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Semiconductor manufacturing apparatus for improved uniformity of semiconductor coating with transfer arm and position detector working in combination

Abstract

A semiconductor manufacturing apparatus includes a substrate storage unit configured to store a semiconductor wafer W, a substrate processing unit including a rotation holding unit configured to rotate the semiconductor wafer W while holding the semiconductor wafer W, and a coating liquid supply unit configured to supply a coating liquid onto the semiconductor wafer W, a substrate transfer unit including a transfer arm configured to take out the semiconductor wafer W and transfer the semiconductor water W to the rotation holding unit, and a moving mechanism configured to move the transfer arm, and a position detection unit configured to detect the position of the transfer arm. The moving mechanism moves the transfer arm onto the rotation holding unit while correcting the position of the transfer arm based on the position detection result of the transfer arm by the position detection unit.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION
(1) This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2020-168342, filed Oct. 5, 2020, the entire contents of which are incorporated herein by reference.
FIELD
(2) Embodiments described herein relate generally to a semiconductor manufacturing apparatus.
BACKGROUND
(3) In the semiconductor device manufacturing process, a process of applying a coating liquid such as a resist liquid onto a semiconductor wafer is performed. The device for applying the coating liquid includes, for example, a wafer carrier (Front Opening Unify Pod: FOUP) that stores the semiconductor wafer, a coating unit including a spin chuck that rotates and holds the semiconductor wafer, and a nozzle that discharges the coating liquid to be applied onto the semiconductor wafer, and a transfer mechanism including a transfer arm that conveys the semiconductor wafer taken out from the wafer carrier to the coating unit. There is a process of applying the coating liquid only to the outer peripheral portion of the semiconductor wafer by using the coating device. In such a coating process, the coating width of the coating film coated on the outer peripheral portion of the semiconductor wafer may become non-uniform.

Description

DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a plan view showing a schematic configuration of a coating device according to a first embodiment;
(2) FIG. **2** is a diagram showing a substrate processing unit of the coating device shown in FIG. **1**;
(3) FIG. **3** is a plan view showing a transfer arm and the substrate processing unit of the coating device shown in FIG. **1**;
(4) FIG. **4** is a diagram showing the transfer arm and the substrate processing unit of the coating device shown in FIG. **1**;
(5) FIG. **5** is a plan view showing the transfer arm and a first process of position detection of the

transfer arm by the substrate processing unit shown in FIG. **3**;
(6) FIG. **6** is a diagram showing the transfer arm and the first process of position detection of the transfer arm by the substrate processing unit shown in FIG. **4**;
(7) FIG. **7** is a plan view showing the transfer arm and a second process of position detection of the transfer arm by the substrate processing unit shown in FIG. **3**;
(8) FIG. **8** is a diagram showing the transfer arm and the second process of position detection of the transfer arm by the substrate processing unit shown in FIG. **4**;
(9) FIGS. **9**A and **9**B are diagrams showing a relationship between the transfer arm and the substrate processing unit after the process of position detection of the transfer arm shown in FIG. **8**;
(10) FIG. **10** is a diagram showing a transfer arm and a substrate processing unit of a coating device of a second embodiment;
(11) FIG. **11** is a diagram showing the transfer arm and a first process of position detection of the transfer arm by the substrate processing unit shown in FIG. **10**;
(12) FIG. **12** is a diagram showing the transfer arm and a second process of position detection of the transfer arm by the substrate processing unit shown in FIG. **10**; and
(13) FIGS. **13**A and **13**B are diagrams showing a relationship between the transfer arm and the substrate processing unit after the process of detecting the position of the transfer arm shown in FIG. **12**.

