CONTROL DEVICE AND CONTROL METHOD OF SEMICONDUCTOR MANUFACTURING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION

This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2016-048663; filed on March 11, 2016; the entire contents of which are incorporated herein by reference.

FIELD

Embodiments described herein relate generally to a control device and a control method of a semiconductor manufacturing apparatus.

BACKGROUND

In a case where a surface of a wafer is ground by a grinding device, when a work layer which is formed on a stopper layer is ground, the grinding is ended by detecting an end point (change point) of the grinding through a certain method. For example, there is a method of detecting the end point of the grinding using a grinding sound. In this case, appropriate collection of the grinding sound is required to accurately detect the end point of the grinding. This is also the same as in a case where a change point of the work of the substrate is detected by using a work sound, when a substrate is manufactured by a semiconductor manufacturing apparatus other than the grinding device.

An example of related art includes JP-A-2003-86551.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view schematically illustrating a configuration of a semiconductor manufacturing system according to a first embodiment.

FIG. 2 is a graph illustrating an end point detecting method according to the first embodiment.

FIG. 3 is a flowchart illustrating the end point detecting method according to the first embodiment.

FIG. 4 is a block diagram illustrating a configuration of a control device according to the first embodiment.

FIG. 5 is a sectional view schematically illustrating a configuration of a semiconductor manufacturing system according to a second embodiment.

FIG. 6 is a flowchart illustrating an end point detecting method according to the second embodiment.

FIG. 7 is a block diagram illustrating a configuration of a control device according to the second embodiment.

FIG. 8 is a graph illustrating an end point detecting method according to a third embodiment.

FIG. 9 is another graph illustrating the end point detecting method according to the third embodiment.

FIG. 10 is a flowchart illustrating the end point detecting method according to the third embodiment.

FIG. 11 is a block diagram illustrating a configuration of a control device according to the third embodiment.

DETAILED DESCRIPTION

[0004]An exemplary embodiment is to provide a control device and a control method of a semiconductor manufacturing apparatus which can accurately detect a change point of work of a substrate using a work sound.

[0005]In general, according to one embodiment, a control device of a semiconductor manufacturing apparatus includes a sound collecting unit that collects a work sound of a substrate which is manufactured by the semiconductor manufacturing apparatus. The control device further includes a change amount calculation unit that that calculates an amount of change of a power spectrum of the work sound. The control device further includes a change point determining unit that determines a change point of work of the substrate, based on the amount of change.

[0007]Hereinafter, embodiments of the invention will be described with reference to the drawings.

First Embodiment

[0008]FIG. 1 is a sectional view schematically illustrating a configuration of a semiconductor manufacturing system according to a first embodiment.

[0009]The semiconductor manufacturing system of FIG. 1 includes a grinding device 1 which grinds a surface of a wafer (substrate) 11 using a grinding pad 12, and a control device 2 which controls an operation of the grinding device 1. The grinding device 1 includes a grinding head 13, a drive unit 14, a grinding table 15, a rotation unit 16, a slurry supplying unit 17, and a sound sensor 18. The grinding device 1 is an example of a semiconductor manufacturing apparatus. The control device 2 is an example of a control device of the semiconductor manufacturing apparatus. The grinding device 1 according to the present embodiment is a chemical mechanical polishing (CMP) device.

[0010]FIG. 1 illustrates an X direction and a Y direction which are parallel to an installation surface of the grinding device 1 and are perpendicular to each other, and a Z direction which is perpendicular to the installation surface of the grinding device 1. In the present specification, the +Z direction is handled as the upper direction, and the –Z direction is handled as the lower direction. For example, it is assumed that the grinding pad 12 is located under the wafer 11, as a relationship between the wafer 11 and the grinding pad 12. In the present embodiment, the –Z direction may coincide with the direction of gravity, or may not coincide with the direction of gravity.

[0011]The grinding head 13 holds the wafer 11 downwardly. The drive unit 14 is connected to the grinding head 13, and drives the grinding head 13. The grinding table 15 holds the grinding pad 12 upwardly. The rotation unit 16 is connected to the grinding table 15, and rotates the grinding table 15. The slurry supplying unit 17 supplies slurry on the surface of the grinding pad 12.

[0012]The grinding device 1 rotates the wafer 11 using the drive unit 14, rotates the grinding pad 12 using the rotation unit 16, and supplies the slurry from the slurry supplying unit 17 to the surface of 12. An arrow R1 indicates a rotation direction of the wafer 11 or the grinding head 13. An arrow R2 indicates a rotation direction of the grinding pad 12 or the grinding table 15. In addition, the grinding device 1 presses the wafer 11 on the grinding pad 12 using the drive unit 14. Accordingly, the surface of the wafer 11 is ground by the grinding pad 12. Operations of the grinding head 13, the drive unit 14, the grinding table 15, the rotation unit 16, and the slurry supplying unit 17 are controlled by the control device 2.

[0013]The sound sensor 18 collects a grinding sound of the wafer 11 which is generated by the grinding device 1, and outputs collecting results of the grinding sound to the control device 2. The sound sensor 18 is, for example, a microphone. The grinding sound is an example of a work sound of a substrate which is manufactured by a semiconductor manufacturing apparatus. An operation of the sound sensor 18 is controlled by the control device 2.

