

BACKGROUND

Technical Field

- 5 **[0001]** The disclosure relates to a method for determining a height of a polishing pad used for polishing a substrate such as a wafer. In addition, the disclosure relates to a polishing system for polishing a substrate such as a wafer using such a method.

Description of Related Art

- 10 **[0002]** Recently, in accordance with semiconductor devices which have become highly integrated and highly dense, wiring for circuits has been further micronized, and the number of layers in multi-layer wiring has also increased. When it is intended to realize multi-layer wiring while achieving micronization of circuits, a step becomes larger with unevenness on a surface of a layer on a lower side. Therefore, when the number of layers of wiring increases, film coverage (step coverage) with respect to the shape of a step in thin film formation deteriorates.
- 15 Therefore, in order to achieve multi-layer wiring, this step coverage has to be ameliorated and flattening processing has to be performed through an appropriate process. In addition, since the depth of focus becomes shallow in accordance with micronization of optical lithography, there is a need to flatten surfaces of semiconductor devices such that uneven steps on the surfaces of the semiconductor devices are confined within the depth of focus.
- 20 **[0003]** Therefore, in a step of manufacturing a semiconductor device, technologies of flattening a surface of a semiconductor device have become increasingly important. The most important technology of these flattening technologies is chemical mechanical polishing. This chemical mechanical polishing (which will hereinafter be referred to as CMP) is polishing performed by supplying a polishing liquid containing abrasive grains such as silica (SiO_2) onto a
- 25 polishing pad and bringing a substrate such as a wafer into sliding contact with a polishing surface.
- 30 **[0004]** A polishing apparatus for performing CMP includes a polishing table that supports a polishing pad having a polishing surface, and a polishing head that holds a substrate. When a substrate is polished using such a polishing apparatus, the substrate is held by the polishing head, and this substrate is pressurized to the polishing surface of the polishing pad at a predetermined pressure. Moreover, the substrate comes into sliding contact with the polishing surface by causing relative movement between the polishing table and the polishing head, and therefore the

surface of the substrate is polished into a flat mirror surface.

[0005] When a substrate is polished, abrasive grains or a polishing residue adheres to the polishing surface of the polishing pad, and polishing performance is degraded. Therefore, in order to regenerate the polishing surface of the polishing pad, the polishing pad is dressed with a dresser. A dresser has hard abrasive grains such as diamond particles which are fixed to its lower surface, and the polishing surface of the polishing pad is regenerated by grinding off the polishing surface of the polishing pad using this dresser. The polishing pad is dressed every time one substrate is polished.

[0006] Polishing pads become gradually abraded as dressing is repetitively performed. When a polishing pad is abraded, intended polishing performance can no longer be exhibited. Therefore, there is a need to regularly replace the polishing pad. Generally, polishing pads are used until their abrasion loss reaches a threshold value set in advance. In the polishing apparatus described above, the height of the polishing surface of the polishing pad is determined by measuring the height of the dresser when the polishing pad is being pressurized. In addition, the amount of change in height of the dresser is monitored as the abrasion loss of the polishing pad.

[0007] [Patent Document 1] Japanese Laid-Open Patent No. 5390807

[Patent Document 2] Japanese Laid-Open Patent No. 5511600

SUMMARY

[0008] When a dressing load applied to a polishing pad from a dresser is changed, the dresser may change in height depending on the characteristics of the polishing pad. Therefore, in order to stably determine the height of a polishing pad, there is a need to measure the height of the dresser with every dressing by pressurizing the polishing pad with the same dressing load.

[0009] However, since the dressing load is arbitrarily set through a recipe depending on the type of a substrate to be polished, the same dressing load is not always applied to a polishing pad every time. Therefore, an error may be caused in the determined height of a polishing pad due to the difference between the dressing loads.

[0010] The disclosure provides a method for determining an accurate height of a polishing pad even when a dressing load applied to the polishing pad is changed. Moreover, the disclosure provides a polishing system for polishing a substrate such as a wafer using such a method.

[0011] According to an embodiment, there is provided a method for determining a polishing

pad height in a polishing apparatus including a polishing table which supports a polishing pad, a polishing head which pressurizes a substrate onto a polishing surface of the polishing pad, and a dresser which dresses the polishing surface of the polishing pad. The method for determining a polishing pad height includes a step of measuring a reference dresser height that is a height of a dressing surface of the dresser when the polishing surface of the polishing pad in an unused state is being pressed with a reference dressing load for polishing the substrate, a step of calculating a correction amount for a dresser height corresponding to an amount of change in dressing load from the reference dressing load, a step of measuring a current dresser height that is a current height of the dressing surface of the dresser when the polishing surface of the polishing pad is being pressed, and a step of correcting the current dresser height using the correction amount.