DETAILED DESCRIPTION

(14) Embodiments provide a semiconductor manufacturing apparatus capable of improving the uniformity of the coating width of the coating liquid.
(15) In general, according to at least one embodiment, the semiconductor manufacturing apparatus includes a substrate storage unit (storage) including a storage container configured to store a semiconductor wafer; a substrate processing unit (processor) including a rotation holding unit (holder) configured to rotate the semiconductor wafer while holding the semiconductor wafer and a coating liquid supply unit (liquid supply) configured to supply a coating liquid onto the semiconductor wafer held by the rotation holding unit; a substrate transfer unit (transferor) including a transfer arm configured to takeout the semiconductor wafer from the storage container and transfer the taken out semiconductor wafer to the rotation holding unit and a moving mechanism configured to move the transfer arm from a transfer position of the semiconductor wafer from the storage container to a transfer position of the semiconductor wafer to the rotation holding unit; and a position detection unit (detector) disposed in the vicinity of the rotation holding unit, the position detection unit being configured to detect the position of the transfer arm that holds the semiconductor wafer. In the semiconductor manufacturing apparatus of the embodiment, the moving mechanism is configured to move the transfer arm to the transfer position of the semiconductor wafer to the rotation holding unit while correcting the position of the transfer arm based on the position detection result of the transfer arm by the position detection unit.
(16) Hereinafter, the semiconductor manufacturing apparatus of at least one embodiment will be described with reference to the drawings. In each embodiment, substantially the same parts are designated by the same reference numerals, and some of the descriptions thereof may be omitted. The drawings are schematic, and the relationship between the thickness and the plane dimensions, the ratio of the thickness of each part, and the like may differ from the actual ones.

First Embodiment

(17) FIG. **1** is a plan view showing a schematic configuration of a coating device **1** to which a semiconductor manufacturing apparatus of the first embodiment is applied, and FIG. **2** is a diagram showing a substrate processing unit and a position detection unit of the coating device **1** shown in FIG. **1**. The coating device **1** shown in FIGS. **1** and **2** includes a substrate storage unit **10**, a substrate processing unit **20**, a substrate transfer unit **30**, a position detection unit **40**, and a control unit **50** that controls the operation of the coating device **1**.
(18) The substrate storage unit **10** includes a storage container such as a sealed cassette (FOUP) **11**

in which a plurality of semiconductor wafers W are stored. The substrate storage unit **10** includes a plurality of sealed cassettes **11**, and the semiconductor wafers W taken out from the respective sealed cassettes **11** are sequentially sent to the substrate processing unit **20**, and the coating process with the coating liquid is performed by the substrate processing unit **20**. In FIG. **1**, the arrangement direction of the sealed cassette **11** is defined as the x direction, the direction intersecting the x direction in a plane is defined as the y direction, and the direction intersecting the x direction and the y direction (vertical direction on the paper surface) is defined as the z direction.

(19) The substrate processing unit **20** includes, for example, a plurality of substrate processing modules **21** arranged in the y direction. As shown in FIG. **2**, the substrate processing module **21** includes a rotation holding unit **22** that rotates a semiconductor wafer W while holding the semiconductor wafer W, and a coating liquid supply unit **23** that supplies a coating liquid onto the semiconductor wafer W held by the rotation holding unit **22**. The rotation holding unit **22** includes, for example, a spin chuck **24** that sucks and holds the semiconductor wafer W, a rotation shaft **25** connected to the spin chuck **24**, and a rotation driving unit **26** such as a motor that transmits a rotation driving force to the rotation shaft **25**. As will be described in detail later, a light transmission hole **27** is provided inside the spin chuck **24** and the rotation shaft **25** so that the light emitted from a light emitting unit **41** of the position detection unit **40** can pass through.

(20) The coating liquid supply unit **23** includes a nozzle **28** that discharges the coating liquid onto the semiconductor wafer W held by the rotation holding unit **22**, and a coating liquid supply tank **29** that supplies the coating liquid to the nozzle **28**. When a coating film of the coating liquid is formed only on the outer peripheral portion of the semiconductor wafer W, the installation position of the nozzle **28** is adjusted so that the coating liquid is supplied to the outer peripheral portion of the semiconductor wafer W. Examples of the coating liquid include a resist liquid. However, the coating device **1** of at least one embodiment is not limited to the device used for coating the resist liquid and may be a device for applying a protective film forming liquid or the like. Further, the coating device **1** of at least one embodiment is effectively used when the coating film is formed only on the outer peripheral portion of the semiconductor wafer W but the coating device **1** is not limited thereto.

(21) The substrate transfer unit **30** includes a first substrate transfer module **31** and a second substrate transfer module **32**. The first substrate transfer module **31** includes a first transfer arm **311** that takes out the semiconductor wafer W from the sealed cassette **11**, and a moving mechanism **314** including a mechanism **312** that moves the first transfer arm **311** in the y direction and a mechanism **313** that moves the first transfer arm **311** in the x direction. Although not shown, the moving mechanism **314** may include a mechanism that moves the first transfer arm **311** in the z direction in order to take out the semiconductor wafers W stored in the sealed cassette **11** in multiple stages.

