

DESCRIPTION

Title of Invention: WAFER PROCESSING DEVICE AND WAFER PROCESSING METHOD

Technical Field

[0001]

The present invention relates to a wafer processing device and a wafer processing method.

Background Art

[0002]

In semiconductor devices, further miniaturization and three-dimensionalization of a device structure are being promoted in order to meet demands for lower consumption power and increase in storage capacity. In manufacture of a device having a three-dimensional structure, since the structure is stereoscopic and complicated, in addition to conventional "vertical etching" in which etching is performed in the direction perpendicular to a wafer plane, "isotropic etching" in which etching also in the horizontal direction can be performed is often used.

Conventionally, isotropic etching is performed

by a wet process using a chemical. However, as miniaturization progresses, a problem of pattern collapse caused by surface tension of the chemical is becoming apparent. In the isotropic etching, therefore, it becomes necessary to replace the conventional wet process using a chemical with a dry process using no chemical.

[0003]

Particularly, in isotropic etching in a three-dimensional semiconductor process, necessity of gas etching is increasing. In gas etching, physical parameters such as pressure and wafer temperature largely contribute to a chemical reaction. It is consequently important to measure the wafer temperature with high accuracy to control the process. However, a method of directly measuring the temperature by using a thermocouple is not suitable for a process step of mass-producing semiconductor devices. Consequently, a technique of detecting temperature of a semiconductor wafer in a contactless manner is demanded.

[0004]

As an example of such a conventional technique, a technique using a radiation thermometer which detects an amount of heat emitted from the

semiconductor wafer to detect temperature is known. This technique is, generally, subject to restrictions such as melting points of various materials. In a process of manufacturing a typical semiconductor device, the temperature of the semiconductor wafer is controlled to a value around 500 °C or less. There is a problem that it is difficult to stably detect such a temperature by a radiation thermometer.

As a technique replacing the technique using the radiation thermometer, there is an absorption edge evaluation technique of stably detecting a temperature by using a temperature dependence of frequencies at an area edge (absorption edge) in a frequency (wavelength) range of electromagnetic waves absorbed by a semiconductor. It is, specifically, a technique of measuring a spectrum of light which passed through the semiconductor wafer or scatter-reflected and evaluating the absorption edge of the spectrum, thereby detecting the temperature of the semiconductor wafer.

[0005]

As a device of detecting temperature of the semiconductor wafer with high accuracy by using the absorption edge evaluation technique in a manufacturing device of manufacturing a semiconductor

device such as a dry etching device, an absorption edge evaluation device provided with an infrared light source for measuring water temperature described in Patent Literature 1 is known.

A technique of providing a lift pin with a thermocouple and indirectly measuring temperature is disclosed in Patent Literature 2.

Citation List

Patent Literature

[0006]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2018-73962

Patent Literature 2: Japanese Unexamined Patent Application Publication No. 2023-13120

Summary of Invention

Technical Problem

[0007]

In the patent literature 1 as a conventional technique, a design of detouring a heater pattern in a wafer stage and a refrigerant circuit so as to avoid a fiber installation hole installed as a light path for temperature measurement is necessary. There is, consequently, the possibility that heat

unevenness occurs on the wafer stage, etching performance/in-plane uniformity is hindered, and product quality deteriorates. A wafer transmission amount of infrared light (also called infrared ray, IR, or IR light) varies depending on the kind of a film of a wafer due to an impurity (dope) content or a resistance value, so that proper light collection time has to be set for each measurement target to perform high-precision temperature measurement (temperature conversion). In measurement of temperature of a gas medium by a temperature sensor used in a lift-pin part described in Patent Literature 2, an operation of lowering backside pressure of gas at the time of heating by emitting IR light is commonly performed. Since it decreases heat transfer via the gas, it is difficult to perform high-precision temperature measurement.

[0008]

An object of the present invention is, therefore, to provide a technique capable of efficiently and precisely perform temperature measurement on wafers of various film kinds and realizing process with excellent product quality in a wafer processing device of processing the wafer by heating using the electromagnetic waves.

Solution to Problem

[0009]

To achieve the object, one of representative wafer processing devices of the present invention includes a processing chamber disposed in a vacuum vessel; a wafer stage disposed in the processing chamber and having a top face on which the wafer to be processed is placed; a lamp disposed above the wafer stage and radiating the electromagnetic wave to the inside of the processing chamber including the wafer stage; an electromagnetic wave transmissive member disposed movably in the wafer stage and transmitting the electromagnetic wave; and a detector receiving the electromagnetic wave passed through the wafer and the electromagnetic wave transmissive member and detecting temperature of the wafer from a reception light spectrum.