[0012] According to the embodiment, the step of calculating a correction amount for the dresser height may include steps of measuring an Nth dresser height when the dresser is pressurizing the polishing pad with a first dressing load differing from the reference dressing load, and calculating the correction amount that is a difference between the Nth dresser height and an N-1th dresser height. The N-1th dresser height may be the height of the dressing surface of the dresser when the polishing surface of the polishing pad is being pressed with the reference dressing load, and may be measured prior to the Nth dresser height.

According to the embodiment, a change in abrasion loss of the polishing pad from a time of measuring the N-1th dresser height to a time of measuring the Nth dresser height may be substantially zero.

According to the embodiment, the N-1th dresser height may be the reference dresser height.

According to the embodiment, the step of calculating a correction amount for the dresser height may further include steps of measuring an N+1th dresser height when the dresser is pressurizing the polishing pad with the first dressing load, measuring an N+2th dresser height when the dresser is pressurizing the polishing pad with a second dressing load differing from the first dressing load, and updating the correction amount based on a difference between the N+2th dresser height and the N+1th dresser height.

According to the embodiment, a change in abrasion loss of the polishing pad from a time of measuring the N+1th dresser height to a time of measuring the N+2th dresser height may be substantially zero.

According to the embodiment, the step of calculating a correction amount for the

dresser height may be a step of calculating a correction amount for the dresser height using a relational expression expressing a relationship between the amount of change in dressing load and an amount of change in dresser height.

The embodiment may further include a step of calculating an abrasion loss of the polishing pad by subtracting the current dresser height being corrected from the reference dresser height.

[0013] According to another embodiment, there is provided a polishing system including at least one polishing apparatus that polishes a substrate, and a polishing pad height monitoring part that is connected to the polishing apparatus. The polishing apparatus includes a polishing table which supports a polishing pad, a polishing head which pressurizes the substrate onto a polishing surface of the polishing pad, a dresser which dresses the polishing surface of the polishing pad, and a displacement sensor which measures a dresser height. The polishing pad height monitoring part includes a correction amount calculation part which calculates a correction amount for the dresser height corresponding to an amount of change in dressing load, and a dresser height correction part which corrects the dresser height measured by the displacement sensor using the correction amount.

[0014] According to the embodiment, the correction amount calculation part may be configured to calculate the correction amount that is a difference between an Nth dresser height and an N-1th dresser height. The N-1th dresser height may be a height of a dressing surface of the dresser when the polishing surface of the polishing pad is being pressed with a reference dressing load. The Nth dresser height may be a height of the dressing surface of the dresser when the polishing surface of the polishing pad is being pressurized with a first dressing load differing from the reference dressing load.

According to the embodiment, the correction amount calculation part may store a relational expression expressing a relationship between the amount of change in dressing load and an amount of change in dresser height.

[0015] According to the disclosure, a dresser height is corrected in a direction in which a change in dressing load is canceled. Therefore, a corrected dresser height can express an accurate current polishing pad height. Accordingly, the accuracy of monitoring an abrasion loss of a polishing pad is improved, and therefore the accuracy of controlling a position for lowering a polishing head and the accuracy of controlling a polishing profile of a substrate can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. 1 is a schematic view illustrating an embodiment of a polishing system.

FIG. 2 is a flowchart showing an embodiment of a method for determining a polishing
5 pad height.

FIG. 3 is a flowchart showing the embodiment of the method for determining a
polishing pad height.

FIG. 4 is a schematic view illustrating another embodiment of the polishing system.

FIG. 5 is a schematic view illustrating still another embodiment of the polishing
10 system.

DESCRIPTION OF THE EMBODIMENTS

[0017] Hereinafter, embodiments of the disclosure will be described with reference to the drawings. FIG. 1 is a schematic view illustrating an embodiment of a polishing system. As
15 illustrated in FIG. 1, the polishing system includes a polishing apparatus 1 for polishing a substrate such as a wafer. This polishing apparatus 1 includes a polishing table 12 supporting a polishing pad 22, a polishing head oscillation arm 16 connected to the upper end of the swivel shaft 14, a polishing head shaft 18 attached to a free end of the polishing head oscillation arm 16, a polishing head 20 connected to the lower end of the polishing head shaft 18, and an operation
20 control part 47. The operation control part 47 has a storage part 47a storing data and a program, and a computation processing part 47b executing computation in accordance with the program. The operation control part 47 operates in accordance with the program stored in the storage part 47a. A dedicated computer or a general-purpose computer can be used as the operation control part 47.

25 [0018] The polishing head shaft 18 is connected to a polishing head rotating motor (not illustrated) disposed inside the polishing head oscillation arm 16, and the polishing head shaft 18 is rotated by the polishing head rotating motor. Due to rotation of this polishing head shaft 18, the polishing head 20 rotates about the polishing head shaft 18 in a direction indicated by an arrow.

30 [0019] The polishing table 12 is connected to a table rotating motor 70 disposed therebelow via a table shaft 12a. The polishing table 12 is rotated by this table rotating motor 70 about the table shaft 12a in a direction indicated by an arrow. The polishing pad 22 is pasted to the upper

surface of this polishing table 12. The upper surface of the polishing pad 22 constitutes a polishing surface 22a for polishing a substrate W such as a wafer.