(22) When the semiconductor wafer W is taken out from the sealed cassette **11** by the first transfer arm **311**, the center position of the semiconductor wafer W taken out from the sealed cassette **11** is measured by a substrate measuring mechanism (not shown), and the semiconductor wafer W is moved on the first transfer arm **311** based on the measurement result such that the center position of the semiconductor wafer W coincides with the center of the first transfer arm **311**. The first substrate transfer module **31** may include a substrate table or the like that transfers the semiconductor wafer W to the second substrate transfer module **32**. The first transfer arm **311** moves from the transfer position of the semiconductor wafer W from the sealed cassette **11** to the transfer position of the semiconductor wafer W to the second substrate transfer module **32**.

(23) The second substrate transfer module **32** includes a second transfer arm **321** that transfers the semiconductor wafer W received from the first substrate transfer module **31** to the spin chuck **24** of the substrate processing module **21**, and a moving mechanism **324** including a mechanism **322** that moves the second transfer arm **321** in the x direction and a mechanism **323** that moves the second transfer arm **321** in the y direction. The moving mechanism **324** may include a mechanism that

moves the second transfer arm **321** in the z direction. The second transfer arm **321** moves from the transfer position of the semiconductor wafer W from the first substrate transfer module **31** to the transfer position of the semiconductor wafer W to the spin chuck **24**.

(24) When the semiconductor wafer W is transferred to the spin chuck **24**, the position of the second transfer arm **321** is detected by the position detection unit **40**. In the coating device **1** of the first embodiment, the position detection unit **40** is provided around the spin chuck **24** of the substrate processing module **21**. The position detection unit **40** is disposed in the vicinity of the rotation holding unit **22** and configured to detect the position of the second transfer arm **321** that holds the semiconductor wafer W.

(25) Specifically, as shown in FIGS. **3** and **4**, the position detection unit **40** includes the light transmission hole **27** provided inside the spin chuck **24** and the rotation shaft **25** described above, and first and second openings **325**A and **325**B provided in the second transfer arm **321**, the light emitting unit **41** that irradiates the first and second openings **325**A and **325**B in order with light through the light transmission hole **27**, and a light receiving unit **42** that receives the light passed through the first and second openings **325**A and **325**B. The second transfer arm **321** may be provided with at least one opening. Here, the second transfer arm **321** is provided with two openings **325**A and **325**B. The light receiving unit **42** is provided on a top plate **21***a* of the substrate processing module **21** for convenience.

(26) As described above, when the semiconductor wafer W is taken out from the sealed cassette **11** by the first transfer arm **311**, the center position of the semiconductor wafer W taken out from the sealed cassette **11** is measured by the substrate measuring mechanism. Based on the measurement result, the semiconductor wafer W is transferred such that the center position of the semiconductor wafer W coincides with the center of the first transfer arm **311**. Further, even when the semiconductor wafer W is transferred from the first transfer arm **311** to the second transfer arm **321**, the semiconductor wafer W is transferred such that the center position of the semiconductor wafer W coincides with the center of the second transfer arm **321**. Therefore, if there is no error in the moving mechanisms of the first transfer arm **311** and the second transfer arm **321** and the like, the semiconductor wafer W will be transferred to the center position of the spin chuck **24**.

(27) However, if the moving mechanism such as the moving belts **371** of the first transfer arm **311** and the second transfer arm **321** is worn, the second transfer arm **321** and the spin chuck **24** are misaligned. Even if the second transfer arm **321** is moved so that the center position thereof coincides with the center position of the spin chuck **24**, the semiconductor wafer W may not be able to be transferred to the center position of the spin chuck **24** due to the movement error of the second transfer arm **321**. Further, when the coating film is formed on the entire surface of the semiconductor wafer W, the coating film can be formed approximately uniformly even if the semiconductor wafer W is held by the spin chuck **24** with some eccentricity. However, when the coating film is formed only on the outer peripheral portion of the semiconductor wafer W, if the mounting position of the semiconductor wafer W is eccentric with respect to the spin chuck **24**, a coating film having a uniform coating width cannot be obtained.