Advantageous Effects of Invention

[0010]

According to the present invention, in the wafer processing device which processes the wafer by heating using the electromagnetic waves, temperature measurement can be performed efficiently and

precisely on the wafers of various film kinds, and process with excellent product quality can be realized.

The other objects, configurations, and effects will become apparent from the following description of embodiments.

Brief Description of Drawings

[0011]

[Fig. 1] Fig. 1 is a cross section schematically illustrating the configuration of a wafer processing device according to a present embodiment.

[Fig. 2] Fig. 2 is a schematic diagram illustrating the configuration of a temperature detecting device for detecting temperature of a wafer in the present embodiment.

[Fig. 3] Fig. 3 is a graph illustrating a state that the reception light spectrum after passage through the wafer changes depending on the wafer temperature.

[Fig. 4] Fig. 4 is a graph illustrating an example of a reception light spectrum passed through the wafer in the case where the wafer is at predetermined temperature.

[Fig. 5] Fig. 5 is a graph illustrating an

example of process of measuring the temperature of the wafer in the present embodiment.

[Fig. 6] Fig. 6 is a schematic diagram illustrating a mechanism of adjusting detection light intensity in the present embodiment.

[Fig. 7] Fig. 7 is a graph illustrating a change in the reception light spectrum after passage through the wafer at the time of adjusting detection light intensity.

[Fig. 8] Fig. 8 is a time chart at the time of adjusting detection light intensity in the present embodiment.

Description of Embodiments

[0012]

Hereinafter, an embodiment of the present invention will be described with reference to the drawings. The configuration described hereinafter is an example and does not limit the scope of the present invention. In the following example, the same reference numeral is designated to members or parts having the same configuration. Unless otherwise necessary, repetitive description will not be given.

[0013]

(Configuration of Wafer Processing)

Fig. 1 is a cross section schematically illustrating the configuration of the wafer processing device according to a present embodiment. A wafer processing device 100 (also called a plasma processing device or an etching device) according to the present embodiment includes a vacuum vessel made of aluminum or the like, and a lamp which radiates an infrared light (IR) to the wafer on a stage in a processing chamber disposed in the lower part of the vacuum vessel to heat the wafer, and is a processing device having a discharge chamber which constitutes the upper part of the vacuum vessel and in which plasma is generated, a path which makes the discharge chamber and a processing chamber below communicate with each other, and a slit disposed on the inside of the path and having a plurality of gaps or holes through which particles of active species such as reactive radicals generated by the generation of the plasma pass.

[0014]

In the plasma processing device of the present embodiment, a processing chamber 101 is a chamber disposed in a base chamber 102 constituting the lower part of the vacuum vessel. In the lower part on the

inside, a wafer stage 104 (also simply called a stage) having a top face on which a wafer 103 is placed is disposed. A plasma source is mounted above the processing chamber 101, and the ICP discharge system is used for the plasma source.

[0015]

A quartz chamber 105 having a cylindrical shape as a component of the ICP plasma source is mounted above the processing chamber 101, and an ICP coil 106 is mounted on the outside of the quartz chamber 105. To the ICP coil, a high-frequency power source 107 for plasma generation is connected via a matching device 108.

[0016]

As the frequency of the high-frequency power, it is assumed that a frequency band of tens MHz such as 13.56 MHz is used. On the upper part of the quartz chamber 105, a top plate 110 constituting the upper part of the vacuum vessel and serving as a lid of a discharge chamber 109 is mounted. Below the top plate 110, a gas dispersion plate 111 and a shower plate 112 are mounted. A processing gas is introduced into the processing chamber 101 via the gas dispersion plate 111 and the shower plate 112 and through the inside of the discharge chamber 109.

[0017]

The supply flow rate of the processing gas is adjusted by a mass flow controller mounted for each of gas kinds. In the example of Fig. 1, the mass flow controllers are connected, as a mass flow controller unit 113 disposed on the inside of a single box-shaped casing, to gas distributors 114 disposed on the downstream side of the mass flow controller unit 113. With the configuration, the flow rate and composition of a gas supplied to the center part in the discharge chamber 109 and those of a gas supplied to the outer peripheral part can be independently controlled and supplied, so that the space distribution of radicals in the discharge chamber 109 can be specifically controlled.