[0020] The polishing head shaft 18 can move upward and downward relative to the polishing head oscillation arm 16 by a lifting/lowering mechanism 24, and the polishing head 20 can move upward and downward relative to the polishing head oscillation arm 16 when this polishing head shaft 18 moves upward and downward. A rotary joint 25 is attached to the upper end of the polishing head shaft 18.

[0021] The polishing head 20 is configured to be able to hold the substrate W such as a wafer on its lower surface. The polishing head oscillation arm 16 is configured to be able to swivel about the swivel shaft 14, and the polishing head 20 holding the substrate W on the lower surface moves between a position (not illustrated) for receiving the substrate W and a position above the polishing table 12 when the polishing head oscillation arm 16 swivels.

[0022] The lifting/lowering mechanism 24 lifting and lowering the polishing head shaft 18 and the polishing head 20 includes a bearing 26 rotatably supporting the polishing head shaft 18, a bridge 28 having the bearing 26 fixed thereto, a ball screw mechanism 32 attached to the bridge 28, a support base 29 supported by struts 30, and a servo motor 38 fixed to the support base 29. The support base 29 supporting the servo motor 38 is connected to the polishing head oscillation arm 16 via the struts 30.

[0023] The ball screw mechanism 32 includes a screw shaft 32a connected to the servo motor 38, and a nut 32b into which this screw shaft 32a is screwed. The nut 32b is fixed to the bridge 28. The polishing head shaft 18 is lifted and lowered (moved upward and downward) integrally with the bridge 28. Therefore, when the servo motor 38 is driven, the bridge 28 moves upward and downward via the ball screw mechanism 32, and therefore the polishing head shaft 18 and the polishing head 20 move upward and downward.

[0024] The substrate W is polished as follows. While the polishing head 20 and the polishing table 12 are respectively rotated, a slurry is supplied onto the polishing pad 22 from a slurry supply nozzle (not illustrated) provided above the polishing table 12. The polishing head 20 is lowered to a predetermined polishing position by the lifting/lowering mechanism 24. Moreover, the polishing head 20 pressurizes the substrate W onto the polishing surface 22a of the polishing pad 22 at the polishing position. In a state where the slurry is present on the polishing surface 22a of the polishing pad 22, the substrate W is brought into sliding contact with the polishing surface 22a of the polishing pad 22. The front surface of the substrate W is

polished by means of a combination of chemical action by chemical components of the slurry and mechanical action by abrasive grains contained in the slurry.

[0025] When polishing of a substrate ends, the polished substrate is detached from the polishing head 20. The polishing head 20 holds a new substrate, and the new substrate is polished in a similar manner. In this manner, polishing of a substrate is repetitively performed, and a plurality of substrates are polished using one polishing pad 22. The polishing pad 22 is used until its abrasion loss reaches a threshold value set in advance. When the abrasion loss of the polishing pad 22 reaches the threshold value, the polishing pad 22 is replaced with a new polishing pad.

[0026] The servo motor 38 is connected to a motor driver 48. The motor driver 48 controls a rotation angle and a rotation frequency of the servo motor 38. The servo motor 38 is connected to the ball screw mechanism 32, and the ball screw mechanism 32 is connected to the polishing head 20 via the bridge 28 and the polishing head shaft 18. Therefore, the height (that is, the position in a vertical direction) of the polishing head 20 is determined based on the rotation angle and the rotation frequency of the servo motor 38. The motor driver 48 is configured to be connected to the operation control part 47 and to send the rotation angle and the rotation frequency of the servo motor 38 to the operation control part 47. The operation control part 47 is configured to calculate the height (that is, the position in the vertical direction) of the polishing head 20 from the rotation angle and the rotation frequency of the servo motor 38.

[0027] The polishing apparatus 1 includes a dressing part 40 which dresses the polishing surface 22a of the polishing pad 22. This dressing part 40 includes a dresser 50 brought into sliding contact with the polishing surface 22a of the polishing pad 22, a dresser shaft 51 having the dresser 50 connected thereto, an air cylinder 53 provided at the upper end of the dresser shaft 51, and a dresser oscillation arm 55 rotatably supporting the dresser shaft 51. The lower surface of the dresser 50 constitutes a dressing surface 50a, and this dressing surface 50a is configured to include abrasive grains (for example, diamond particles). The air cylinder 53 is disposed on a support base 57 supported by struts 56, and these struts 56 are fixed to the dresser oscillation arm 55.

[0028] When a motor (not illustrated) connected to a swivel shaft 58 is driven, the dresser oscillation arm 55 swivels about the swivel shaft 58. The dresser shaft 51 rotates in accordance with driving of a dresser motor (not illustrated) disposed inside the dresser oscillation arm 55, and the dresser 50 rotates about the dresser shaft 51 in a direction indicated by an arrow in

accordance with rotation of this dresser shaft 51. The air cylinder 53 is connected to the dresser 50 via the dresser shaft 51. The air cylinder 53 causes the dresser shaft 51 and the dresser 50 to integrally move upward and downward and pressurizes the dressing surface 50a of the dresser 50 onto the polishing surface 22a of the polishing pad 22 with a predetermined pressurizing force.