[0014]FIG. 2 is a graph illustrating an end point detecting method according to the first embodiment.

[0015]FIG. 2(a) illustrates a power spectrum of the grinding sound in a point of time t1. A horizontal axis of FIG. 2(a) denotes a frequency of the grinding sound. A vertical axis of FIG. 2(a) denotes the power spectrum of the grinding sound, that is, power of the grinding sound for each frequency. The control device 2 collects the grinding sound from the sound sensor 18, and calculates the power spectrum of the point of time t1 based on the collected grinding sound. The control device 2 also calculates the power spectrum in a point of time other than the point of time t1 in the same manner as above.

[0016]FIG. 2(b) illustrates the amount of change of the power spectrum of the grinding sound in a time period between the point of time t1 and a point of time t2. A horizontal axis of FIG. 2(b) denotes the frequency of the grinding sound. A vertical axis of FIG. 2(b) denotes the amount of change of the power spectrum of the grinding sound, that is, the amount of change of the power of the grinding sound for each frequency. The control device 2 pulls the power spectrum in the point of time t2 from the power spectrum in the point of time t1, thereby calculating the amount of change of the power spectrum in the time period between the point of time t1 and the point of time t2. In addition, the control device 2 sets a difference between the point of time t1 and the point of time t2 to a unit time, thereby calculating the amount of change of the power spectrum per unit time. The control device 2 also calculates the amount of change in a time period other than the time period between the point of time t1 and the point of time t2, in the same manner as above.

[0017]FIG. 2(c) illustrates a signal frequency bandwidth RS and a noise frequency bandwidth RN in the amount of change of the power spectrum in the time period between the point of time t1 and the point of time t2. The control device 2 takes an average of the amount of change of the grinding sound in the signal frequency bandwidth RS, thereby calculating an average value of the amount of change of the power spectrum in the signal frequency bandwidth RS. The signal frequency bandwidth RS is an example of a first frequency bandwidth, and an average value thereof is an example of a first value. Furthermore, the control device 2 takes an average of the amount of change of the power of the grinding sound in the noise frequency bandwidth RN, thereby calculating an average value of the amount of change of the power spectrum in the noise frequency bandwidth RN. The noise frequency bandwidth RN is an example of the second frequency bandwidth, and an average value thereof is an example of a second value. The control device 2 also calculates the average value in a time period other than the time period between the point of time t1 and the point of time t2, in the same manner as above.

[0018]FIG. 2(d) illustrates a time change of an S/N ratio (signal to noise ratio) of the grinding sound. A horizontal axis of FIG. 2(d) denotes time. A vertical axis of FIG. 2(d) denotes the S/N ratio per unit time. The control device 2 divides the average value in the signal frequency bandwidth RS by the average value in the noise frequency bandwidth RN, thereby calculating an S/N ratio per unit time. For example, an S/N ratio per unit time in the point of time t2 is calculated by calculating an S/N ratio in the time period between the point of time t1 and the point of time t2 from an average value in the time period between the point of time t1 and the point of time t2 and setting a difference between the point of time t1 and the point of time t2 to the unit time.

[0019]The control device 2 determines an end point of grinding of the wafer 11, based on the S/N ratio. Specifically, in a case where the S/N ratio reaches a threshold value at a certain time t, the control device 2 determines that the time t is the end point of grinding (refer to a surrounding line P of FIG. 2(d)). Accordingly, the control device 2 can detect the end point of grinding, based on the amount of change of the power spectrum of the grinding sound. In a case where the end point of grinding is detected, the control device 2 controls an operation of the grinding device 1 such that grinding of the wafer 11 is ended. For example, in a case where the end point of grinding is detected, the control device 2 lifts the wafer 11 and separates from the grinding pad 12.

[0020]A function of collecting the grinding sound, among the functions of the control device 2, is an example of a sound collecting unit. The function of calculating the amount of change, the average value, and the S/N ratio is an example of a change amount calculating unit. The function of determining the end point of grinding is an example of a change point determining unit. The function of controlling the grinding device 1 such that grinding is ended is an example of an end controlling unit. Details of such functions will be described with reference to FIG. 3 and FIG. 4.

[0021]FIG. 3 is a flowchart illustrating the end point detecting method according to the first embodiment. The method is performed by the control device 2.

[0022]First, the grinding device 1 starts grinding of the wafer 11 (step S11). Subsequently, the sound sensor 18 collects the grinding sound of the wafer 11 (step S12). Subsequently, frequency analysis (FFT) and time-frequency analysis are performed to the collected grinding sound (steps S13 and S14). As a result, the power spectrum of the grinding sound illustrated in FIG. 2(a) is calculated.

[0023]Subsequently, the amount of change of the power spectrum per unit time is calculated (step S21). The example of the amount of change is the same as the graph illustrated in FIG. 2(b). The unit time of the present embodiment is an interval of time decomposition at the time of frequency analysis.