[0018]

Although NH_3 , H_2 , CH_2F_2 , CH_3F , CH_3OH , O_2 , NF_3 , Ar, N_2 , CHF_3 , CF_4 , and H_2O are written as processing gases in Fig. 1, a gas other than the above-described gases may be used.

[0019]

The lower part of the processing chamber 101 is connected to exhausting means 116 by a vacuum exhaust pipe 115 to depressurize the inside of the processing chamber 101. It is assumed that the exhausting means

116 is configured by, for example, a turbo-molecular pump, a mechanical booster pump, and a dry pump. To adjust the pressure in the processing chamber 101 and the discharge chamber 109, adjusting means 117 is mounted on the upstream side of the exhausting means 116.

[0020]

Above the processing chamber 101 and below the ICP coil 106, an IR lamp unit for heating the wafer is mounted. The IR lamp unit is mainly constructed by an IR lamp 118, a reflector 119 reflecting the electromagnetic wave (also called light) from the IR lamp, and an IR light transmissive window 120 positioned below the IR lamp 118 and made of a transmissive material such as quartz constituting the top face of the processing chamber 101. The reflector 119 is mounted above the IR lamp 118 and reflects the electromagnetic wave emitted from the IR lamp 118 downwardly.

[0021]

As the IR lamp 118, a circular-shaped lamp is used. In the present embodiment, the electromagnetic wave emitted from the IR lamp 118 is light mainly from visible light to light in an infrared light range (called IR light in this disclosure). However,

the bandwidth of the electromagnetic wave is not limited to it. It may be simply called a lamp in the case where the light is not limited. The IR lamp 118 has IR lamps 118-1, 118-2, and 118-3 arranged concentrically and triply. Although triplication is employed in the present embodiment, duplication, quadruplication, or the like may be used.

[0022]

An IR lamp power source 121 is connected to the IR lamp 118, and a high-frequency cutoff filter 122 for preventing noise of high-frequency power for plasma generation from flowing in the IR lamp power source is mounted therebetween. The IR lamp power source 121 has the function of independently controlling powers supplied to the IR lamps 118-1, 118-2, and 118-3, and a radial-direction distribution of the heat amount of the wafer can be adjusted. In Fig. 1, a part of lines accompanying this function is not illustrated.

[0023]

Above the wafer stage 104, a flow channel 124 for introducing particles in plasma 123 generated in the discharge chamber 109 into the processing chamber 101 through communication between the processing chamber 101 and the discharge chamber 109 is formed.

In the flow channel 124, a plate member 125 in which a plurality of through holes or slits are formed in predetermined positions is mounted. The plate member 125 blocks introduction of charged particles such as ions and electrons generated in the plasma 123 into the processing chamber 101, introduces only neutral gas and a neutral radical, and supplies them onto the wafer 103.

[0024]

A refrigerant channel 126 for cooling the stage is formed in the wafer stage 104, and a refrigerant is cyclically supplied by a chiller 127. To fix the wafer 103 by electrostatic adsorption, plate-shaped electrode plates 128 are embedded in the stage, and a DC power source 129 is connected to each of the electrode plates 128.

[0025]

To efficiently perform cooling and temperature adjustment on the wafer 103, He gas can be supplied between the backside of the wafer 103 and the wafer stage 104. To prevent the backside of the wafer from being scarred even when heating/cooling is performed while the wafer 103 is adsorbed, the face on which the wafer 103 is placed of the wafer stage 104 is coated with a resin such as polyimide.

[0026]

A thermocouple 130 for measuring the temperature of the stage is mounted in the wafer stage 104, and the thermocouple 130 is connected to a thermocouple thermometer 131. Although one thermocouple 130 and one thermocouple thermometer 131 are illustrated in Fig. 1, a plurality of them may be mounted.

[0027]

(Temperature Detecting Device)

Fig. 2 is a schematic diagram illustrating the configuration of the temperature detecting device for detecting temperature of the wafer in the present embodiment. A temperature detecting device 140 has pins 132, a drive shaft 133, a drive mechanism 134, a photoreceiver 135, an optical fiber 136, a spectroscope 137, and a photodetector 138. As illustrated in Fig. 2, one or plural pins 132 are provided in the wafer stage 104 so as to penetrate the stage. At least one of the pins is a pin 132-1 made of a transmissive material such as sapphire and the others are pins 132-2 made of a non-permeable material such as ceramics. All of the pins may be made of a transmissive material.

[0028]

An O ring is mounted between the pin 132 made of

a transmissive material or a non-permeable material and the wafer stage 104 to perform airtight sealing so that atmosphere below the stage does not flow in the processing chamber 101.