5 In this specification, a load applied to the polishing surface 22a of the polishing pad 22 from the dresser 50 when the dresser 50 is pressurizing the polishing pad 22 is defined as a dressing load.

[0029] The polishing surface 22a of the polishing pad 22 is dressed as follows. While the polishing pad 22 is rotated by the table rotating motor 70 together with the polishing table 12, pure water is supplied to the polishing surface 22a from a pure water supply nozzle (not
10 illustrated). While the dresser 50 rotates about the dresser shaft 51, the dressing surface 50a of the dresser 50 is pressurized onto the polishing surface 22a by the air cylinder 53. In a state where pure water is present on the polishing surface 22a, the dresser 50 is brought into sliding contact with the polishing surface 22a. While the dresser 50 rotates, the dresser 50 is moved in a radial direction of the polishing surface 22a by causing the dresser oscillation arm 55 to swivel
15 about the swivel shaft 58. In this manner, the polishing pad 22 is ground off by the dresser 50, and the polishing surface 22a is dressed (regenerated). The polishing surface 22a of the polishing pad 22 is dressed every time one substrate is polished.

[0030] The dressing part 40 further includes a displacement sensor 60 measuring the height (that is, the position of the dresser 50 in the vertical direction) of the dresser 50, a target plate 61,
20 and a sensor holder 63. The sensor holder 63 is fixed to the dresser shaft 51, and the sensor holder 63 moves upward and downward integrally with the dresser shaft 51 and the dresser 50. The displacement sensor 60 is fixed to the sensor holder 63. The target plate 61 is fixed to the dresser oscillation arm 55, and the height of the target plate 61 is unchangeable. The displacement sensor 60 moves upward and downward integrally with the dresser shaft 51, the
25 dresser 50, and the sensor holder 63.

[0031] A displacement of the displacement sensor 60 with respect to the target plate 61 is measured by the displacement sensor 60. The displacement sensor 60 can indirectly measure the height of the dresser 50 by measuring a displacement of the displacement sensor 60 with respect to the target plate 61. In this specification, the height of the dressing surface 50a of the
30 dresser 50 from a certain original position when the dresser 50 is pressurizing the polishing surface 22a of the polishing pad 22 is defined as a dresser height.

[0032] In the present embodiment, a contact-type displacement sensor which comes into

contact with the target plate 61 is used as the displacement sensor 60. However, a non-contact-type displacement sensor which does not come into contact with the target plate 61 may be used. Specifically, a linear scale, a laser sensor, an ultrasound sensor, an eddy current-type sensor, or the like can be used as the displacement sensor 60.

5 **[0033]** As polishing of a substrate and dressing of the polishing pad 22 are repetitively performed, the polishing pad 22 gradually wears. In the present embodiment, the polishing system further includes a polishing pad height monitoring part 80 monitoring the height of the polishing surface 22a of the polishing pad 22 (which will hereinafter be referred to as a polishing pad height). This polishing pad height is measured by the displacement sensor 60 when the
10 dressing surface 50a of the dresser 50 is pressurizing the polishing surface 22a of the polishing pad 22. As described above, the height of the dressing surface 50a of the dresser 50 when the dresser 50 is pressurizing the polishing surface 22a of the polishing pad 22 is defined as a dresser height. Thus, the polishing pad height corresponds to the dresser height.

[0034] The polishing pad height monitoring part 80 is connected to the polishing apparatus 1.

15 More specifically, the displacement sensor 60 and the operation control part 47 are electrically connected to the polishing pad height monitoring part 80. The displacement sensor 60 may be connected to the polishing pad height monitoring part 80 via the operation control part 47. The polishing pad height monitoring part 80 may be an edge server connected to the polishing apparatus 1 through a communication line, may be a cloud server connected to the polishing
20 apparatus 1 through a network such as the internet, or a fog computing device (a gateway, a fog server, a router, or the like) installed in a network connected to the polishing apparatus 1. The polishing pad height monitoring part 80 may be a plurality of servers connected through a network such as the internet. For example, the polishing pad height monitoring part 80 may be a combination of an edge server and a cloud server.

25 **[0035]** The polishing pad height monitoring part 80 includes a correction amount calculation part 83 calculating a correction amount for the dresser height corresponding to an amount of change in dressing load, a dresser height correction part 85 correcting the dresser height using the correction amount, and a pad abrasion loss calculation part 86 calculating an abrasion loss of a polishing pad based on a reference dresser height (which will be described below) and a
30 corrected dresser height.

