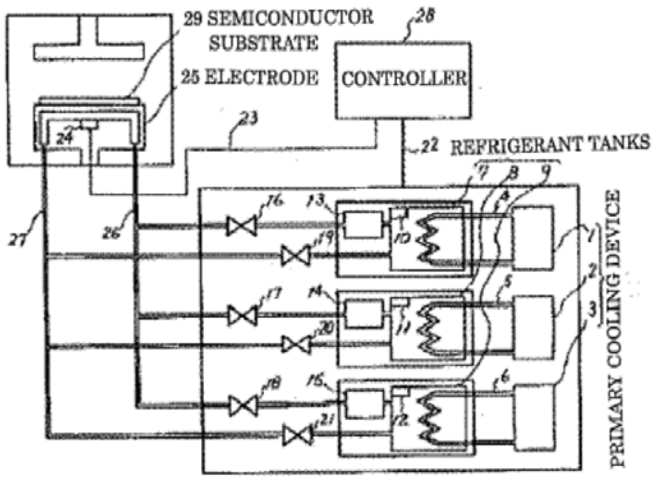
[Fig. 2] Fig. 2 is a cross-sectional view illustrating an etching target object on a semiconductor substrate, which is etched using a temperature control system of the invention.

[Fig. 3] Fig. 3 is a diagram illustrating a configuration of a conventional temperature control system.

[Reference Signs List]

1, 2, 3: Primary cooling device
4, 5, 6: Pipe
7, 8, 9: Refrigerant tank
10, 11, 12: Temperature monitor
13, 14, 15: Pump
16, 17, 18: Valve
19, 20, 21: Valve
22, 23: Signal cable
24: Temperature sensor
25: Electrode
26, 27: Pipe
28: Controller
29: Semiconductor substrate

FIG. 1


29 SEMICONDUCTOR SUBSTRATE
25 ELECTRODE
28
CONTROLLER
23
24
22 REFRIGERANT TANKS
7 8 9
27
26
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19 10
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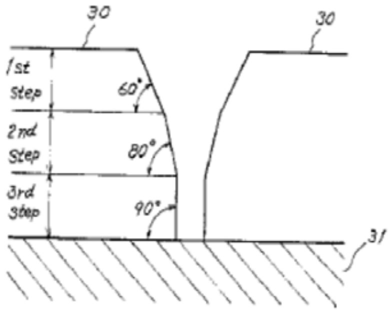
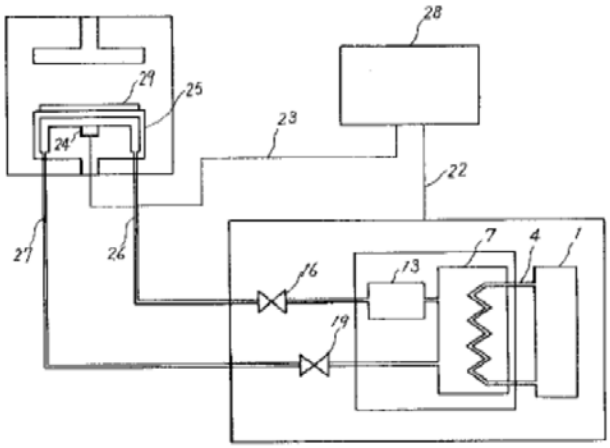
2
17 14 5
20 11
3
PRIMARY COOLING DEVICE
18 15 6
21 12


30
30
1st Step
60°
2nd Step
80°
3rd Step
90°
31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