[0024]Subsequently, the amount of change of the power spectrums in the signal frequency bandwidth RS and the noise frequency bandwidth RN is averaged (step S22). As a result, an average value of the amount of change in the signal frequency bandwidth RS and an average value of the amount of change in the noise frequency bandwidth RN are calculated. For example, the signal frequency bandwidth RS and the noise frequency bandwidth RN are illustrated in FIG. 2(c). A method of averaging according to the present embodiment may be a method of a simple moving average, or may be other methods.

[0025]If the grinding of the wafer 11 reaches the end point, a grinding sound having a characteristic frequency is generated from the wafer 11. Here, the control device 2 according to the present embodiment detects a grinding sound having a characteristic frequency or a frequency near the frequency as a signal, and detects a grinding sound having other frequencies as noise, and thereafter, calculates an S/N ratio based on the signal and the noise, and determines an end point of the grinding based on the S/N ratio. The reason is that, if the grinding of the wafer 11 reaches the end point, a ratio of a signal to the grinding sound increases and the S/N ratio increases. In the present embodiment, a bandwidth with a characteristic frequency is set as the signal frequency bandwidth RS, other bandwidths are set as the noise frequency bandwidth RN, and the S/N ratio is calculated by using the bandwidths.

[0026]However, the characteristic frequencies are changed according to a type of the wafer 11. For example, a characteristic frequency in a case where a silicon oxide film on the wafer 11 is ground is different from a characteristic frequency in a case where a silicon nitride film on the wafer 11 is ground. Hence, in the present embodiment, an upper limit and a lower limit of the signal frequency bandwidth RS are stored in a database in advance for each type of the wafer 11. In a case where a certain wafer 11 is ground, the control device 2 according to the present embodiment acquires identification information of the wafer 11, reads the upper limit and the lower limit corresponding to the identification information, sets the signal frequency bandwidth RS based on the upper limit and the lower limit, and sets other bandwidths as the noise frequency bandwidth RN. The identification information is an example of information on the substrate.

[0027]Subsequently, the S/N ratio per unit time is calculated based on the average value in the signal frequency bandwidth RS and an average value in the noise frequency bandwidth RN (step S23). For example, the S/N ratio is illustrated in FIG. 2(d).

[0028]Subsequently, a change point of the grinding is extracted based on the S/N ratio, and the change point is determined to be the end point of the grinding (steps S24 and S25). Specifically, the time t when the S/N ratio reaches the threshold value is extracted as the change point, and the time t is determined to be the end point of the grinding. In a case where the end point of the grinding is detected, the grinding of the wafer 11 which is performed by the grinding device 1 ends (step S26).

[0029]Thereafter, the control device 2 repeatedly performs processing of steps S11 to S26 with respect to the entire wafers 11 of the amount of one lot (step S27). At this time, the wafers 11 of the same lot generally have the same characteristic frequency, and thus, processing for the wafers 11 in step S22 is normally performed by using the same upper limit and lower limit. Accordingly, grinding of the wafers 11 of the amount of one lot is performed.

[0030]The end point of the grinding is detected by using, for example, a torque current value. In this case, the current value is smoothed before and after differentiation of the current value, and thus, it is possible to increase accuracy of detection of the end point. Meanwhile, in a case where the end point is detected by using the grinding sound, the grinding sound contains a signal and noise which are mixed with each other, and thus, even in this case, smoothing (movement averaging) of the grinding sound is mostly performed. However, if the smoothing of the grinding sound is performed, there is a possibility that detection of the end point is delayed or the end point is unable to be detected.

[0031]Hence, in the present embodiment, the end point of the grinding is determined based on the amount of change of the power spectrum of the grinding sound. For example, according to the present embodiment, the S/N ratio per unit time is calculated from the amount of change, the end point is determined by using the S/N ratio per unit time, and thus, it is possible to detect the end point without using the smoothing. Thus, according to the present embodiment, it is possible to reduce a possibility that the detection of the end point is delayed, and a possibility that the end point is unable to be detected, and to reliably detect the end point in a short time.

[0032]FIG. 4 is a block diagram illustrating a configuration of the control device 2 according to the first embodiment.

[0033]As illustrated in FIG. 4, the control device 2 includes a sound collecting unit 21, a characteristic extraction unit 22, an end point determining unit 23, an output unit 24, a frequency bandwidth determining unit 25, and a record unit 26.

[0034]The sound collecting unit 21 performs the processing of step S12. Hence, the sound collecting unit 21 collects the grinding sound of the wafer 11 from the sound sensor 18.

[0035]The characteristic extraction unit 22 performs processing of steps S13 to S23. Hence, the characteristic extraction unit 22 calculates the power spectrum, the amount of change, the average value, and the S/N ratio.

[0036]The end point determining unit 23 performs the processing of steps S24 and S25. Hence, the end point determining unit 23 extracts the change point of the grinding based on the S/N ratio, and determines that the change point is the end point of the grinding.

[0037]The output unit 24 performs the processing of steps S11 and S26. Hence, the output unit 24 controls the grinding device 1 such that the grinding of the wafer 11 starts and ends. In a case where the end point of the grinding is detected by the end point determining unit 23, the output unit 24 ends the grinding of the wafer 11 which is performed by the grinding device 1.