[0036] Hereinafter, a method for determining a polishing pad height will be described. In this specification, a load applied to the polishing surface 22a of the polishing pad 22 from the

dresser 50 when the dresser 50 is pressurizing an unused polishing pad 22 is defined as a reference dressing load, and the height of the dressing surface 50a of the dresser 50 from a certain original position when the dresser 50 is pressurizing the polishing surface 22a of an unused polishing pad 22 is defined as a reference dresser height. The abrasion loss of the polishing pad 22 corresponds to an amount of change in dresser height from the reference dresser height under a condition of the same dressing load.

[0037] FIGS. 2 and 3 are a flowchart showing the embodiment of the method for determining a polishing pad height. In Step 1, while the polishing surface 22a of an unused polishing pad 22 which has not been used for polishing a substrate is dressed by the dresser 50 with the reference dressing load, the dresser height is measured by the displacement sensor 60. In the following description, the dresser height obtained in Step 1 will be referred to as a reference dresser height.

[0038] In Step 2, the substrate is polished on the polishing pad 22 dressed in Step 1. In Step 3, while the polishing surface 22a of the polishing pad 22 is dressed by the dresser 50 with the reference dressing load after the substrate is polished, the dresser height is measured by the displacement sensor 60. Steps 2 and 3 are performed at least $k-1$ times (k is a natural number equal to or larger than 1). When k is 1, Steps 2 and 3 are not performed.

[0039] In Step 4, the dressing load applied to the polishing pad 22 is changed to a first dressing load from the reference dressing load. After a k th substrate is polished, the polishing surface 22a of the polishing pad 22 is dressed by the dresser 50 with the first dressing load, and a current dresser height is measured by the displacement sensor 60.

[0040] When the dressing load is changed from the reference dressing load, an amount of pushing the polishing pad 22 by the dresser 50 is changed. As a result, a correct abrasion loss of the polishing pad 22 cannot be calculated. Therefore, in Step 5, in order to cancel the change in dresser height caused by the change in dressing load, the correction amount for the dresser height corresponding to the amount of change in dressing load is calculated.

[0041] Hereinafter, details of Step 5 will be described.

(i) When k is 1

When k is 1, after a first substrate is polished, the polishing surface 22a of the polishing pad 22 is dressed by the dresser 50 with the first dressing load differing from the reference dressing load, and an N th dresser height is measured by the displacement sensor 60. The correction amount calculation part 83 calculates the correction amount for the dresser height as

the difference between the Nth dresser height and the reference dresser height. More specifically, the correction amount calculation part 83 calculates the correction amount for the dresser height by subtracting the reference dresser height from the Nth dresser height. In the embodiment, the correction amount calculation part 83 may calculate the correction amount for the dresser height by subtracting the Nth dresser height from the reference dresser height.

[0042] In this case (i), the reference dresser height is an N-1th dresser height. The N-1th dresser height is a dresser height when the dresser 50 is pressurizing the polishing pad 22 with the reference dressing load and is measured prior to the Nth dresser height. The characters N-1, N, N+1, N+2, and so on are characters irrelevant to the number of substrates.

[0043] In the present embodiment, the polishing surface 22a of the polishing pad 22 is dressed every time one substrate is polished. As polishing of a substrate and dressing of the polishing pad 22 are repetitively performed, the polishing pad 22 gradually wears. However, the abrasion loss of the polishing pad 22 in one dressing is insignificant to the extent that the change in abrasion loss of the polishing pad 22 can be disregarded. In this specification, when the change in abrasion loss of the polishing pad 22 is less than an upper limit value (for example, less than 1 μm) set in advance, the change in abrasion loss of the polishing pad 22 is substantially regarded as zero.

[0044] In the case (i) described above, the Nth dresser height is a dresser height when the polishing pad 22 is dressed after the first substrate is polished. The change in abrasion loss of the polishing pad 22 during a period from measurement of the reference dresser height to measurement of the Nth dresser height is substantially zero. In the embodiment, as long as the change in abrasion loss of the polishing pad 22 during a period from measurement of the reference dresser height to measurement of the Nth dresser height is substantially zero, the dresser height when the polishing pad 22 is dressed after a $1+\alpha$ th substrate (α is a natural number equal to or larger than 1) is polished may be adopted as the Nth dresser height.

[0045] (ii) When k is a natural number other than 1

When k is a natural number other than 1, before the kth substrate is polished, the polishing pad 22 is dressed with the reference dressing load. After the kth substrate is polished, the polishing pad 22 is dressed with the first dressing load differing from the reference dressing load. More specifically, after a k-1th substrate is polished, the polishing surface 22a of the polishing pad 22 is dressed by the dresser 50 with the reference dressing load, and the N-1th dresser height is measured by the displacement sensor 60. After the kth substrate is polished,

the polishing surface 22a of the polishing pad 22 is dressed by the dresser 50 with the first dressing load, and the Nth dresser height is measured by the displacement sensor 60.

[0046] The correction amount calculation part 83 calculates the correction amount for the dresser height as the difference between the Nth dresser height and the N-1th dresser height.