(28) Therefore, in the coating device **1** of at least one embodiment, the position of the second transfer arm **321** holding the semiconductor wafer W is detected by the position detection unit **40** immediately before the semiconductor wafer W is transferred to the spin chuck **24**. If there is an error in the position of the second transfer arm **321** and the second transfer arm **321** deviates from the normal position, the second transfer arm **321** is moved with correction based on the detection result by the position detection unit **40**. The movement correction of the second transfer arm **321** is performed by, for example, the control unit **50** of the entire device including the control of the movement mechanism **324** of the second substrate transfer module **32**.

(29) In this way, immediately before transferring the semiconductor wafer W to the spin chuck **24**, the position of the second transfer arm **321** is detected and the movement of the second transfer arm **321** is corrected based on the detection result. Therefore, even if the moving mechanism such

as the moving belts **371** of the first transfer arm **311** and the second transfer arm **321** is worn, the semiconductor wafer W can be transferred to the center position of the spin chuck **24**. Even when the coating film is formed only on the outer peripheral portion of the semiconductor wafer W, a coating film having a uniform coating width can be obtained.

(30) The process of detecting the position of the second transfer arm **321** described above by the position detection unit **40** will be described with reference to FIGS. **5** to **8**. In the coating device **1** of the first embodiment, the light emitting unit **41** and the light receiving unit **42** of the position detection unit **40** are disposed directly below and directly above the spin chuck **24**. Therefore, as shown in FIGS. **5** and **6**, the second transfer arm **321** passes the position directly above the spin chuck **24** and is moved such that the first opening **325**A reaches directly above the center position of the spin chuck **24**. At this first position, light is emitted from the light emitting unit **41**, and the light that has passed through the first opening **325**A is received by the light receiving unit **42**, thereby measuring the amount of light that has passed through the first opening **325**A (first process).

(31) Next, as shown in FIGS. **7** and **8**, the second transfer arm **321** is moved such that the second opening **325**B reaches directly above the center position of the spin chuck **24**. At this second position, light is emitted from the light emitting unit **41**, and the light that has passed through the second opening **325**B is received by the light receiving unit **42**, thereby measuring the amount of light that has passed through the second opening **325**B (second process). The position of the second transfer arm **321** is obtained from the amount of light at the two points of the first position and the second position. The misalignment of the second transfer arm **321** is detected by comparing with the position of the second transfer arm **321** based on the amount of light between the two preset points.

(32) Since the second transfer arm **321** has once passed the position directly above the spin chuck **24**, as shown in FIG. **9**A, the second transfer arm **321** is retracted so that the center position of the second transfer arm **321** coincides with the center position of the spin chuck **24**. At this time, if the second transfer arm **321** is misaligned, the second transfer arm **321** is moved while correcting the movement of the second transfer arm **321** so that the center position of the second transfer arm **321** coincides with the center position of the spin chuck **24**. As a result, as shown in FIG. **9**B, the semiconductor wafer W can be transferred to the center position of the spin chuck **24**. In FIG. **9**A, the arrow T indicates the moving direction of the second transfer arm **321**.

Second Embodiment

(33) The substrate processing unit **20** and the position detection unit **40** of the coating device **1** of the second embodiment are shown in FIG. **10**. The coating device **1** of the second embodiment has the same configuration as the coating device **1** of the first embodiment except that the arrangement positions of the light emitting unit **41** and the light receiving unit **42** of the position detection unit **40** are different from those of the first embodiment. Although the arrangement positions of the light emitting unit **41** and the light receiving unit **42** are different, the first and second openings **325**A and **325**B of the second transfer arm **321** are the same as those in the first embodiment. The light emitting unit **41** and the light receiving unit **42** in the second embodiment are disposed in front of the spin chuck **24** in the moving path of the second transfer arm **321**.

(34) Therefore, the process of detecting the position of the second transfer arm **321** by the position detection unit **40** is performed as follows, as shown in FIGS. **11** and **12**. In FIG. **10**, the arrow T indicates the moving direction of the second transfer arm **321**. First, as shown in FIG. **11**, the second transfer arm **321** is moved so that the first opening **325**A reaches directly above the light emitting unit **41** before reaching above the spin chuck **24**. At this first position, light is emitted from the light emitting unit **41**, and the light that has passed through the first opening **325**A is received by the light receiving unit **42**, thereby measuring the amount of light that has passed through the first opening **325**A (first process).