[0029]

The pin 132 is connected to the drive shaft 133 provided below the stage, and the drive shaft 133 is connected to the drive mechanism 134 provided in the lower part of the vacuum vessel. The drive mechanism 134 is constructed by, for example, a stepping motor or the like. The drive mechanism 134 is not limited to a stepping motor. A simpler drive means may be used. By driving the drive shaft in the vertical direction by the drive mechanism 134, the position of the height of the pin is adjusted.

[0030]

The pin 132-1 made of a transmissive material transmits the electromagnetic wave (light) passed through the wafer 103 as the electromagnetic wave transmissive member. The transmitted light is received by the photoreceiver 135. The received light is transferred from one end of the optical fiber 136 to the spectroscope 137 connected to the other end, and dispersed every predetermined plural wavelengths. The dispersed light is transmitted to

the photodetector 138. The photodetector 138 measures light intensity at each wavelength, thereby obtaining data of the reception light spectrum (also simply called spectrum) expressing the detection light intensity at each wavelength.

[0031]

The pin may also have a function of mounting the wafer 103 at its upper end and supporting it. In this case, by driving the drive shaft by the drive mechanism 134 in the vertical direction, the height upper from the stage top face of the pin 132 is adjusted in the vertical direction as a pusher pin which supports the wafer, and the pin 132 can be used for supporting and delivering the wafer at the time of wafer carry-in and carry-out. The number of pins in this case is, desirably, the number which is sufficient to support the wafer, for example, three or more.

[0032]

The temperature detecting device is assembled in the etching device. However, it is not limited to the etching device. The temperature detecting device may be assembled in various semiconductor processing devices or semiconductor manufacturing devices. Further, the temperature detecting device may be used

alone.

[0033]

(Controller)

The wafer processing device 100 has a controller 139 controlling the entire wafer processing device 100. The controller 139 controls the operation and an output magnitude of each of units such as the high-frequency power source 107, the matching device 108, the DC power source 129, the pressure adjusting means 117 such as a pressure adjustment valve, the exhausting means 116, the mass flow controller unit 113, the gas distributor 114, the IR lamp power source 121, or a not-illustrated gate valve.

[0034]

The controller 139 receives outputs of the thermocouple thermometer 131 and the photodetector 138 and generates a command signal for adjusting operations of the power source, the valve, the pump, and the like so as to be suitable to a process on the basis of measurement data expressed by the outputs. The controller 139 may adjust the temperature of the wafer 103 by feeding back the temperature of the wafer 103 obtained on the basis of a signal from the photodetector 138, controlling the IR lamp power source 121, and adjusting intensity of the

electromagnetic waves emitted from the infrared light lamp. Further, the controller 139 may change or adjust conditions of a process such as the kind and composition of a gas introduced to the processing chamber 101 or the discharge chamber 109, the pressure in the vacuum vessel, and the like in accordance with the temperature of the wafer 103 detected on the basis of the signal from the photodetector 138.

[0035]

The temperature of the wafer stage 104 is desirably controlled by a combination of the IR lamp 118 and the chiller 127. On this occasion, the controller 139 may control the temperature of the wafer stage 104 correlated to the temperature of the wafer 103 by a complementary combination of the temperature of the wafer 103 obtained on the basis of a signal from the photodetector 138 and the temperature of the wafer stage 104 detected by the thermocouple thermometer 131.

[0036]

(Principle of Temperature Measurement)

The principle and the method of temperature measurement will now be described with reference to Figs. 3 and 4. Fig. 3 is a graph illustrating a

state that the reception light spectrum after passage through the wafer changes depending on the wafer temperature. The horizontal axis indicates wavelength, and the vertical axis indicates light intensity. As illustrated in Fig. 3, the value of each of lines Y (Y0, Y1, and Y2) each indicating light intensity after passing through the inside of the wafer decreases relative to a line X indicating intensity of IR light before irradiation to the wafer, and the profile of each of the lines has a characteristic change before and after a specific wavelength. Specifically, as indicated by α in Fig. 3, a range of values including a specific wavelength at which intensity of IR light increases/decreases sharply before and after that is generated.

[0037]

The band gap of a semiconductor decreases as the temperature becomes higher, and a photon of lower energy can be excited. As a result, the absorption edge shifts to a longer wavelength side. When the temperature of the wafer changes, the bandgap accordingly changes in such a range of the wavelengths, and the wavelength of IR light absorbed and transmitted changes, so that the wavelength of α also changes. For example, using Y0 in Fig. 2 as a

reference, when the temperature of the wafer decreases, the wavelength shifts to the short wavelength side like Y1. When the temperature of the wafer increases, the wavelength shifts to the long wavelength side like Y2.