[0038]The frequency bandwidth determining unit 25 outputs the setting information of the signal frequency bandwidth RS and the noise frequency bandwidth RN to the characteristic extraction unit 22, according to the request from the characteristic extraction unit 22. Specifically, if the identification information of the wafer 11 which is a grinding target is acquired from the characteristic extraction unit 22, the frequency bandwidth determining unit 25 reads master information from the record unit 26 so as to set the signal frequency bandwidth RS and the noise frequency bandwidth RN of the wafer 11, and outputs the setting information corresponding to the master information to the characteristic extraction unit 22. For example, the master information is an upper limit and a lower limit of the signal frequency bandwidth RS.

[0039]If the wafer 11 can be identified, the identification information may be any information. For example, the identification information is recipe information on products to be manufactured from the wafer 11.

[0040]An upper limit and a lower limit of the master information can be set by collecting in advance the grinding sound of the wafer 11 which is performed by the grinding device 1, and picking up a frequency bandwidth in which the power spectrum changes the largest at the end point of the grinding. The frequency bandwidth can be picked up by, for example, recording standard deviation of the power spectrum for each time, roughly estimating a time zone of the end point from a grinding rate of the wafer 11, and investigating a change of the standard deviation of the time zone.

[0041]The upper limit and the lower limit of the master information may be set by only one type with respect to the wafer 11 of one type, and may be set by multiple types with respect to the wafer 11 of one type. In a case of the latter, the control device 2 may select automatically an upper limit and a lower limit for grinding of the wafer 11, according to a state or an environment of the grinding device 1, when a certain wafer 11 is ground. This is also applied to other master information.

[0042]The record unit 26 is used to record, for example, the identification information or the master information of the wafer 11 that is previously ground or the wafer 11 which is planned to be ground hereafter. The control device 2 may include an input and output unit for newly registering, updating, and editing the identification information or the master information. The control device 2 according to the present embodiment can automatically specify the master information of the wafer 11 based on the identification information, and can automatically set the signal frequency bandwidth RS and the noise frequency bandwidth RN of the wafer 11 based on the master information, if the identification information of a certain wafer 11 is acquired. Hence, in the present embodiment, in a case where the type of the wafer 11 which is a grinding target is replaced, a user can change the signal frequency bandwidth RS and the noise frequency bandwidth RN without being conscious of the replacement.

[0043]As described above, in the present embodiment, it is possible to determine the end point of the grinding, based on the amount of change of the power spectrum of the grinding sound. Hence, according to the present embodiment, it is possible to detect quickly and reliably the end point of the grinding, using the grinding sound.

Second Embodiment

[0044]FIG. 5 is a sectional view schematically illustrating a configuration of a semiconductor manufacturing system according to a second embodiment.

[0045]The semiconductor manufacturing system of FIG. 5 includes a grinding device 1 and a control device 2. The grinding device 1 includes a calibration speaker 19 in addition to the configuration element illustrated in FIG. 1.

[0046]The calibration speaker 19 generates a reference sound (test sound) for calibrating a sound sensor 18. An operation of the calibration speaker 19 is controlled by the control device 2. The sound sensor 18 collects a grinding sound and the reference sound, and outputs collection results of the sound to the control device 2. The collection results are collected by a sound collecting unit 21 of the control device 2. The control device 2 calibrates the sound sensor 18, based on the collected reference sound.

[0047]In a case where the sound sensor 18 is calibrated by the reference sound, it is considered that a sound pressure of the reference sound is used for calibration. In this case, the reference sound with a predetermined sound pressure is generated from the calibration speaker 19, the reference sound is collected by the sound sensor 18, the control device 2 determines whether or not the sound pressure of the collected reference sound is a defined sound pressure, and thereby the sound sensor 18 is calibrated. However, the collected sound pressure is changed by a state of the grinding device 1, an environment of the grinding device 1, a frequency of the grinding sound, or the like. Accordingly, in a case where the sound sensor 18 is calibrated by the sound pressure, there is a possibility that correct calibration is hard to be performed, and accuracy of detection of the end point decreases. In addition, in a case where the end point of the grinding is detected based on the power spectrum of the grinding sound, correct detection of the frequency of the grinding sound is requested.

[0048]Hence, in the present embodiment, a frequency of the reference sound is used for calibration. Specifically, a reference sound with a predetermined frequency is generated from the calibration speaker 19, the reference sound is collected by the sound sensor 18, the control device 2 determines whether or not a frequency of the collected reference sound is a defined frequency, and thereby the sound sensor 18 is calibrated. Accordingly, it is possible to perform correct calibration, and to increase accuracy of the detection of the end point.

[0049]In a case where the sound sensor 18 is calibrated by the sound pressure, a frequency of the reference sound is mainly set to a frequency of an audible range. Meanwhile, a characteristic frequency at the end point of the grinding is higher than the frequency of the audible range, and can be equal to or higher than, for example, 10 kHz. In this case, when the sound sensor 18 is calibrated to detect the end point, the frequency of the reference sound needs to be set higher than the frequency of the audible range. Thereby, it is possible to perform calibration suitable for detecting the end point, and to reduce a measurement error of the frequency when the end point is detected.