(35) Next, as shown in FIG. **12**, the second transfer arm **321** is moved so that the second opening

325B reaches directly above the light emitting unit **41**. At this second position, light is emitted from the light emitting unit **41**, and the light that has passed through the second opening **325**B is received by the light receiving unit **42**, thereby measuring the amount of light that has passed through the second opening **325**B (second process). The position of the second transfer arm **321** is obtained from the amount of light at the two points of the first position and the second position. The misalignment of the second transfer arm **321** is detected by comparing with the position of the second transfer arm **321** based on the amount of light between the two preset points.

(36) Since the position of the second transfer arm **321** is detected in front of the spin chuck **24** (in front of the moving path), as shown in FIG. **13**A, the second transfer arm **321** is advanced so that the center position of the second transfer arm **321** coincides with the center position of the spin chuck **24**. At this time, if the second transfer arm **321** is misaligned, the second transfer arm **321** is moved while correcting the movement of the second transfer arm **321** so that the center position of the second transfer arm **321** coincides with the center position of the spin chuck **24**. As a result, as shown in FIG. **13**B, the semiconductor wafer W can be transferred to the center position of the spin chuck **24**.

(37) The configurations of the above-described embodiments can be applied in combination and can be partially replaced. 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 disclosure. 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 disclosure. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the disclosure.

Claims

1. A semiconductor manufacturing apparatus comprising: a substrate storage including a storage container configured to store a semiconductor wafer; a substrate processor including: a rotation holder configured to rotate the semiconductor wafer while holding the semiconductor wafer, a coating liquid supply configured to supply a coating liquid onto the semiconductor wafer held by the rotation holder; said rotation holder including a spin chuck; a substrate transferor including: a first transfer arm configured to remove the semiconductor wafer from the storage container to a second transfer arm; wherein the second arm includes a first opening and a second opening; the second transfer arm configured to transfer the semiconductor wafer from the first transfer arm to the rotation holder in a moving path; and a position detector configured to: determine a first amount of light at a first position of the second transfer arm at a first preset point, determine a second amount of light at a second position of the second transfer arm at a second preset point, obtain a position of the second transfer arm holding the semiconductor wafer from the first amount of light at the first position and the second amount of light at the second position; and determine a position detection result indicative of a misalignment of the second transfer arm by comparing the first amount of light and the second amount of light, wherein the second transfer arm is configured to move to the second transfer arm while correcting the position of the second transfer arm based on a misalignment indicated by a position detection result of the position detector, said first opening and said second opening are located in order along the moving direction of the second transfer arm such that a light emitter is able to irradiate each of the openings as the second transfer arm moves in the moving direction towards the rotary holder; the position detector includes: the light emitter configured to irradiate each of the first opening at the first position and the second opening at the second position with a light, wherein said first opening is located directly above the light emitter at the first position and the second opening is located directly above the light emitter at the second position; a light receiver configured to receive the light passed through each of the first opening

and the second opening, the light emitter and the light receiver are disposed in front of the spin chuck in the moving path of the second transfer arm, the first opening and the second opening are disposed in front of the spin chuck in the moving path of the second transfer arm; the position of the second transfer arm is detected when the second transfer arm is in front of the spin chuck, wherein the second transfer arm is configured to advance so that a center position of the second transfer arm coincides with the center position of the spin chuck; when misalignment of the second transfer arm is detected, the second transfer arm is moved while correcting the movement of the second transfer arm so that a center position of the second transfer arm coincides with the center position of the spin chuck.

2. The semiconductor manufacturing apparatus according to claim 1, wherein the storage container includes at least one sealed cassette.

3. The semiconductor manufacturing apparatus according to claim 1, wherein one or more moving belts are configured to move the first and second transfer arms.

4. The semiconductor manufacturing apparatus according to claim 1, wherein the first transfer arm is configured to move in a first direction and in a second direction perpendicular to the first direction.

5. The semiconductor manufacturing apparatus according to claim 4, wherein the first transfer arm is configured to move in a third direction, perpendicular to the first direction and the second direction.