[0038]

As IR light to be detected, other than transmission light, light diffusely reflected by the surface or backside of the wafer can be also used. In this case, however, since the intensity of light measured is relatively weaker as compared with that in Fig. 3, a device to increase the S/N ratio is necessary.

[0039]

Fig. 4 is a graph illustrating an example of the reception light spectrum passed through the wafer in the case where the wafer is at predetermined temperature. The horizontal axis indicates wavelength, and the vertical axis indicates light intensity. Fig. 4(a) illustrates a raw spectrum obtained by the photodetector 138 of the light which passes through the wafer 103, is received by the photoreceiver 135 via the pin 132-1, transmitted to the spectroscope 137, and dispersed. Fig. 4(b) illustrates a normalized spectrum obtained by

performing normalization including smoothing on the raw spectrum. In the present embodiment, a wavelength determined by a specific intensity as indicated by β on the normalized spectrum of Fig. 4(b) is determined as an absorption edge wavelength (also simply called absorption edge). Prior to manufacture of a semiconductor device, correlation data between the temperature of the wafer with respect to an infrared light source of predetermined light intensity and a shift amount γ at the absorption edge from reference temperature, for example, a calibration formula is obtained. By converting the shift amount in the wafer as a measurement target to the temperature of the wafer by using the infrared light source having the predetermined light intensity, a process of calculating the temperature of the wafer 103 (absorption edge evaluation) is executed.

[0040]

At the time of processing the wafer 103, for example, Ar gas is introduced into the processing chamber 101 to heat the wafer 103. Since the absorption wavelength of light by the gas molecule exists on the longer wavelength side as compared with the absorption edge wavelength of a semiconductor,

the influence exerted on detection of temperature based on the absorption edge wavelength as described in the present embodiment is small. Therefore, as the gas introduced into the processing chamber 101 and used at the time of heating the wafer 103, a plurality of kinds of gases can be used.

[0041]

(Process of Temperature Measurement)

A process of temperature measurement will now be described. Fig. 5 is a graph illustrating an example of process of measuring the temperature of the wafer in the present embodiment. The wafer 103 is carried into the processing chamber 101, fixed to the stage by electrostatic adsorption by the DC power source 129, and He gas for cooling is supplied to the backside of the wafer (Fig. 5(c)). The flow rate of process gas supplied to the inside of the processing chamber and a gas composition distribution in the processing chamber 101 are adjusted by the mass flow controller unit 113 and the gas distributor 114, and plasma discharge is started by the high-frequency power source 107 (Fig. 5(a)). The process gas is ionized and disassociated in the plasma 123, and neutral gas and radicals pass through the plate member 125 and are supplied to the wafer 103. After

that, the high-frequency power source 107 is turned off to stop the plasma discharge (Fig. 5(a)). Then, the supply of the He gas to the wafer backside is stopped (Fig. 5(c)), and the pressure adjusting means 117 (pressure adjustment valve) is opened to depressurize the backside of the wafer.

Subsequently, the output of the IR lamp power source 121 is set to ON to turn on the IR lamp 118 (Fig. 5(b)). IR light emitted from the IR lamp 118 passes through the IR light transmissive window 120 and heats the wafer 103. After that, the output of the IR lamp power source 121 is set to OFF (Fig. 5(b)) to stop the heating of the wafer 103. Then, while supplying Ar gas into the processing chamber, the He gas is supplied to the wafer backside to start cooling the wafer (Fig. 5(c)). When the cooling is finished, the process shifts to the next cycle again, and cycle etching process is performed.

[0042]

During the period of heating by the IR lamp 118 (Fig. 5(b)), as illustrated by A in Fig. 5(d), the light from the IR lamp 118 is subjected to spectroscopic measurement, and the wafer temperature is estimated from the absorption edge wavelength. In the following cooling period, there is no light and

the electromagnetic wave from the IR lamp 118, as illustrated by the dotted line (imaginary line) of B in Fig. 5(d), the wafer temperature cannot be estimated by the wafer temperature detecting method from the absorption edge evaluation. On the other hand, as illustrated by C in Fig. 5(d), in the case where the output of the IR lamp 118 is dropped during the cooling period and the IR lamp 118 is turned on at low power, the wafer temperature can be detected from the absorption edge evaluation of the spectrum passed through the wafer like in the heating period. As compared with the case of B in the same cooling period, drop in the wafer temperature is suppressed. Alternatively, by complementarily combining the temperature of the wafer stage 104 detected by the thermocouple thermometer 131, the wafer temperature at the time of cooling may be estimated. When it is unnecessary to measure the wafer temperature at the time of cooling, B in which the IR lamp 118 is turned off may be employed.