[0050]The frequency of the reference sound according to the present embodiment may be one type or multiple types, and may be spread in a certain bandwidth. In addition, the frequency of the reference sound may be changed according to a change of a state or an environment of the grinding device 1. Thereby, it is possible to perform calibration in a state or en environment in which the end point is detected, and to reduce a measurement error of the frequency when the end point is detected.

[0051]FIG. 6 is a flowchart illustrating an end point detecting method according to the second embodiment. The method is performed by the control device 2.

[0052]First, the reference sound is generated by the calibration speaker 19, and the reference sound is collected by the sound sensor 18, before grinding of the wafer 11 starts (step S1). The control device 2 according to the present embodiment automatically selects the upper limit and the lower limit of the signal frequency bandwidth RS according to a state or an environment of the grinding device 1, automatically selects a frequency of the reference sound according to the upper limit and the lower limit, and generates the reference sound only for a predetermined time using a constant sound pressure. The state or the environment of the grinding device 1 are, for example, a temperature around the grinding device 1 or sound collecting conditions of the grinding device 1. The frequency of the reference sound is, for example, a frequency corresponding to the upper limit, a frequency corresponding to the lower limit, a medium frequency of the upper limit and the lower limit, or the like.

[0053]The control device 2 may select the frequencies of the reference sounds of N types (N is an integer equal to or greater than 2) in step S1. In this case, the control device 2 sequentially generates the reference sounds of the frequencies of N types. The reference sounds of each frequency may be output only for the predetermined time. In addition, the reference sounds of the frequencies of N types are sequentially output with an interval of Dt. That is, since the output of a certain reference sound ends at the time t, an output of a subsequent reference sound starts at time t + Dt.

[0054]Subsequently, frequency analysis (FFT) of the collected reference sounds is performed (step S2). Accordingly, a power spectrum of the reference sounds is calculated (step S3). In a case where the reference sounds of the frequencies of N types are output, the frequency analysis is performed at a resolution of Dt. The power spectrum is, for example, a decibel (dB) value.

[0055]Subsequently, the sound sensor 18 is calibrated based on the power spectrum of the reference sounds (step S4). The control device 2 according to the present embodiment acquires a measurement value of the frequency of the reference sound from the power spectrum of the reference sound, reads a setting value of the frequency of the reference sound from the record unit 26 (refer to FIG. 4), and the sound sensor 18 is calibrated based on the measurement value and the setting value.

[0056]For example, the measurement value of the frequency of the reference sound can be performed by specifying a frequency in which the power spectrum of the reference sound is maximum. In addition, the setting value of the frequency of the reference sound is a frequency which is selected in step S1.

[0057]In addition, the control device 2 calibrates the sound sensor 18 such that the measurement value is equal to the setting value. In the present embodiment, the measurement value is changed by changing the setting of the sound sensor 18, and thereby the sound sensor 18 may be calibrated. In addition, the setting value is changed by updating the setting value of the record unit 26 into the measurement value, and thereby the sound sensor 18 may be calibrated. The control device 2 according to the present embodiment calibrates the sound sensor 18 using a method of the latter. The method of the latter has an advantage in which the sound sensor 18 can be simply calibrate without detaching the sound sensor 18 from the grinding device 1 so as to change the setting of the sound sensor 18.

[0058]Among the functions of the control device 2, a function of acquiring the measurement value of the frequency of the reference sound is an example of a function of an acquisition unit. A function of reading the setting value of the frequency of the reference sound is an example of the function of a read unit. A function of calibrating the sound sensor 18 is an example of the function of a calibration unit. Details of such functions will be described below with reference to FIG. 7.

[0059]Subsequently, a calibration value of the sound sensor 18 is recorded in the record unit 26 (step S5). The calibration value according to the present embodiment is the measurement value of the frequency of the reference sound, and is recorded as a new setting value. In addition, in the present embodiment, the master information of the upper limit and the lower limit of the signal frequency bandwidth RS is also updated based on the new setting value. For example, in a case where the setting value increases by 20 Hz, the upper limit and the lower limit of the signal frequency bandwidth RS also increase by 20 Hz.

[0060]The control device 2 may also collect background noise of a background when the sound sensor 18 is calibrated, in step S1. In this case, the control device 2 calculates a difference between the reference sound and the background noise, and performs frequency analysis with respect to the difference, in step S2. Accordingly, it is possible to perform calibration with high accuracy even in an environment where background noise exists.

[0061]Thereafter, in the present embodiment, the processing of steps S11 to S27 is performed in the same manner as in the first embodiment. At this time, the processing of step S22 is performed by using the upper limit and the lower limit which are updated. In a case where the setting of the upper limit and the lower limit is changed during the grinding of the wafer 11 of the amount of one lot, the processing of the steps S1 to S5 may be performed again before the setting is changed.

[0062]FIG. 7 is a block diagram illustrating a configuration of the control device 2 according to the second embodiment.

[0063]The control unit 2 includes a sound collecting unit 21, a record unit 26, a calibration unit 31, a device state determining unit 32, and an input and output unit 33, as illustrated in FIG. 7. The control device 2 according to the present embodiment may also include the characteristic extraction unit 22, the end point determining unit 23, the output unit 24, and the frequency bandwidth determining unit 25, in the same manner as the control device 2 according to the first embodiment, and configuration elements thereof are not illustrated in the figures.