5 More specifically, the correction amount calculation part 83 calculates the correction amount for the dresser height by subtracting the N-1th dresser height from the Nth dresser height. In the embodiment, the correction amount calculation part 83 may calculate the correction amount for the dresser height by subtracting the Nth dresser height from the N-1th dresser height.

[0047] The change in abrasion loss of the polishing pad 22 during a period from measurement
10 of the N-1th dresser height to measurement of the Nth dresser height is substantially zero. In the embodiment, as long as the change in abrasion loss of the polishing pad 22 during a period from measurement of the N-1th dresser height to measurement of the Nth dresser height is substantially zero, the dresser height when the polishing pad 22 is dressed after a $k+\alpha$ th substrate (α is a natural number equal to or larger than 1) is polished may be adopted as the Nth dresser
15 height.

[0048] After the correction amount for the dresser height is calculated, polishing of a new substrate and dressing of the polishing pad 22 are repetitively performed. In Step 6, after the substrate is polished, the polishing surface 22a of the polishing pad 22 is dressed by the dresser 50 with the first dressing load, and the current dresser height is measured by the displacement
20 sensor 60.

[0049] In Step 7, the current dresser height measured in Step 6 is corrected based on the correction amount calculated in Step 5. Specifically, the dresser height correction part 85 corrects the current dresser height by subtracting the correction amount from the current dresser height. In the embodiment, the dresser height correction part 85 corrects the current dresser
25 height by adding the correction amount to the current dresser height.

[0050] The corrected current dresser height obtained in this manner corresponds to a current polishing pad height. According to the present embodiment, the current dresser height is corrected in a direction in which the change in dressing load is canceled. Therefore, a corrected current dresser height can express an accurate current polishing pad height. Accordingly, the
30 accuracy of monitoring an abrasion loss of a polishing pad is improved, and therefore the accuracy of controlling a position for lowering the polishing head 20 and the accuracy of controlling a polishing profile of a substrate can be improved.

[0051] In Step 8, the pad abrasion loss calculation part 86 calculates the abrasion loss of the polishing pad 22 by subtracting the corrected current dresser height obtained in Step 7 from the reference dresser height.

[0052] Thereafter, polishing of a new substrate and dressing of the polishing pad 22 are repetitively performed. The following is steps when the dressing load is further changed to a second dressing load from the first dressing load after a plurality of new substrates are polished. In the embodiment described below, before an mth substrate is polished, the polishing pad 22 is dressed with the first dressing load, and after the mth substrate is polished, the polishing pad 22 is dressed with the second dressing load differing from the first dressing load.

[0053] In Step 9, after an m-1th substrate is polished, the polishing surface 22a of the polishing pad 22 is dressed by the dresser 50 with the first dressing load, and an N+1th dresser height is measured by the displacement sensor 60.

In Step 10, after the mth substrate is polished, the polishing surface 22a of the polishing pad 22 is dressed by the dresser 50 with the second dressing load differing from the first dressing load, and an N+2th dresser height is measured by the displacement sensor 60.

[0054] The change in abrasion loss of the polishing pad 22 from a time of measuring the N+1th dresser height to a time of measuring the N+2th dresser height is substantially zero. On the other hand, since the second dressing load differs from the first dressing load, the amount of pushing the polishing pad 22 by the dresser 50 when the N+2th dresser height is being measured changes. Therefore, the N+2th dresser height differs from the N+1th dresser height.

[0055] In Step 11, the correction amount calculation part 83 updates the correction amount based on the difference between the N+2th dresser height and the N+1th dresser height. More specifically, the correction amount calculation part 83 updates the correction amount by adding the value obtained by subtracting the N+1th dresser height from the N+2th dresser height to the correction amount calculated in Step 5. In the embodiment, the correction amount calculation part 83 may update the correction amount by subtracting the value, which is obtained by subtracting the N+2th dresser height from the N+1th dresser height, from the correction amount calculated in Step 5, or by adding the value to the correction amount calculated in Step 5. The difference between the N+2th dresser height and the N+1th dresser height is equivalent to the difference between the amounts of pushing the polishing pad 22.

[0056] In the embodiment, as long as the change in abrasion loss of the polishing pad 22 from a time of measuring the N+1th dresser height to a time of measuring the N+2th dresser height is

substantially zero, the dresser height at the time of dressing after a $m+\alpha$ th substrate (α is a natural number equal to or larger than 1) is polished may be adopted as the $N+2$ th dresser height.

[0057] Thereafter, polishing of a new substrate and dressing of the polishing pad 22 are repetitively performed. In Step 12, after the substrate is polished, the polishing surface 22a of the polishing pad 22 is dressed by the dresser 50 with the second dressing load, and the current dresser height is measured by the displacement sensor 60.

[0058] In Step 13, the current dresser height measured in Step 12 is corrected based on the updated correction amount obtained in Step 10. Specifically, the dresser height correction part 85 corrects the current dresser height by subtracting the updated correction amount from the current dresser height. In the embodiment, the dresser height correction part 85 corrects the current dresser height by adding the correction amount to the current dresser height. The corrected current dresser height obtained in this manner corresponds to the current polishing pad height.

