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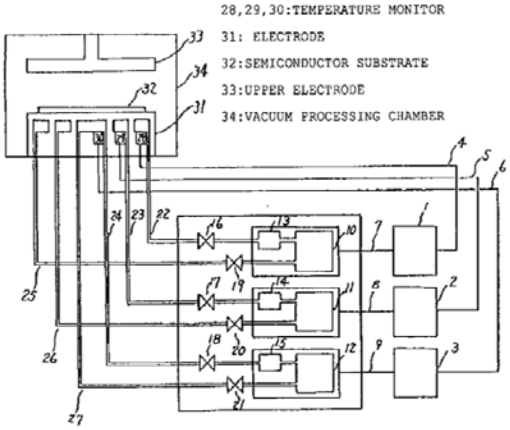
(54) [Title of the Invention] DRY ETCHING DEVICE

(57) [ABSTRACT]
[PURPOSE] To enable the shape control by the temperature control of a semiconductor substrate due to the importance of the control of the etching shape of a material to be etched in dry etching.

[CONSTITUTION] A plurality of coolant supply paths 22, 23, and 24 are provided in an electrode 31 on which a semiconductor substrate 32 is installed, and the control is performed using each of controllers 1, 2, and 3, coolant baths 10, 11, and 12, temperature monitors 28, 29, and 30, and the likes. Therefore, the control of an etching depth direction such as a through-hole can be performed.

[FIG. 1]

1,2,3:CONTROLLER
4,5,6:SIGNAL CABLE
7,8,9:SIGNAL CABLE
10,11,12:COOLING BATH
13,14,15:PUMP
16,17,18:VALVE
19,20,21:VALVE
22,23,24:COOLANT SUPPLY PATH
25,26,27:COOLANT SUPPLY PATH
28,29,30:TEMPERATURE MONITOR
31: ELECTRODE
32:SEMICONDUCTOR SUBSTRATE
33:UPPER ELECTRODE
34:VACUUM PROCESSING CHAMBER



[Claim(s)]

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

a plurality of coolant supply paths provided in an inner portion of an electrode on which the semiconductor substrate is mounted;

a plurality of coolant baths supplying coolant to the coolant supply paths; and

a temperature control device controlling individually the temperature of each coolant bath.

[Detailed Description of the Invention]

[0001]

[Industrial Applicability] The present invention relates to semiconductor producing equipment, and particularly, to a temperature control system of a dry etching device, the temperature control system performing the temperature control of an electrode on which a semiconductor substrate is installed.

[0002]

[Description of the Prior Art] Fig. 3 is a view illustrating a temperature control system of a dry etching device of the related art. A controller 1 controls a coolant bath 10 via a signal cable 7 so that a monitoring temperature sent from a temperature monitor 28 via a signal cable 4 is the same as a preset temperature.

[0003] The coolant bath 10 controls the temperature of the coolant in the coolant bath 10 in accordance with the preset temperature sent from the controller 1 via the signal cable 7.

[0004] The coolant in the coolant bath 10 is sent into an electrode 31 by a pump 13 via a coolant supply path 22 and a valve 16. Then, the coolant changes the temperatures so that the monitoring temperature output from the temperature monitor 28 to the controller 1 via the signal cable 4 is the same as the preset temperature of the controller 1. Next, the coolant returns the coolant bath 10 via a coolant supply path 25 and a valve 19.

[0005] The temperature control system of the dry etching device of this type of the related art has only one set of the coolant bath 10, the coolant supply paths 22 and 25, and the temperature monitor 28 as described above, and thus the temperature control of the electrode 31 on which the semiconductor substrate 32 is mounted is focused on only one place. Reference numeral 33 indicates an upper electrode and reference numeral 34 indicates a vacuum processing chamber.

[0006]

[Problem to be solved by the invention] The dry etching device of this type has only one set of coolant bath and temperature monitor in the temperature control system. This does not cause much problem in keeping the temperature of the semiconductor substrate 32 within a certain temperature range. However, the temperature control cannot be sufficiently performed when the temperature difference in a surface of the semiconductor substrate 32 is tried to be kept within 1 to 2 degrees.

[0007] Meanwhile, the etching shape of a material to be etched on the semiconductor substrate 32 is dependent on the temperature distribution in the surface of the semiconductor substrate 32. Therefore, there is a problem in that, when the temperature control cannot be properly performed in the surface, the etching shape becomes uneven in the surface of the semiconductor substrate 32.