[0043]

(Adjustment of Detection Light Intensity)

The transmission light amount of the electromagnetic wave which passes through the wafer changes depending on the difference of an impurity

content amount or a resistance value caused by it (the difference in a film kind) and the like. Therefore, when setting of the temperature detecting device is fixed, depending on the kind of a film of the wafer, the detection light intensity of the reception light spectrum passed through the wafer may exceed the measurable range of a detector. Hereinafter, means for handling the problem will be described by referring to Figs. 6 to 8. Fig. 6 is a schematic diagram illustrating the mechanism of adjusting detection light intensity in the present embodiment. Fig. 7 is a graph illustrating a change in the reception light spectrum after passage through the wafer at the time of adjusting detection light intensity. Fig. 8 is a time chart at the time of adjusting detection light intensity in the present embodiment.

[0044]

First, when the wafer process starts, the wafer 103 is placed on the wafer stage 104. At this time, the pin 132-1 is moved to the pin position of P indicated in Fig. 6(a) (step 1 in Fig. 8). As heating by the IR lamp 118 which is not related to the product process of processing and manufacturing the wafer, for example, IR irradiation at high power

like output 70% of the maximum output is performed for 25 seconds (pre-IR irradiation, step 2 in Fig. 8). An output of the IR lamp is not limited. For example, tens kw may be used as the maximum output. With respect to transmission light which passed through the wafer 103, the reception light spectrum is obtained by the spectroscope 137 and the photodetector 138 via the pin 132-1 made of a transmissive material (step 3 in Fig. 8).

[0045]

Subsequently, the controller 139 makes a determination of whether or not detection light intensity of the reception light spectrum obtained in step 3 is out of the measurable range of the photodetector 138 in a predetermined wavelength interval (for example, 20 nm) in a wavelength range (for example, 1000 to 1320 nm) necessary for normalization or temperature conversion in an absorption edge evaluation (for example, whether or not it exceeds 64000 counts as the dynamic range upper limit of the detector) (intensity O.F. (Overflow) determination, step 4 in Fig. 8). In the case where it is determined that the detection light intensity exceeds the measurable upper limit in a predetermined wavelength interval (YES) as

illustrated by the spectrum of the pin position P in Fig. 7, the process advances to step 5 in Fig. 8. On the other hand, when it is determined as (NO), the process advances to step 6 in Fig. 8. In the case where a charge accumulation member (CCD or the like) is included in the spectroscope 137, the above-described determination may be performed on the basis of the measurable range (dynamic range) in the spectroscope 137.

[0046]

A pin position Q at which detection light intensity of a spectrum does not depart from the measurable range (does not exceed the measurable range upper limit) is determined by using the wafer whose film kind has a large transmission amount in advance. In the case where it is determined as YES, as illustrated in Fig. 6(b), the controller 139 moves the pin 132-1 to the pin position Q so as to widen the distance from the wafer 103 via the drive shaft 133 by the drive mechanism 134 connected to the pin 132-1 made of the transmissive material (step 5 in Fig. 8). By the operation, the amount of the electromagnetic wave incident on and passes through the pin 132-1 is reduced and, as illustrated by the spectrum at the pin position Q in Fig. 7, the

detection light intensity of the spectrum can be kept in the dynamic range. Although the distance between the pin 132-1 and the wafer 103 may be adjusted by two points such as the pin positions P and Q in Fig. 6, it may be also adjusted by pin positions of the number larger than two or may be adjusted linearly (continuously). At the time of performing the absorption edge evaluation, the larger the value of the spectrum obtained is, the more the temperature estimation can be performed with high precision. Consequently, it is preferable not to widen the distance between the pin position and the wafer as long as the intensity does not exceed the measurement upper limit. In such a manner, the absorption edge evaluation is performed with high precision and at an optimum light amount without adjusting light collection time for each film kind of the wafer, and the wafer temperature can be obtained.

[0047]

After that, the pin 132-1 is fixed in the pin position Q in FIG. 6(b) except for vertical drive at the time of carrying the wafer 103, and the normal product process is continuously executed to wafers of the same kind and of a predetermined number, for example, one lot (step 6 in FIG. 8). After execution

of the product process, the controller determines that the process completes, and controls the drive mechanism 134 again to move the pin back to the initial pin position indicated by P in Fig. 6(a). The above steps can be automatically performed by executing software stored in the controller.