In Step 14, the pad abrasion loss calculation part 86 calculates the abrasion loss of the polishing pad 22 by subtracting the corrected current dresser height obtained in Step 13 from the reference dresser height.

[0059] Thereafter, polishing of a new substrate and dressing of the polishing pad 22 are repetitively performed. Even when the dressing load is further changed, the current dresser height corrected through steps similar to Steps 9 to 13, that is, the current polishing pad height can be determined.

[0060] FIG. 4 is a schematic view illustrating another embodiment of the polishing system. Since configurations and operations which are not particularly described in the present embodiment are the same as those in the embodiment which has been described with reference to FIGS. 1 to 3, duplicate description thereof will be omitted. The polishing pad height monitoring part 80 of the present embodiment further includes a data accumulation part 87 and a relational expression determination part 91.

[0061] The data accumulation part 87 accumulates data such as measurement values of dresser heights measured by the displacement sensor 60, and the dressing loads set in advance. The relational expression determination part 91 receives the accumulated data from the data accumulation part 87 and obtains a relational expression expressing the relationship between the amount of change in dressing load and the amount of change in dresser height based on the amount of change in plurality of dressing loads and the amount of change in plurality of dresser

heights corresponding to the amount of change in plurality of dressing loads. For example, a regression equation is determined by plotting a plurality of data points determined from the amounts of change in plurality of dressing loads and corresponding amounts of change in plurality of dresser heights on a coordinate system having the vertical axis indicating the amount of change in dressing load and the horizontal axis indicating the amount of change in dresser height, and performing regression analysis with respect to the plurality of data points. This regression equation is a relational expression expressing the relationship between the amount of change in dressing load and the amount of change in dresser height.

[0062] The relational expression determined by the relational expression determination part 91 is sent to the correction amount calculation part 83 and is stored in the correction amount calculation part 83. The correction amount calculation part 83 can calculate the correction amount for the dresser height corresponding to the amount of change in dressing load from the relational expression described above. The dresser height correction part 85 corrects the dresser height based on the correction amount calculated by the relational expression described above.

[0063] FIG. 5 is a schematic view illustrating still another embodiment of the polishing system. The polishing system of the present embodiment includes a plurality of polishing apparatuses 1 and the polishing pad height monitoring part 80 which has been described with reference to FIG. 1 or 4. Since configurations of the polishing system which are not particularly described in the present embodiment are the same as those in the embodiment which has been described with reference to FIG. 1 or 4, duplicate description thereof will be omitted. The polishing pad height monitoring part 80 is connected to the plurality of polishing apparatuses 1 via a network such as the internet. In the embodiment, the polishing system may include one polishing apparatus 1.

[0064] The polishing system of the present embodiment can correct the dresser heights of the plurality of polishing apparatuses 1 using one polishing pad height monitoring part 80. The dresser height can be corrected by a method similar to the method in the embodiment which has been described with reference to FIGS. 2 and 3, or the method in the embodiment which has been described with reference to FIG. 4. The data accumulation part 87 illustrated in FIG. 4 can accumulate pieces of data including the dresser heights of the plurality of polishing apparatuses 1 and the dressing loads of the plurality of polishing apparatuses 1, and the relational expression determination part 91 can obtain the relational expression between the amount of change in dressing load and the amount of change in dresser height based on the amount of

change in plurality of dresser heights corresponding to the amount of change in plurality of dressing loads. Since the relational expression determination part 91 can obtain the foregoing relational expression based on more pieces of data, the polishing system of the present embodiment can improve the accuracy of calculating the correction amount for the dresser height corresponding to the amount of change in dressing load.

[0065] According to the embodiments described above, the correction amount for the dresser height corresponding to the amount of change in dressing load is calculated, and the dresser height is corrected based on the correction amount. Therefore, a corrected dresser height can express an accurate current polishing pad height. Accordingly, the accuracy of monitoring an abrasion loss of a polishing pad is improved, and therefore the accuracy of controlling a position for lowering a polishing head and the accuracy of controlling a polishing profile of a substrate can be improved.

[0066] The embodiments described above are disclosed to allow persons having general knowledge in the technical field where the disclosure belongs to perform the disclosure.