[0064]In step S1, the device state determining unit 32 generates a reference sound from the calibration speaker 19, and the sound collecting unit 21 collects the reference sound from the sound sensor 18. At this time, the device state determining unit 32 automatically selects the upper limit and the lower limit of the signal frequency bandwidth RS, according to a state or an environment of the grinding device 1, automatically selects a frequency of the reference sound, according to the upper limit and the lower limit, and generates the reference sound only for a predetermined time using a constant sound pressure.

[0065]Furthermore, the device state determining unit 32 performs the processing of steps S2 and S3. Hence, the device state determining unit 32 performs frequency analysis of the reference sound, and calculates the power spectrum of the reference sound. In addition, the calibration unit 31 performs the processing of steps S4 and S5. Hence, the calibration unit 31 calibrates the sound sensor 18, and records a calibration value of the sound sensor 18 in the record unit 26.

[0066]The device state determining unit 32 determines a change of the state or the environment of the grinding device 1. For example, the device state determining unit 32 reads the setting value of the frequency of the reference sound from the record unit 26, based on the identification information of the wafer 11 which is a grinding target. The setting value is used, when the reference sound is generated in step S1, or when the sound sensor 18 is calibrated in step S4. In addition, the device state determining unit 32 acquires information from the grinding device 1 to the effect that a member of the grinding device 1 is changed, and selects the setting value which is read from the record unit 26, based on the information.

[0067]A relationship between the change of the state or the environment of the grinding device 1, and the characteristic frequency of the grinding sound is registered in the record unit 26 as the master information in advance. The input and output unit 33 uses the master information, for new registration, updating, and editing.

[0068]As describe above, in the present embodiment, the sound sensor 18 is calibrated based on the frequency of the reference sound which is collected from the sound sensor 18. Hence, according to the present embodiment, it is possible to perform a correct calibration of the sound sensor 18, and to increase accuracy of the detection of the end point.

Third Embodiment

[0069]FIG. 8 is a graph illustrating an end point detecting method according to a third embodiment. The end point detecting method according to the third embodiment is performed by the control device 2 in the semiconductor manufacturing system of FIG. 1.

[0070]Curves C1, C2, and C3 of FIG. 8(a) respectively denote power spectrums of grinding sounds at time t1, t2, and t3. A horizontal axis of FIG. 8(a) denotes the frequency of the grinding sound. A vertical axis of FIG. 8(b) denotes the power spectrum of the grinding sound. An axis in a depth direction of FIG. 8(a) denotes time.

[0071]The control device 2 can calculates an average value of the amount of change of the power spectrum at a predetermined frequency bandwidth R, and can calculates an S/N ratio based on the average value, and can determine the end point based on the S/N ratio. The predetermined frequency bandwidth R is set so as to include the characteristic frequency of the grinding sound which is generated from the wafer 11 when the grinding of the wafer 11 reaches the end point. A symbol f1 denotes the frequency of the lower limit of the frequency bandwidth R. A symbol f2 denotes the frequency of the upper limit of the frequency bandwidth R. The control device 2 calculates an average value of the amount of change of the power spectrum within the frequency bandwidth R, divides the average value into an average value of a signal time band and an average value of a noise time band, on a time axis, and calculates the S/N ratio based on the average values.

[0072]The wafer 11 includes, for example, a semiconductor substrate, a stopper layer on the semiconductor substrate, and a work layer on the stopper layer. In this case, the control device 2 controls the grinding device 1 so as to grind the work layer, and sets the timing when the work layer is removed and thereby the stopper layer is exposed, as the end point. If the grinding reaches the end point, a characteristic change occurs at the power spectrum of the grinding sound due to a different selection ratio between the work layer and the stopper layer. For example, the power spectrum of a certain frequency is maximum or minimum at the end point. The frequency bandwidth R is set so as to include the frequency.

[0073]FIG. 8(b) illustrates a power spectrum of the frequency. A horizontal axis of FIG. 8(b) denotes time. A vertical axis of FIG. 8(b) denotes a power spectrum of the grinding sound. A symbol U denotes a maximum of the power spectrum. A symbol V denotes a minimum of the power spectrum. FIG. 8(b) illustrates that the grinding reaches the end point at time t and the power spectrum reaches the minimum V at the time t.

[0074]The characteristic frequency (or frequency bandwidth) can be changed by a state of a body of the grinding device 1, or a state of a consumable member such as the grinding pad 12 or a grinding dresser. For example, the frequency changes toward a high frequency side or a low frequency side, and the frequency bandwidth changes into a broad bandwidth or a narrow bandwidth. Accordingly, if the predetermined frequency bandwidth R is fixed, detection accuracy of the end point varies in each wafer 11, and correct detection of the end point can be hard to be made.

[0075]Hence, the control device 2 according to the present embodiment determines the end point by setting the predetermined frequency bandwidth R to a first bandwidth DfA, when a certain wafer 11 (first wafer 11) is ground. Furthermore, the control device 2 according to the present embodiment determines a second bandwidth DfB as new setting of the frequency bandwidth R, based on the grinding sound which is collected when the first wafer 11 is ground. Furthermore, the control device 2 according to the present embodiment determines the end point by changing the frequency bandwidth R to the second bandwidth DfB, when a next wafer 11 (second wafer 11) is ground.