[0008] Fig. 4 is a cross-sectional view of a Si oxide film on a semiconductor substrate subjected to etching in a dry etching device having a temperature control system of the related art. The preset temperature of an electrode is -20℃. Fig. 4(a) is a cross-sectional view of a central portion of the semiconductor substrate and Fig. 4(b) is a cross-sectional view of a peripheral portion. Reference numeral 40 indicates a semiconductor substrate, 41 indicates a Si oxide film, 42 indicates a photoresist, and 43 indicates a reaction product.

[0009] Since the semiconductor substrate is exposed to plasma during etching, the semiconductor substrate is heated to equal to or more than the preset temperature of the electrode. Particularly, the cooling efficiency of the peripheral portion of the semiconductor substrate is lower than that of the central portion, and thus the peripheral portion is heated to a higher temperature. Therefore, when the temperature control is performed so that the peripheral portion is cooled as much as needed, the central portion tends to be cooled excessively. Fig. 2(b) is a view illustrating the temperature distribution of the semiconductor substrate. When the temperature of the peripheral portion is set to 70℃, the temperature of the central portion is lower by about 10℃ to 30℃.

[0010] When forming a contact hole as illustrated in Fig. 4, for example, excess reaction products are attached to, compared to the peripheral portion, the central portion cooled excessively. This reaction product hinders the progress of etching. As a result, etching is stopped in the middle thereof, and thus etching is insufficiently performed compared to the peripheral portion. Particularly, when a fine contact hole of a VLSI, the size of the hole being 0.5 μm or less, is formed, this problem becomes critical.

[0011] An object of the present invention is to provide a dry etching device capable of controlling the etching shape by temperature control of a semiconductor substrate.

[0012] [Means for solving problem] In order to achieve the object described above, according to the present invention, there is provided a dry etching device which generates plasma of a process gas introduced into a vacuum processing chamber by applying high-frequency power and etches a material to be etched on a semiconductor substrate using the plasma, the dry etching device including a plurality of coolant supply paths provided in an inner portion of an electrode on which the semiconductor substrate is mounted, a plurality of coolant baths supplying coolant to the coolant supply paths, and a temperature control device controlling individually the temperature of each coolant bath.

[0013] [Function] A plurality of coolant supply paths are provided in an inner portion of an electrode on which a semiconductor substrate is mounted and temperature-adjusted coolant is supplied to the coolant supply paths.

[0014] [Embodiment] Hereinafter, an embodiment of the present invention will be described with reference to drawings. Fig. 1 is a view illustrating the configuration of an embodiment of the present invention.

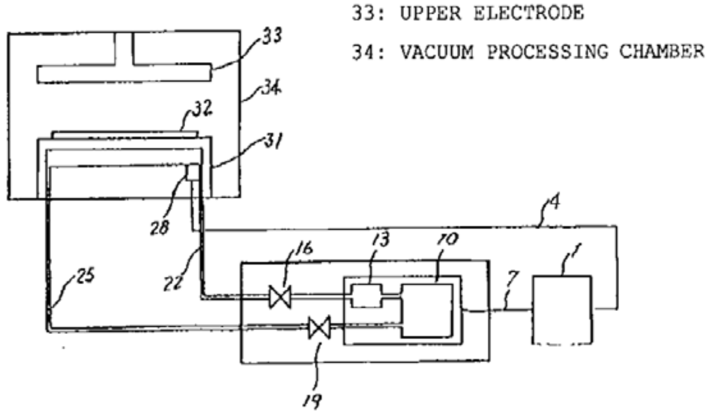
[0015] In Fig. 1, coolant supply paths 22, 23, 24, 25, 26, and 27 are provided in an inner portion of an electrode 31 on which a semiconductor substrate 32 is mounted, in concentric circles from the center of the semiconductor substrate 32.

[0016] A controller 1 controls a coolant bath 10 via a signal cable 7 so that the monitoring temperature sent from a temperature monitor 28 via a signal cable 4 is the same as the preset temperature.