Various modification examples of the foregoing embodiments can be naturally performed by those skilled in the art, and the technical idea of the disclosure can also apply to another embodiment. Therefore, the disclosure is not limited to the disclosed embodiments and is to be interpreted within a widest scope in accordance with the technical idea defined by the claims

Reference Signs List

- [0067]** 1 Polishing apparatus
 - 12 Polishing table
 - 12a Table shaft
 - 14 Swivel shaft
 - 16 Polishing head oscillation arm
 - 18 Polishing head shaft
 - 20 Polishing head
 - 22 Polishing pad
 - 22a Polishing surface
 - 24 Lifting/lowering mechanism
 - 25 Rotary joint
 - 26 Bearing
 - 28 Bridge

	29 Support base
	30 Strut
	32 Ball screw mechanism
	32a Screw shaft
5	32b Nut
	38 Servo motor
	40 Dressing part
	47 Operation control part
	48 Motor cylinder
10	50 Dresser
	50a Dressing surface
	51 Dresser shaft
	53 Air cylinder
	55 Dresser oscillation arm
15	56 Strut
	57 Support base
	58 Swivel shaft
	60 Displacement sensor
	61 Target plate
20	63 Sensor holder
	70 Table rotating motor
	80 Polishing pad height monitoring part
	83 Correction amount calculation part
	85 Dresser height correction part
25	86 Pad abrasion loss calculation part
	87 Data accumulation part
	91 Relational expression determination part

CLAIMS

WHAT IS CLAIMED IS:

1. A method for determining a polishing pad height in a polishing apparatus including a polishing table which supports a polishing pad, a polishing head which pressurizes a substrate onto a polishing surface of the polishing pad, and a dresser which dresses the polishing surface of the polishing pad, the method for determining a polishing pad height comprising:
 - a step of measuring a reference dresser height that is a height of a dressing surface of the dresser when the polishing surface of the polishing pad in an unused state is being pressed with a reference dressing load for polishing the substrate;
 - a step of calculating a correction amount for a dresser height corresponding to an amount of change in dressing load from the reference dressing load;
 - a step of measuring a current dresser height that is a current height of the dressing surface of the dresser when the polishing surface of the polishing pad is being pressed; and
 - a step of correcting the current dresser height using the correction amount.
2. The method for determining a polishing pad height according to claim 1, wherein the step of calculating a correction amount for the dresser height includes steps of measuring an Nth dresser height when the dresser is pressurizing the polishing pad with a first dressing load differing from the reference dressing load, and calculating the correction amount that is a difference between the Nth dresser height and an N-1th dresser height, and wherein the N-1th dresser height is the height of the dressing surface of the dresser when the polishing surface of the polishing pad is being pressed with the reference dressing load, and is measured prior to the Nth dresser height.
3. The method for determining a polishing pad height according to claim 2, wherein a change in abrasion loss of the polishing pad from a time of measuring the N-1th dresser height to a time of measuring the Nth dresser height is substantially zero.
4. The method for determining a polishing pad height according to claim 2 or 3, wherein the N-1th dresser height is the reference dresser height.
5. The method for determining a polishing pad height according to any one of claims 2 to 4,

wherein the step of calculating a correction amount for the dresser height further includes steps of

measuring an N+1th dresser height when the dresser is pressurizing the polishing pad with the first dressing load,

5 measuring an N+2th dresser height when the dresser is pressurizing the polishing pad with a second dressing load differing from the first dressing load, and

 updating the correction amount based on a difference between the N+2th dresser height and the N+1th dresser height.

10 6. The method for determining a polishing pad height according to claim 5,

 wherein a change in abrasion loss of the polishing pad from a time of measuring the N+1th dresser height to a time of measuring the N+2th dresser height is substantially zero.

 7. The method for determining a polishing pad height according to claim 1,

15 wherein the step of calculating a correction amount for the dresser height is a step of calculating a correction amount for the dresser height using a relational expression expressing a relationship between the amount of change in dressing load and an amount of change in dresser height.

20 8. The method for determining a polishing pad height according to any one of claims 1 to 7, further comprising:

 a step of calculating an abrasion loss of the polishing pad by subtracting the current dresser height being corrected from the reference dresser height.

25 9. A polishing system comprising:

 at least one polishing apparatus that polishes a substrate; and

 a polishing pad height monitoring part that is connected to the polishing apparatus,

 wherein the polishing apparatus includes

 a polishing table which supports a polishing pad,

30 a polishing head which pressurizes the substrate onto a polishing surface of the polishing pad,

 a dresser which dresses the polishing surface of the polishing pad, and

a displacement sensor which measures a dresser height, and
wherein the polishing pad height monitoring part includes
a correction amount calculation part which calculates a correction amount for the dresser
height corresponding to an amount of change in dressing load, and
5 a dresser height correction part which corrects the dresser height measured by the
displacement sensor using the correction amount.

10. The polishing system according to claim 9,
wherein the correction amount calculation part is configured to calculate the correction
10 amount that is a difference between an Nth dresser height and an N-1th dresser height,
wherein the N-1th dresser height is a height of a dressing surface of the dresser when the
polishing surface of the polishing pad is being pressed with a reference dressing load, and
wherein the Nth dresser height is a height of the dressing surface of the dresser when the
polishing surface of the polishing pad is being pressurized with a first dressing load differing
15 from the reference dressing load.

11. The polishing system according to claim 9,
wherein the correction amount calculation part stores a relational expression expressing a
relationship between the amount of change in dressing load and an amount of change in dresser
20 height.