[0048]

The detection light intensity can be adjusted by, for example, adjusting light collection time (for example, thousands ms) by the spectroscope 137 (or the photodetector 138), by another method, or by properly combining those means.

[0049]

As described above, according to the present embodiment, the electromagnetic wave transmissive member which transfers transmission light of the wafer to the spectroscope and the photodetector is disposed movably in the wafer stage. Consequently, the detection light intensity can be adjusted. Also against a risk that the detection light intensity of transmission light departs from the measurable range depending on the film kind of the wafer, the position of the electromagnetic wave transmissive member can be easily adjusted in advance so that the intensity lies within the measurable range. Therefore, the

temperature of the wafer can be measured efficiently and precisely, and a high-quality process can be realized in product process. Further, in the case where the electromagnetic wave transmissive member is a pin (pusher pin) which is equipped as standard in a wafer stage and supports and carries the wafer, it is unnecessary to provide an optical path for wafer temperature measurement in the wafer stage. Since occurrence of heat unevenness and an obstacle to etching performance/in-plane uniformity can be also avoided, further improvement in the product quality can be expected.

[0050]

Although the present invention has been concretely described above on the basis of the embodiment, the present invention is not limited to the embodiment but can be variably changed without departing from the gist.

[0051]

Possible aspects of the present invention will be described hereinafter. However, the present invention is not limited to the aspects.

(Aspect 1)

The wafer processing device includes the processing chamber disposed in a vacuum vessel; the

wafer stage disposed in the processing chamber and having a top face on which the wafer to be processed is placed; the lamp disposed above the wafer stage and radiating an electromagnetic wave to the inside of the processing chamber including the wafer stage; the electromagnetic wave transmissive member disposed movably in the wafer stage and transmitting the electromagnetic wave; and a detector receiving the electromagnetic wave passed through the wafer and the electromagnetic wave transmissive member and detecting temperature of the wafer from the reception light spectrum.

(Aspect 2)

The wafer processing device according to aspect 1, further including the controller for adjusting intensity of the electromagnetic wave radiated from the lamp on the basis of an output of the detector.

(Aspect 3)

In the wafer processing device according to aspect 2, the controller determines whether or not detection light intensity of the reception light spectrum departs from a measurable range of the detector in a predetermined wavelength interval and, in the case where it is determined as YES, moves the electromagnetic wave transmissive member so that the

intensity lies within the measurable range.

(Aspect 4)

In the wafer processing device according to any one of aspects 1 to 3, the electromagnetic wave transmissive member is a pin which is housed in a through hole provided in the wafer stage and supports and delivers the wafer by being moved vertically.

(Aspect 5)

In the wafer processing device according to any one of aspects 1 to 4, the electromagnetic wave includes an infrared ray (IR).

(Aspect 6)

In the wafer processing device according to any one of aspects 1 to 5, the detector detects temperature of the wafer on the basis of a shift amount of an absorption edge wavelength determined from the reception light spectrum.

(Aspect 7)

The wafer processing method includes: placing the wafer to be processed on a top face of a wafer stage disposed in a processing chamber in the vacuum vessel; radiating the electromagnetic wave to the inside of the processing chamber including the wafer stage from a lamp disposed above the wafer stage; and in a detector, receiving the electromagnetic wave

passed through the wafer and the electromagnetic wave transmissive member disposed movably in the wafer stage, and detecting temperature of the wafer from the reception light spectrum.

(Aspect 8)

In the wafer processing method according to aspect 7, the intensity of the electromagnetic wave emitted from the lamp is adjusted by the controller on the basis of an output from the detector.

(Aspect 9)

In the wafer processing method according to aspect 8, the controller determines whether or not detection light intensity of the reception light spectrum departs from a measurable range of the detector in a predetermined wavelength interval and, in the case where it is determined as YES, moves the electromagnetic wave transmissive member so that the intensity lies within the measurable range.

(Aspect 10)

In the wafer processing method according to aspect 9, prior to execution of a product process on the wafer, the lamp radiates the electromagnetic wave for a predetermined period, and the controller makes the determination and, in the case where it is determined as YES, moves the electromagnetic wave

transmissive member.

(Aspect 11)

In the wafer processing method according to any one of aspects 7 to 10, the detector detects temperature of the wafer on the basis of a shift amount of an absorption edge wavelength determined from the reception light spectrum.