[0017] The coolant bath 10 controls the temperature of the coolant in the coolant bath 10 in accordance with the preset temperature sent from the controller 1 via the signal cable 7.
[0018] The coolant in the coolant bath 10 is sent into the electrode 31 by a pump 13 via the coolant supply path 22 and a valve 16. Then, the coolant changes the temperature so that the monitoring temperature output from the temperature monitor 28 to the controller 1 via the signal cable 4 is the same as the preset temperature of the controller 1. Next, the coolant returns the coolant bath 10 via the coolant supply path 25 and a valve 19.
[0019] These are similar in controllers 2 and 3, signal cables 8 and 9, coolant baths 11 and 12, pumps 14 and 15, valves 17, 18, 20, and 21, coolant supply paths 23, 24, 26, and 27, and temperature monitors 29 and 30.
[0020] As illustrated in Fig. 2(a), the temperature distribution of the semiconductor substrate is uniform when the temperature control is performed by this embodiment.
[0021]
[Effect of the invention] As described above, the present invention has a plurality of coolant supply paths in an inner portion of an electrode on which a semiconductor substrate is mounted, a plurality of coolant baths supplying coolant to the coolant supply paths, and a temperature control device controlling individually the temperature of each coolant bath, and thus the temperature distribution in the semiconductor substrate can be controlled to be uniform.
[0022] Therefore, the etching-shape distribution of a material to be etched on the semiconductor substrate, the etching-shape distribution being dependent on the temperature, can be controlled to be uniform.
[0023] Particularly, when a contact hole of a VLSI is formed, significant effects can be achieved in forming a contact hole having a small diameter and a large depth in a small-margin part. Practically, it is confirmed that, when the temperature distribution of a semiconductor substrate is kept within 5% of the temperature range, contact holes of 0.5 μm can be etched with the proper distribution in a surface.

[Brief Description of the Drawings]
[Fig. 1] Fig. 1 is a view illustrating an embodiment of the present invention.
[Fig. 2] Fig. 2(a) is a view illustrating the temperature distribution of a semiconductor substrate at the time of using a temperature control system of the present invention and Fig. 2(b) is a view illustrating the temperature distribution of a semiconductor substrate at the time of using a temperature control system of the related art.
[Fig. 3] Fig. 3 is a view illustrating an example of the related art.
[Fig. 4] Fig. 4 illustrates a material to be etched on the semiconductor substrate, the material being subjected to etching using the temperature control system of the related art, in which Fig. 4(a) is a cross-sectional view of a central portion of the semiconductor substrate and Fig. 4(b) is a cross-sectional view of a peripheral portion.
[Reference Signs List]
1, 2, 3: controller
4, 5, 6: signal cable
7, 8, 9: signal cable
10, 11, 12: cooling bath
13, 14, 15: pump
16, 17, 18: valve
19, 20, 21: valve
22, 23, 24: coolant supply path
25, 26, 27: coolant supply path
28, 29, 30: temperature monitor
31: electrode
32: semiconductor substrate
33: upper electrode
34: vacuum processing chamber
40: semiconductor substrate
41: Si oxide film
42: photoresist
43: reaction product

[FIG. 3]



[FIG. 1]

1,2,3:CONTROLLER
4,5,6:SIGNAL CABLE
7,8,9:SIGNAL CABLE
10,11,12:COOLING BATH
13,14,15:PUMP
16,17,18:VALVE
19,20,21:VALVE
22,23,24:COOLANT SUPPLY PATH
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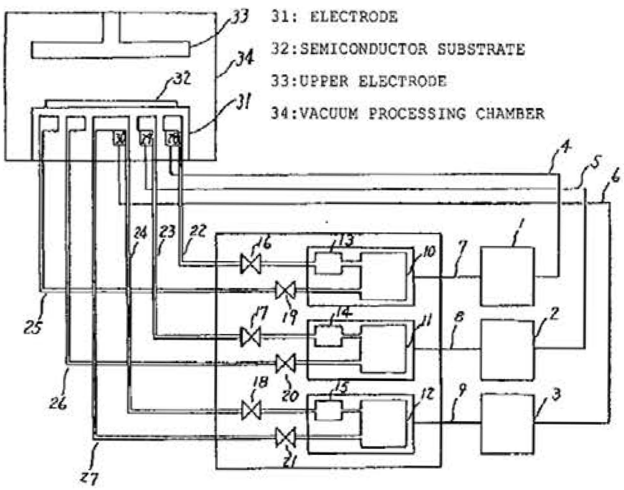
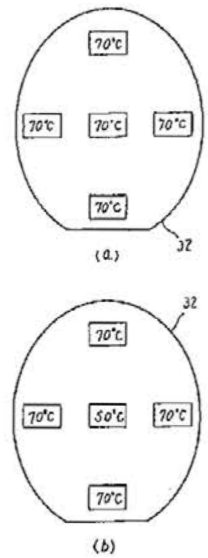
28,29,30:TEMPERATURE MONITOR
31: ELECTRODE
32:SEMICONDUCTOR SUBSTRATE
33:UPPER ELECTRODE
34:VACUUM PROCESSING CHAMBER



[FIG. 2]



[FIG. 4]

40: SEMICONDUCTOR SUBSTRATE
41: Si OXIDE FILM
42: PHOTORESIST
43: REACTION PRODUCT