[0076]As described above, the control device 2 according to the present embodiment corrects the frequency bandwidth R when the next wafer 11 is ground, based on the grinding sound which is collected when a certain wafer 11 is ground. The control device 2 according to the present embodiment can correct the frequency bandwidth R by changing an upper limit (f2) and a lower limit (f1) of the master information.

[0077]Among the functions of the control device 2, the function of determining the new setting of the frequency bandwidth R is an example of a function of a determination unit. The function of changing the frequency bandwidth R according to the new setting is an example of a function of a change unit. Details of such functions will be described with reference to FIG. 9 to FIG. 11.

[0078]FIG. 9 is another graph illustrating the end point detecting method according to the third embodiment.

[0079]FIG. 9(a) illustrates a power spectrum of the grinding sound which is collected when the first wafer 11 is ground. Specifically, FIG. 9(a) illustrates a time transition waveform of a power spectrum of the characteristic frequency, in the same manner as in FIG. 8(b). The frequency is included in the first bandwidth DfA. Symbols UA, VA, and tA respectively denote a maximum, a minimum, and the end point. A symbol DPA denotes a power difference between the maximum UA and the minimum VA of the power spectrum.

[0080]FIG. 9(b) also illustrates the power spectrum of the grinding sound which is collected when the first wafer 11 is ground. However, FIG. 9(b) illustrates time transition waveforms of power spectrums of various frequencies. The control device 2 acquires the time transition waveforms of FIG. 9(b) by analyzing the time transition waveform of the power of the grinding sound for each frequency. Furthermore the control device 2 generates first image data in which the time transition waveform is represented as a two-dimensional image.

[0081]In the first image data, a horizontal axis denotes time, and a vertical axis denotes a power spectrum. The first image data includes time transition waveforms of various frequencies, and each time transition waveform denotes a relationship between power spectrums of each frequency and time. Content of the first image data is the same as, for example, the graph illustrated in FIG. 9(b). The first image data includes not only the time transition waveforms of the frequencies within the first bandwidth DfA,but also time transition waveforms of other frequencies that the sound sensor 18 can detect. The function of generating the first image data is an example of a function of an image generating unit.

[0082]The control device 2 hold the second image data which is collated with the first image data in advance in the record unit 26 (refer to FIG. 4). The second image data includes the time transition waveform (reference waveform) of the characteristic frequency or a frequency near the characteristic frequency. The reference waveform is the time transition waveform close to the end point of the grinding. A size (reference space) of the second image data is DT ´ Df as illustrated by a rectangular shape in FIG. 9(b). The second image data can be generated by grinding the wafer 11 for test is ground by the grinding device 1 in advance and collecting the grinding sound at the time of grinding.

[0083]The control device 2 scans the first image data as denoted by an arrow of FIG. 9(b), and collates the first image data with the second image data. In addition, the control device 2 extracts an area including an image closet to the second image data the second image data from the first image data using a pattern recognition technology.

[0084]A symbol KA denotes an area in which the first bandwidth DfA is set to a vertical width. A symbol KB denotes an area in which the second bandwidth DfB is set to a vertical width. In a case where the area KB is extracted as an area including an image which is the most different from the second image data, the control device 2 determines the second bandwidth DfB as the new setting of the frequency bandwidth R. The function of determining the new setting of the frequency bandwidth R using the image collation is an example of a function of an image collating unit.

[0085]The control device 2 may hold the second image data of two types or more. Values of DT and Df may be different from each other. In addition, the pattern recognition technology may be any technology.

[0086]FIG. 9(c) illustrates a power spectrum of the grinding sound which is collected when the second wafer 11 is ground. Specifically, a solid line of FIG. 9(c) denotes the time transition waveform of the power spectrum of a frequency within the second bandwidth DfB. For comparison, a dashed line of FIG. 9(c) denotes the time transition waveform of the power spectrum of the frequency within the first bandwidth DfA. Symbols UB, VB, tB, and DPB respectively denote a maximum, a minimum, an end point, and a power difference.

[0087]FIG. 10 is a flowchart illustrating the end point detecting method according to the third embodiment.

[0088]First, the grinding of the first wafer 11 starts (step S11), and processing of steps S12 to S14 is performed for the grinding sound of the first wafer 11. Accordingly, the power spectrum of the grinding sound is calculated.

[0089]Subsequently, the amount of change of the power spectrum per unit time is calculated (step S21), and the end point (change point) of the grinding is determined based on the amount of change in a predetermined frequency bandwidth R (step S31). For example, the end point can be determined based on an S/N ratio between a signal time band and a noise time band. In a case where the end point of the grinding is detected, the grinding of the first wafer 11 ends (step S26).

[0090]After the grinding of the first wafer 11 ends, a characteristic frequency bandwidth is extracted from the grinding sound of the first wafer 11 (step S31). Specifically, the bandwidth DfB of the aforementioned area KB is extracted by the collation processing of FIG. 9(b).