(Aspect 12)

In the wafer processing method according to any one of aspects 7 to 11, in a period of cooling the wafer, the lamp radiates an electromagnetic wave at an output lower than that in a heating period, and the detector detects temperature of the wafer.

List of Reference Signs

[0052]

100: wafer processing device, 101: processing chamber, 102: base chamber, 103: wafer, 104: wafer stage, 105: quartz chamber, 106: ICP coil, 107: high-frequency power source, 108: matching device, 109: discharge chamber, 110: top plate, 111: gas dispersion plate, 112: shower plate, 113: mass flow controller unit, 114: gas distributor, 115: vacuum exhaust pipe, 116: exhausting means, 117: pressure adjusting means, 118 (118-1, 118-2, 118-3): IR lamp,

119: reflector, 120: IR light transmissive window,
121: IR lamp power source, 122: high-frequency cutoff
filter, 123: plasma, 124: flow channel, 125: plate
member, 126: refrigerant channel, 127: chiller, 128:
electrode plate, 129: DC power source, 130:
thermocouple, 131: thermocouple thermometer, 132
(132-1, 132-2): pin, 133: drive shaft, 134: drive
mechanism, 135: photoreceiver, 136: optical fiber,
137: spectroscope, 138: photodetector, 139:
controller, 140: temperature detecting device

CLAIMS

[Claim 1]

A wafer processing device comprising:

- a processing chamber disposed in a vacuum vessel;
- a wafer stage disposed in the processing chamber and having a top face on which a wafer to be processed is placed;
- a lamp disposed above the wafer stage and radiating an electromagnetic wave to the inside of the processing chamber including the wafer stage;
- an electromagnetic wave transmissive member disposed movably in the wafer stage and transmitting the electromagnetic wave; and
- a detector receiving the electromagnetic wave passed through the wafer and the electromagnetic wave transmissive member and detecting temperature of the wafer from a reception light spectrum.

[Claim 2]

The wafer processing device according to claim 1,

further comprising a controller for adjusting intensity of an electromagnetic wave radiated from the lamp on the basis of an output of the detector.

[Claim 3]

The wafer processing device according to claim 2, wherein

the controller determines whether or not detection light intensity of the reception light spectrum departs from a measurable range of the detector in a predetermined wavelength interval and, in the case where it is determined as YES, moves the electromagnetic wave transmissive member so that the intensity lies within the measurable range.

[Claim 4]

The wafer processing device according to claim 1, wherein

the electromagnetic wave transmissive member is a pin which is housed in a through hole provided in the wafer stage and supports and delivers the wafer by being moved vertically.

[Claim 5]

The wafer processing device according to claim 1 or 2, wherein

the electromagnetic wave includes an infrared ray (IR).

[Claim 6]

The wafer processing device according to claim 1 or 2, wherein

the detector detects temperature of the wafer on

the basis of a shift amount of an absorption edge wavelength determined from the reception light spectrum.

[Claim 7]

A wafer processing method comprising:

placing a wafer to be processed on a top face of a wafer stage disposed in a processing chamber in a vacuum vessel;

radiating an electromagnetic wave to the inside of the processing chamber including the wafer stage from a lamp disposed above the wafer stage; and

in a detector, receiving the electromagnetic wave passed through the wafer and an electromagnetic wave transmissive member disposed movably in the wafer stage, and detecting temperature of the wafer from a reception light spectrum.

[Claim 8]

The wafer processing method according to claim 7, wherein intensity of the electromagnetic wave emitted from the lamp is adjusted by a controller on the basis of an output from the detector.

[Claim 9]

The wafer processing method according to claim 8, wherein

the controller determines whether or not

detection light intensity of the reception light spectrum departs from a measurable range of the detector in a predetermined wavelength interval and, in the case where it is determined as YES, moves the electromagnetic wave transmissive member so that the intensity lies within the measurable range.

[Claim 10]

The wafer processing method according to claim 9, wherein,

prior to execution of a product process on the wafer, the lamp radiates an electromagnetic wave for a predetermined period, and the controller makes the determination and, in the case where it is determined as YES, moves the electromagnetic wave transmissive member.

[Claim 11]

The wafer processing method according to claim 7 or 8, wherein

the detector detects temperature of the wafer on the basis of a shift amount of an absorption edge wavelength determined from the reception light spectrum.

[Claim 12]

The wafer processing method according to claim 7, wherein

in a period of cooling the wafer, the lamp radiates an electromagnetic wave at an output lower than that in a heating period, and the detector detects temperature of the wafer.