[0091]Subsequently, a monitoring frequency bandwidth is changed into an extracted bandwidth (step S32). Specifically, the frequency bandwidth R is determined to the second bandwidth DfB.

[0092]Subsequently, the grinding of the second wafer 11 starts (step S11), and processing after step S12 is performed. At this time, the second bandwidth DfB is used as the frequency bandwidth R.

[0093]The control device 2 repeats the aforementioned processing for the entire wafer 11 of the amount of one lot (step S27). Accordingly, the grinding of the wafer 11 of the amount of one lot is performed.

[0094]FIG. 11 is a block diagram illustrating a configuration of the control device 2 according to the third embodiment.

[0095]The control device 2 includes the sound collecting unit 21, the end point determining unit 23, a characteristic frequency extracting unit 41, and a monitoring frequency bandwidth changing unit 42, as illustrated in FIG. 11. The control device 2 according to the present embodiment also includes the characteristic extraction unit 22, the output unit 24, the frequency bandwidth determining unit 25, and the record unit 26, in the same manner as the control device 2 according to the first embodiment, and the configuration elements are not illustrated in FIG. 11.

[0096]The characteristic frequency extracting unit 41 extracts a characteristic frequency bandwidth from the grinding sound in step S31. The monitoring frequency bandwidth changing unit 42 changes a monitoring frequency bandwidth into the extracted bandwidth in step S32. The control device 2 according to the present embodiment corrects the frequency bandwidth R using the configuration elements.

[0097]As described above, in the present embodiment, the frequency bandwidth R is corrected when the second wafer 11 is ground, based on the grinding sound which is collected when the first wafer 11 is ground. For example, the correction is made by collating the first image data with the second image data. Hence, according to the present embodiment, sensitivity of the collection of the grinding sound can be increased by correction of the frequency bandwidth R, and thus, it is possible to increase accuracy of the detection of the end point.

While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

WHAT IS CLAIMED IS:

1. A control device of a semiconductor manufacturing apparatus comprising:

a sound collecting unit that collects a work sound of a substrate which is manufactured by the semiconductor manufacturing apparatus;

a change amount calculation unit that that calculates an amount of change of a power spectrum of the work sound; and

a change point determining unit that determines a change point of work of the substrate, based on the amount of change.

2. The device according to Claim 1,

wherein the change amount calculation unit calculates a first value, based on the amount of change in a first frequency bandwidth, and calculates a second value, based on the amount of change in a second frequency bandwidth, and

wherein the change point determining unit determines the change point, based on the first value and the second value.

3. The device according to Claim 2,

wherein the first value is an average value of the amount of change in the first frequency bandwidth, and

wherein the second value is an average value of the amount of change in the second frequency bandwidth.

4. The device according to Claim 2 or 3, wherein the change amount calculation unit changes the first and second frequency bandwidths, based on information on the substrate.

5. The device according to any one of Claims 2 to 4,

wherein the change amount calculation unit calculates a signal to noise ratio (S/N ratio) of the work sound, based on the first and second values, and

wherein the change point determining unit determines the change point, based on the S/N ratio.

6. The device according to Claim 1,

wherein the sound collecting unit collects the work sound and a reference sound for calibration of a sound sensor from the sound sensor, and

wherein the device further comprises

an acquisition unit that acquires a measurement value of a frequency of the reference sound, using the collected reference sound,

a read unit that reads a setting value of a frequency of the reference sound from a record unit, and

a calibration unit that calibrates the sound sensor, based on a measurement value of a frequency of the reference sound and a setting value of a frequency of the reference sound.

7. The device according to Claim 1,

wherein the change point determining unit determines the change point, based on the amount of change in a predetermined frequency bandwidth, and

wherein the device further comprises

a determination unit that determines setting of the predetermined frequency bandwidth, based on the work sound which is collected when a first substrate is worked, and

a change unit that changes according to the setting of the predetermined frequency bandwidth, when a second substrate is worked.

8. The device according to Claim 7, wherein the determination unit includes

an image generating unit that generates first image data which denotes a relationship between the power spectrums of the work sound which is collected when the first substrate is worked and time, and

an image collating unit that determines the setting value of the predetermined frequency bandwidth by collating the first image data with second image data which denotes a relationship between the power spectrum of the change point and time.

9. The device according to any one of Claims 1 to 8, further comprising:

an end controlling unit that controls the semiconductor manufacturing apparatus such that work of the substrate ends, in a case where the change point is detected by the change point determining unit.

10. A control method of a semiconductor manufacturing apparatus, the method comprising:

collecting a work sound of a substrate which is manufactured by the semiconductor manufacturing apparatus;

calculating an amount of change of a power spectrum of the work sound; and

determining a change point of work of the substrate, based on the amount of change.

ABSTRACT

According to one embodiment, a control device of a semiconductor manufacturing apparatus includes a sound collecting unit that collects a work sound of a substrate which is manufactured by the semiconductor manufacturing apparatus. The control device further includes a change amount calculation unit that that calculates an amount of change of a power spectrum of the work sound. The control device still further includes a change point determining unit that determines a change point of work of the substrate, based on the amount of change.